Impact of Spatial Cognitive Abilities on the Effectiveness of Augmented Reality in Construction and Fabrication

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Modular construction has emerged to help address the challenges posed to the construction industry by stagnant productivity rates and a shortage of skilled labor as it allows for greater automation and for work to be completed in a controlled fabrication shop environment as opposed to on a construction site. This requires tighter tolerance controls than traditional stick-built construction because the components must fit together easily with minimal on-site intervention.

Modular construction has become widespread in industrial piping construction projects. Pipe spools are assembled in a fabrication shop, installed in a module and then the modules are shipped to the construction site for installation. Since piping components account for up to 50% of the cost of an industrial construction project, it is imperative to assemble these components quickly and correctly.

In recent years, augmented reality has become increasingly prevalent as technological advances allow for higher quality digital environments at lower price points. These advances coupled with the increased accessibility of high-quality inexpensive 3D scanning technologies has made it possible to develop augmented reality solutions for real-time conformance control of pipe spool assemblies.

An experiment was designed and conducted with the objective of assessing how an augmented reality software can increase productivity and reduce rework in pipe spool assembly. Forty engineers and twenty-one pipe fitters were recruited to assemble a PVC pipe spool using either a two-sided isometric drawing or an augmented reality software. The participants were assessed for the time required to complete the assembly and for the amount of rework they had to complete to create a compliant assembly. They were also surveyed regarding their personal interest in technology and their input on how to best implement this technology. Participants were asked to complete a short test to assess their spatial skills.

The results of the completed study show that the use of an augmented reality software can increase productivity and minimize the impact of rework for both expert (pipe fitter) and drawing-literate (engineer) users. The revised workflow created through the usage of such a software essentially eliminates traditional rework. It was found that all users can benefit from the use of such a tool but that users who have lower spatial cognitive skills benefit the most.

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Chapter 1
Introduction

1.1 Background and Need

As humans began the shift from rural communities to urban centers during the industrial revolution, the need for infrastructure grew as it became critical to find a means to link people with the new industrial growth. First there was a need for buildings to house factories and transportation networks to facilitate the movement of goods from factories to the people who would use them. Then came the need for networks to spread utilities, allowing people to heat their homes and have access to potable water, as cities began to develop and became key driving factors for urban development. Infrastructure that is able to meet the needs of the society serves a critical role in the social and economic development of a nation. This role is so critical that one of the fundamental building blocks of Canadian confederation was the promise to construct a railway from the Atlantic Ocean to the Pacific Ocean, a massive undertaking by any standards, but one that was deemed critical for the development of the nation.

Based on this codependent evolution and growth, it is apparent that manufacturing and construction are heavily linked in terms of their ability to ameliorate living conditions and the challenges they face in creating accurate final products that comply with the design intent. The construction industry is often compared to the manufacturing and automotive industries, as at their core, all three industries exist to create goods based on thought-out and engineered designs that are subject to strict codes, regulations and requirements to ensure user safety and satisfaction. In many ways, the challenges and objectives of these three industries are the same. Ideally final products should be produced in a way that maximizes productivity and output while minimizing costs and mitigating risks with respect to safety and insufficient assemblies.

Manufacturing and the automotive industry have been able to increase productivity in recent years by implementing automation and 3D spatial data acquisition into their processes and workflows. Many have been quick to suggest these technologies as solutions to the stagnation in the construction industry. The single biggest obstacle in the adaptation of these technologies into the construction industry is the fundamental difference between manufacturing and the automotive industry compared to construction: repetition. Manufacturing and the automotive industry fabricate hundreds of thousands identical products based on a single design, justifying the costs and efforts

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associated with the creation of detailed updated 3D design models and refined processes. The construction industry, conversely, focuses on the creation of distinct, unique projects where minimal repetition is typically expected as each application, location and situation is unique and requires its own assembly [1], [2]. In an attempt to rectify its issues with productivity, the construction industry has seen modular construction become an increasingly popular design alternative over the last .

Modular construction is the construction equivalent of assembly line production. It removes many of the risk factors faced by traditional stick-built on-site construction by changing construction from an outdoor activity in a highly unpredictable environment to an indoor one occurring in a highly controlled environment [3],[4]. Portions of structures, referred to as modules, are assembled in a fabrication shop and are then transported on flatbed trucks to the location where they are to be installed. Once the modules arrive on site they are joined together to complete the assembly. The key to success using modular construction is to minimize the variety of modules that need to be constructed so that modules can be installed interchangeably and to enforce and construct within tight tolerances so that modules fit together easily on site.

The emphasis on repetitive design and minimal tolerance allowances in modular construction have motivated the construction industry to utilize the automation and quality control technologies that have been utilized by the manufacturing and automotive industries for years. The ubiquity of 3D models and the increased quality and accessibility of tools to capture 3D spatial point cloud data has made incorporating scan-to-BIM (building information model) for quality control purposes feasible. It is now possible to equip craft workers, for minimal cost, with 3D models of the assemblies they are creating. Similarly, it is now quick and simple to capture accurate as-built data using one of many commercially available 3D scanners.

The law of accelerating returns proposed by Kurzweil [5] suggests that as these technologies develop further over the coming years they will continue to develop at increasingly faster rates making many of the once seemingly preposterous promises by the manufacturers and developers of this technology commonplace. It is imperative that the construction industry continues to evaluate these technologies and develop them into tools that can aid managers, engineers and craft workers work more efficiently, intuitively and minimize the gaps in communication and the sharing of information that are massive sources of delay in current methodologies and best practices.

1.2 Research Motivation

In countries with high labor costs, it is imperative to incorporate new technologies to maximize productivity [6],[7]. With the strict tolerances provided on most projects and the lack of skilled labor in countries like Canada and the United States [8], finding the means to minimize the impact of rework once it is encountered on a project is critical.

While work has been done to assess the impact of rework on a project's schedule and budget, and studies have been completed to determine how the format used to convey design information impacts productivity, there has been no work done in assessing how the use of an augmented reality application tailored for pipe fitting will increase productivity and reduce rework through the clearer communication of design information coupled with visual feedback on the assembly as it is completed in real-time.

The focus of this work is on piping elements, since they can account for up to 50% of the total cost of an industrial construction project and of module fabrication [9]. Incorporating automation into the piping industry is challenging leaving it susceptible to project delays and cost overruns caused by rework. These challenges with automation are largely due to the nature of piping work and its dependence on skilled craft workers, as most components in a piping project are custom-made based on the design, by cutting and welding sections of pipe, elbows, reducers and tees. The raw materials coupled with the extensive hands-on time from craft workers makes piping portions of projects costly to complete and critical with respect to the project schedule. Additionally, current quality control methods for piping are time consuming, requiring use of conventional measuring tools and utilize traditional paper based drawings to convey information. This method is inefficient, as it is not conducive to the sharing of information regarding an assembly's fit for use amongst project stakeholders [10]. While this study is focusing on pipe elements, the general concept could be applied to fabrication of other construction project assemblies.

Traditional quality control practices exist in two stages, utilizing standard measuring tools such as levels, callipers and metal measuring tapes to verify the accuracy of an assembly. Craft workers conduct routine checks as they assemble to verify their progress. Following the completion of an assembly, quality control personnel complete a final check before the assembly is deemed complete. Should an instance of non-conformance requiring rework be detected, the quality control personnel must take note of the issues and explain them to the craft worker. The craft worker will be responsible for remedying the situation through interpreting the information presented by the quality control person and comparing it with the design information presented on the isometric drawing. The work

proposed in this study would facilitate the self-checking during the assembly process by the craft workers by providing them with quick visual feedback regarding their work in addition to assisting quality control personnel with conveying information to craft workers.

1.3 Scope

The scope of this thesis is limited to assessing the impact of an augmented reality application tailor-made for pipe fitting on craft worker productivity in completing the assembly and on the rework that needs to be completed. The impact of the participant's spatial cognition skills on the participant's productivity and rework is taken into account in the analysis to help determine how best to deploy such technology to obtain its maximal benefits. In order to complete this assessment an experiment was designed, conducted and analyzed with a total of 61 recruited participants, including both engineers and pipe fitters in a wide range of ages and experience levels.

1.4 Objectives

The overall objective of this thesis is to assess how the use of an augmented reality application assists in the assembly of pipe spools. Sub objectives include understanding which workers will benefit the most and why; how workflow and form factors influence the usefulness of the application; and in what production circumstances the application is most useful. The following hypotheses were made in relation to this study:

- The use of this augmented reality application will increase productivity by making design information easier to interpret and facilitating the craft workers' ability to troubleshoot any confusion they may have regarding the design.

- The use of the augmented reality software will eliminate traditional rework as it will modify the workflow used to complete pipe spool assemblies.

- Scanning the assembly and overlaying in on the 3D model will reduce the time and number of iterations needed by the craft workers to manipulate components that are incorrectly placed, minimizing the non-traditional and undocumented rework.

1.5 Methodology

An experimental study was completed using an augmented reality application developed as part of a joint four-year project between the University of Waterloo and Aecon Industrial West. The

experiment consisted of two experimental cases with two experiment groups per case. The two experimental cases consisted of participants working with either the augmented reality application or with a two-sided isometric to assemble a PVC pipe spool. The two experiment groups consisted of a total of 40 engineers and engineering students and 21 welders and pipe fitters. Experimental trials were conducted to assess the productivity of workers assembling a pipe assembly using the application. Their productivity was measured in terms of the amount of time spent completing the assembly and the amount of rework that needed to be completed.

1.6 Structure of Thesis

This thesis is divided into six sections. A brief summary of each section is provided as follows.

Chapter 1, *Introduction*, provides an overview of the background, scope and objectives of the work presented.

Chapter 2, *Background and Literature Review*, presents an overview of current relevant industry standards and processes and provides a summary of the literature that is relevant to this work.

Chapter 3, *Experimental Design*, describes the decision making process related to designing the spool utilized for the experiment, the validation of the methodology selected for verifying the experimental results, and an overview of the scanning options for the experiment.

Chapter 4, *Methodology*, presents the experimental process used to collect the data for the analysis and an overview of how the data was categorized for analysis. This chapter presents the assumptions and underlying logic behind the decision making used for the analysis.

Chapter 5, *Results*, presents the results of the productivity and rework studies completed based on the data sets collected, considering the impact of spatial skills on the outcomes of the study.

Chapter 6, *Summary Conclusions and Recommendations*, draws this thesis to a close, presenting the conclusions of the work presented and makes recommendations to further the work presented herein. This chapter also features ideas and commentary from experiment participants. This input from participants was highly valuable from an implementation perspective as it provided ideas for features that would increase the functionality of the augmented reality application while making the experience more user friendly.

Chapter 2

Background and Literature Review

2.1 Modular Construction

Modular construction and prefabrication have become increasingly popular means of construction as they allow for greater automation and allow for more work to be completed in a controlled fabrication shop environment as opposed to on a construction site [1]. Shifting construction from an exterior activity where it is impacted by the elements to an interior activity has helped reduce rework. Minimizing the amount of work that needs to be done directly in the field is widely regarded as one of the most effective ways to aid projects to reach their schedule and budget targets [11]. Currently, rework is believed to account for 6 to 12% of the cost of a typical construction project [12]–[14]. While modular construction has helped introduce automation to construction, not every task can be automated. This is particularly true for the pipe fabrication industry, leaving it susceptible to project delays and cost overruns caused by rework.

Modular construction requires tighter tolerance controls than traditional stick-built construction, because it requires that components fit together like giant Lego pieces with minimal on-site intervention [4]. There are five fit issues that can be encountered when trying to compile an assembly. They can be described as "pull", "twist", "bend", "pivot" and "size" problems, where pull, twist, bend and pivot are the four modifications that need to somehow be imposed onto the assembly to rectify the situation and size refers to a component of the wrong size being erroneously installed. These five can be standalone actions on a single spool, can occur in conjunction with each other on the same spool or can be coexist within a single module.

A "pull" error, shown in Figure 1, occurs when the components of the assembly are constructed too short to meet the docking location. In this kind of error, the desire is to be able to pull the component, elongating it, to allow it to reach the designated docking location. A common resolution to this problem is to find a scrap piece of pipe that matches the assembly, cut it to the appropriate length and then weld it on to the existing piece. If the existing piece is a cut end of a pipe it can be welded directly on to the end. If the existing end is a flange, the flange must be cut off, the piece must be slid in between the cut and then two welds must be performed. In addition to the time and labor wasted to perform the two welds in the field, if the installation of the module is critical to the timely completion of the project, the time needed to procure the required material will impose delays on the project. By detecting these errors before the module leaves the shop the instead of once the module is

being installed, the procurement of the required component can begin sooner, which will minimize the delay on the project.
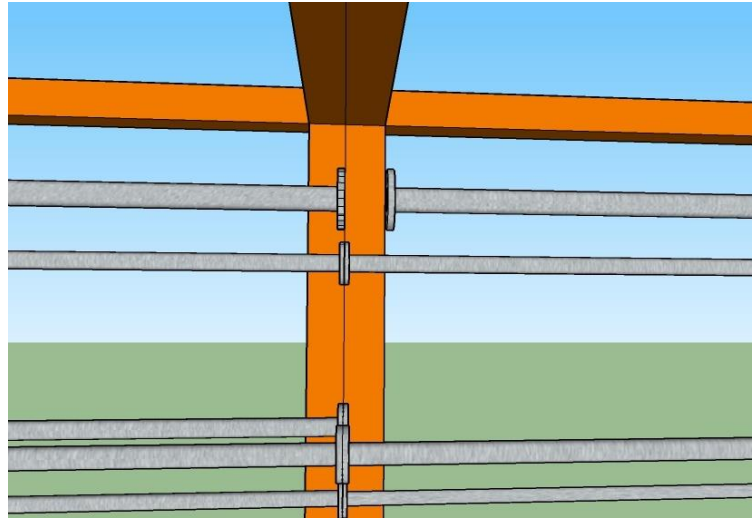
Figure 1. The 'pull' error type

A "twist" error, shown in Figure 2, occurs when the component to be mated with the other portion experiences an angular deviation about its principal axis. A common example of this problem can be found with flanges. For example, a standard four bolt flange has the holes arranged in a square pattern, but it has to mate with a flange that has its bolts in a diamond pattern. In this case, the desire is to twist the pipe, by the flange, along its principal axes to make the bolt holes line up. This is not possible as the pipe can not be twisted like that without experiencing plastic deformation and reduced strength. To fix this situation the pipe must be cut and then the rewelded at the correct orientation.
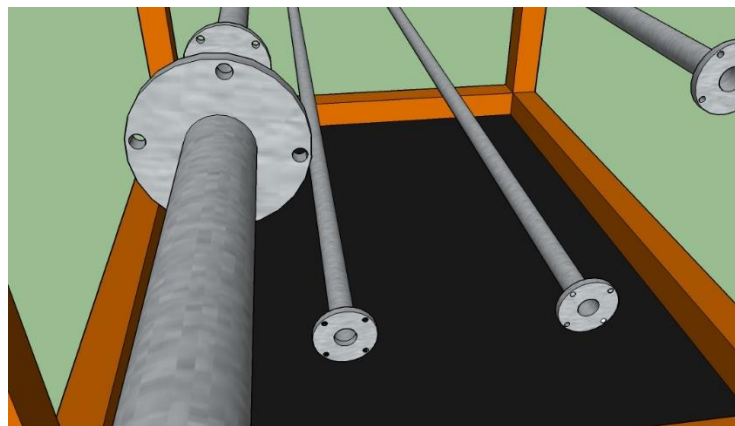
Figure 2. The 'twist' error type

A "bend" error, shown in Figure 3, occurs when the XYZ coordinates of the piece to be docked do not match these of the docking location. The desire is to induce a bend in the pipe to shift the coordinates of the piece to be docked. This can be done to an extent, but too much bending will likely create another fit issue if too much bending is induced. A "pivot" error, shown in Figure 4, occurs when a component that is to be fit is not inline with the XY plane. A "size" error, shown in Figure 5, occurs when a component of the wrong size is installed. In the case of pipe spools, this would be installing a pipe with the wrong diameter.
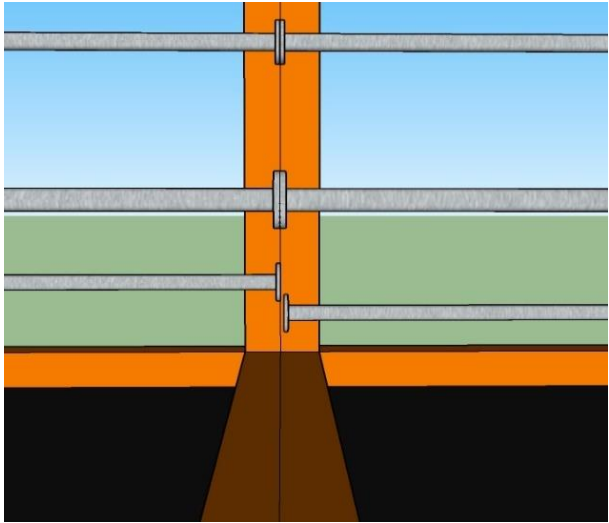
Figure 3. The 'bend' error type
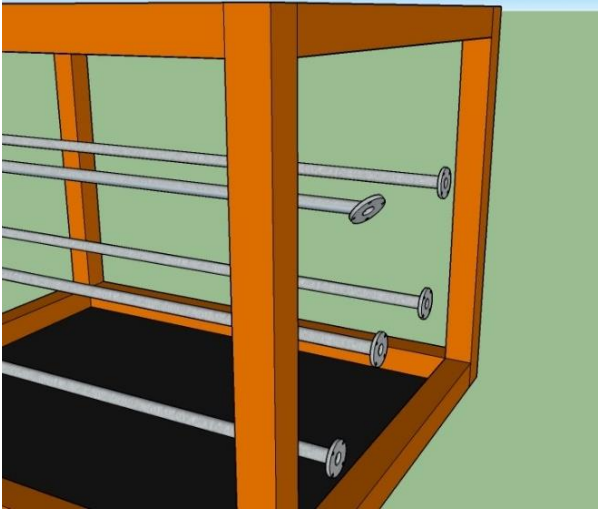
Figure 4. The 'pivot' error type
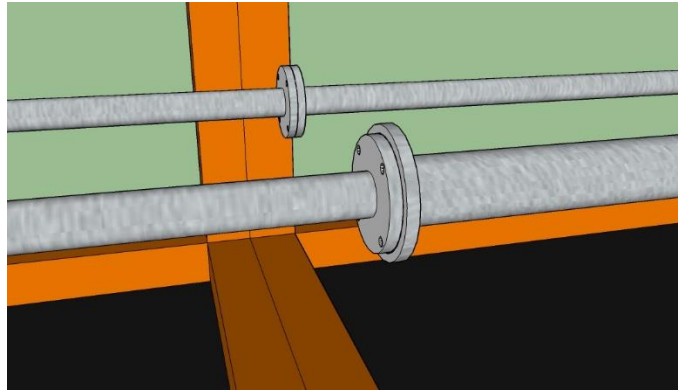
Figure 5. The 'size' error type

2.2 Pipefitting

In a traditional industrial project, pipe fitters are given isometric drawings containing all the information pertaining to the assembly they are fabricating. These drawings represent the pipes as a single straight lines using a 45°, 90°, 45° projection system [15]. These drawings provide information about assembly geometry, welds and components such as elbows and flanges.

In a typical pipe spool fabrication project, summarized in Figure 6, straight lengths of pipes and accessory components: elbows, flanges, valves and reducers, are procured from a supplier. These prefabricated components are all referred to as pipe spools. The straight pipe lengths are cut down to the lengths required for the work being completed [16]. These components are then given to a pipe fitter who will assembly them by interpreting the information presented on the isometric drawing and then manipulating the components to get them into position. Once the piping components are positioned, their accuracy is verified before they are tack welded together.

Components are then tacked together by the fitter. They are checked for fit, and then the tacked components are then given to a welder who completes the welds. On any given assembly this process of tacking and welding is somewhat iterative as components of an assembly are assembled in a way that maximizes the number of semi-automated roll welds and minimizes the number of manual positon welds. This is done because roll welds are quicker to complete and are more consistently completed to a high standard. When completing a roll weld, the assembly is mounted into an apparatus that rolls the assembly at a rate controlled by the welder who is completing the welding. The welder remains in a single position and the material that is to be welded turns under the torch. The other option for completing a weld is to perform a position weld. Position welds are minimized, because they are more time consuming to complete as the welder must move around the components

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to be welded. Position welds are only completed when the assembly that is being welded can no longer be rolled, because either one of the pieces that needs to be rotated would collide with the surrounding equipment or because the assembly bends back onto itself.
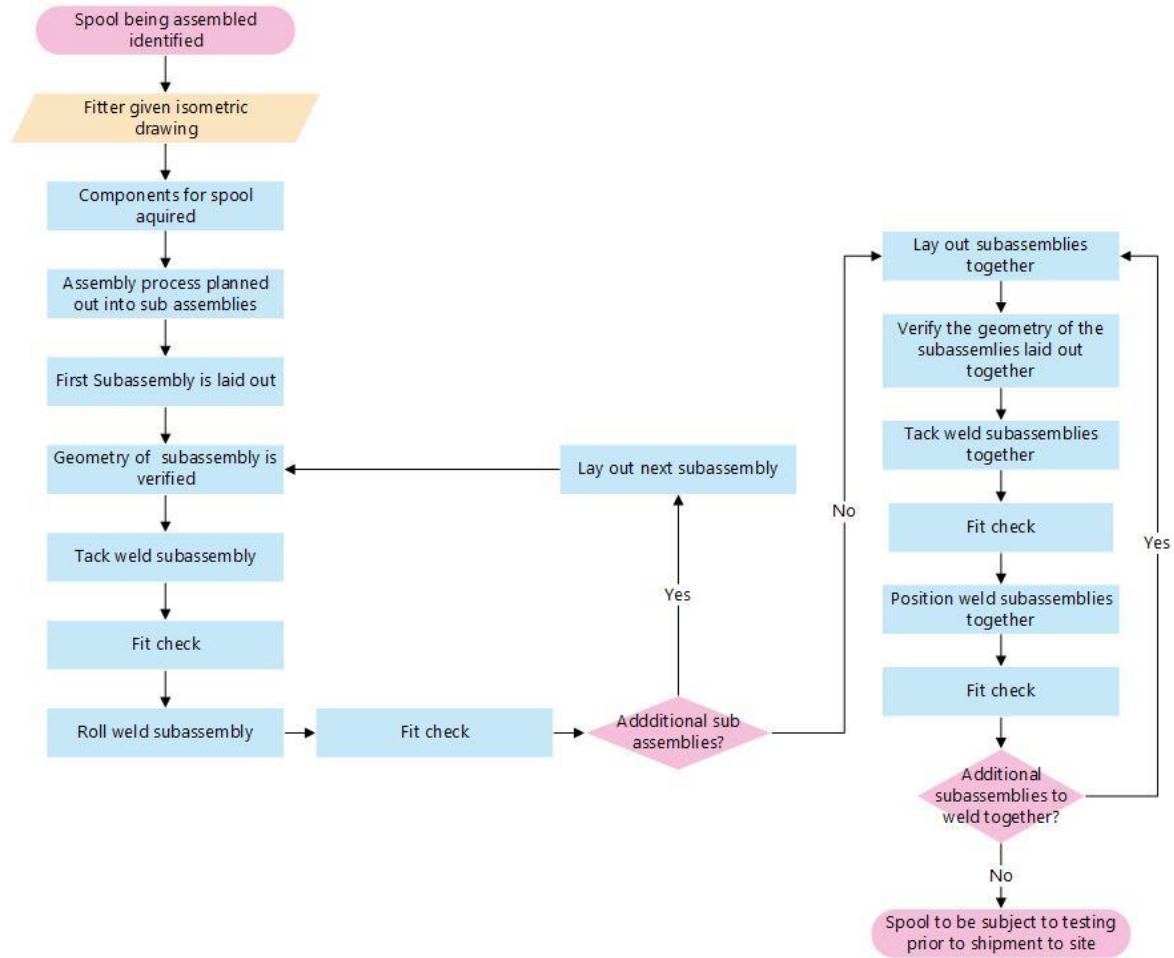
Figure 6. Pipe spool assembly workflow

2.3 Rework

Rework is responsible for losses in the construction industry and is a major contributor to projects being completed behind schedule and over budget. In an industrial project, measured rework is believed to be approximately 2.4% of the contract value, representing millions of dollars in losses [17]. Normal process iteration is not considered part of rework. In general, minimizing rework and its impact on a project's ability to meet its budget and schedule is viewed as the key in improving construction productivity [11]. Minimizing process iteration is also an opportunity.

It has been found that craft workers believe that 32% of their negative productivity is caused by the insufficient quality of the information they are provided, and this insufficient quality of information was deemed to contribute to reduced morale within the group of workers [18]. In addition to the direct costs of rework in general construction projects, which may total up to 25% of the contract value , rework has an impact valued at 3 to 6 times its direct cost given the impact it has on workers and the decreased site moral experienced when workers are asked to redo work that was previously completed [19].

There are essentially two types of rework: (1) traditional documented rework where the completed assembly is either taken apart or modified once it was deemed completed to rectify an erroneous assembly, and (2) non-traditional undocumented rework where processes are iterated and work is redone without being documented. The main difference between these two types of rework lies in how and by whom they are detected. Documented rework is typically identified by an engineer's inspection or a quality control inspection and is tracked and logged throughout the project. Undocumented rework is typically identified by craft workers themselves and is corrected without being logged or reported through official means. This undocumented rework is detected by project management through fabrication shop and onsite progress and productivity reports. Undocumented rework is essentially identified as lower than anticipated rates of output from craft workers.

There are two main sources of rework: process based sources and human performance based sources. Process based rework is largely due to management deficiencies surrounding design and engineering, instruction and inspection, schedule and material and equipment supply. Factors contributing to this type of rework include insufficient details or erroneous design, ineffective decision making and poor communication, poor scheduling of resources and unrealistic expectations of workflow as well as insufficient equipment and delayed delivery of materials. Human performance based rework is due to gaps in knowledge, skill and self-discipline of humans working on a project. These include insufficient knowledge to complete a task, lack of adequate training to complete a specific task and lack of motivation to complete work in a timely and efficient manner [11].

It is clear that the issues contributing to rework and reduced productivity in construction projects are complicated, rooted in the existing structures of workflows and best practices and that responsibility for these issues and their rectification is shared by management and craft workers.

2.4 Augmented Reality

In recent years, enhanced digital reality has become increasingly prevalent as technological advances allow for higher quality digital environments at lower price points. There are two areas of enhanced digital reality: virtual reality and augmented reality. Virtual reality consists of an immersive environment while augmented reality is an enhancement of the existing surroundings by overlaying digital information [20]. Augmented reality is generally preferable to virtual reality for applications in the construction industry as it does not inhibit a user's awareness of their physical environment in the way that virtual reality does [6], making it a safer option for hazardous construction sites. Augmented reality makes uses of a user's situational awareness and is a more user-focused approach to implementing new technology compared to older more technology-focused approaches where the technology is developed and the user must accept it as is [6] which makes it preferable for target users of craft workers as it allows them to maintain pride in their work.

Mobile augmented reality is expected to become increasingly present in the construction industry as it is becoming inexpensive to deploy and has a wide range of potential applications, with the primary challenge being to develop applications that are scalable and can readily conform to the current task or environment [6].

2.5 Information Formats

Isometric drawings can be hard to interpret depending on the geometric complexity of the assembly and the worker's experience and level of comfort with the drawing format. A number of studies have been conducted showing the impact of different information formats on the productivity and quality of work performed by craft workers.

In 2015, Hou et al. [20] focused on improving productivity and performance through lowering the cognitive load experienced by craft workers using augmented reality. The study was executed on graduate students in construction, computer science, architecture and engineering. Students were tasked with assembling a PVC pipe system. Half of the students were given a 2D isometric drawing while the other were given a 3D model on a TV display. The model could be rotated by moving a hand-held remote sensor in the direction they wanted to move the model. This study found that the use of 3D models reduced the cognitive load experienced by the participants and reduced the time required to complete the assembly by 50%

In 2016, Goodrum et al [9] completed a study in which 54 pipe fitters were given different formats of information to assemble a pipe assembly. One group was given a traditional 2D isometric

drawing. The second group was given a two-sided isometric drawing, which consists of a 2D isometric drawing with a 2D projection of the corresponding 3D model on the back. The third group was given a 2D drawing with a 3D printed model of the assembly. The latter two groups both benefitted from the additional information; however, the second group, the one with the two-sided isometric drawing, was the fasted group. The results of this study were the main motivation behind providing the participants who did not use the augmented reality application with a two-sided isometric instead of a standard isometric drawing in the current study as two-sided isometrics are now an industry best-practice.

In 2014, Dadi et al [15], recruited 26 individuals, both engineering professionals and craft workers to assemble a 3D structure. The individuals were separated into three groups and each group was given the design in a different format. One group had a 2D set of drawings, the second a 3D computer model of the assembly and the third had a 3D printed model of the assembly. The study found that 3D printed models increased direct work and lowered the required mental work load more than 3D computer models and 2D drawings.

2.6 3D BIM

The increased prevalence of 3D Building Information Modeling (BIM) over the last two decades is a major contributor to the feasibility of the augmented reality application being investigated in this work, as the proposed workfow is contingent on having access to accurate, updated 3D models. BIM is a digital, three dimensional representation of a construction project that provides information about the project's schedule, lifecycle and costs as additional dimensions to the model, referred to as the 4th, 5th and 6th dimensions of BIM [21]. Utilizing BIM offers many benefits to project stakeholders and BIM is considered to be of greatest value on projects that utilize integrated project delivery as this project-delivery style places a focus on collaborative work between project stakeholders [22]. Projects that utilize BIM are able to achieve increases in productivity of up to 30% while reducing the Requests for Information and Change Orders by a factor of 10 [23]. With design errors and omissions having the highest impact on the project cost for industrial projects, adopting 3D models to better integrate the different aspects of the design can help reduce the cost of a major industrial project [24]. Project managers believe that 3D modeling is a worthwhile investment and, specifically for the piping industry, that failing to create a model will increase the cost of piping project by 10% [25].

The presence of 3D BIM had led to the research and development of scan-to-BIM applications. These applications can be used for compliance checking of materials and assemblies, with applications in the assessment of pipe spools being an area of focus [26]–[28]. 4D BIM, where the fourth dimension is the project schedule, has also made use of scan-to-BIM technology to monitor the progress of construction projects based on the ability to accurately capture the project's current status using a laser scanner [29]–[31].

2.7 3D Point Clouds and Spatial Data Acquisition

A 3D point cloud is a digital representation of an object or scene where information is contained in a set of Cartesian coordinates that represent the geometry of the shape [21]. 3D point clouds can be generated using numerous established and emerging technologies, with laser scanning and image based techniques being the most extensively evaluated methods in terms of civil applications [21].

The use of laser scanners to acquire 3D spatial data is well established in construction management [32]. Laser scanners have been used for automated progress tracking [29], [30] and for compliance checking of fabricated elements [33], [34]. Laser scanners use a laser to acquire data about physical objects in a dense and accurate point cloud. In addition to the Cartesian coordinates of each voxel of the object scanned, laser scanners can record the color and intensity of every point. While highly accurate, this technology is somewhat time consuming to use and is expensive to acquire [35]. The main drawback to the use of a laser scanner is the post-processing that must be done once the scans themselves are acquired. A laser scanner is a stationary scanning device, requiring that multiple scans be completed to get a complete view of the object being considered. Data from a single scan is subject to occlusions caused by objects blocking the path of the scanner to the subject of the scan and reflections from the object being scanned [36]. Before any work can be done with the obtained point clouds, they must be registered together [37]. Currently this requires transferring the scans to a computer and registering the scans through use of a specialized software. Automatic registration of point clouds is an area of active research [34].

While laser scanners are able to provide highly accurate and broad range data, the processing required to make the data useable is time consuming making it difficult to incorporate the technology into real time processes. For this reason, portable structured light scanners present a unique opportunity to acquire 3D spatial data that does not require processing and can thus be used in real time. Structured light scanners work by using a multiple camera and projector system to acquire

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spatial data by projecting a 2D pattern onto a 3D object which distorts the pattern. The multiple cameras then use triangulation to compute the distortion create by the object and generate a 3D point cloud.

Some additional technologies used to acquire 3D point clouds include photogrammetry, range images and structure from motion. Photogrammetry is an image-based technology that reconstructs 3D objects from 2D images. It requires multiple images of the same object from different angles and orientations to reconstruct a 3D scene [38]. Range images are obtained using 3D range imaging cameras. Compared to laser scanners, 3D range imaging cameras are faster and more portable but their small scanning range makes them inefficient for use on big construction sites [35]. Structure-from-motion is a range imaging technique [39] that generates a 3D environment based on 2D motion. [40]

With the technology used to acquire 3D spatial data becoming increasingly more affordable, and the ubiquity of 3D models for construction projects, it is now possible to show craft workers the rework that needs to be completed by overlaying the 3D as-built scan over the 3D design model, simplifying the process of conveying this information.

2.8 Spatial Cognition Skills

There is debate in the area of psychometric research as spatial ability does not consider a single factor but rather an assortment of factors that work in conjunction with one another including: spatial perception, spatial visualization and mental rotation [41]. However, the focus of studies that link spatial abilities with science, technology, engineering and mathematics (STEM) education is on spatial visualization skills [42]. It is believed to be different from spatial perception and mental rotation because it requires multiple mental steps and have multiple solution strategies [41]. This is also the most readily applicable aspect of spatial cognition of the pipe fitting industry as it is the process of constructing, maintaining and manipulating 3D objects in one's mind[43] and the ability to do so is critical to parse design information in order to build the required assemblies.

Studies have found that men outperform women on spatial tests and that while training will improve womens' results, the gender gap does often remain [42], [44]. It has also been found that the spatial experiences of playing sports and video games increase spatial abilities and males, having more exposure to these activities in their childhood, have more benefit from this form of visuospatial training [44].

It has been found that strong spatial abilities are critical to developing an understanding of STEM concepts [42] and that this disparity in skill level is especially noticed in early stages of one's career. Strong spatial abilities allow younger students to excel in geometry, physics and chemistry and pushes them towards university degree programs in STEM [42]. It is difficult to find if similar trends exist within pipe fitters or other craft workers within the literature surrounding spatial skills, likely because these studies are most frequently conducted at universities which tend to not have access to craft workers.

There are several tests that have been developed to assess spatial abilities which include: the Mental Rotations Test (MRT) which presents a key figure that is to be compared against potential figures to determine which ones match the original figure; the Mental Cutting Test (MCT) which presents a 3D object cut by a hypothetical plane are requires the test subject identify the figure that corresponds to the cut shape's cross section; the Differential Aptitude Test: Space Relations (DAT:SR) which presents a 2D pattern to be matched with a 3D shape that would result from folding the 3D pattern and the Lappan Test which assesses the understanding of isometric sketching and orthographic projections [43]. Many tests have been developed by institutions that utilize these types of questions applied to both 2D and 3D environments to assess a test participant's spatial skills. One such test is the Factor-References Cognitive Test Kit developed by Educational Test Services (ETS) in 1976 [45]. This test was used in the study to evaluate the participants.

2.9 Worker Motivations

To successfully implement new technology into an existing area of manual work, the workers who will be using the technology must be receptive to the implementation and adaptation of these new tools. Workers may be reluctant to learn new technologies that are viewed as threatening to the social dynamics and solidarity expressed through their unionization [46]. In a 2001 study by Bratton [46] that focused on the Canadian pulp and paper industry, it was found that while workers and their unions recognize the personal gains to be made by learning new skills at work and becoming more flexible employees for their employer, they also identify the social cost imposed on their colleagues by increasing their skill set. If one worker learns additional skills that infringe on the job description of a colleague, then it stands to reason that that colleague may be out of a job during the next round of downsizing.

Utilizing a user-focused approach to implementing technology, wherein the technology serves as a tool to help the craft worker and not to replace the craft worker, will enable the end user of

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the technology to remain engaged in their work which is beneficial to the long term success of the new technology [6].

Chapter 3
Experimental Design

It was deemed infeasible from a financial, logistical and safety perspective to conduct an experiment using a welded metal pipe assembly as would be the normal use scenario for the augmented reality process once it is deployed. Thus, a spool utilizing 1.5" diameter black PVC pipes was designed in the place of a metal spool. To help simulate the act of tack welding, the flexible couplings shown in Figure 7 were used. These connections require that a participant use a screwdriver to tighten the metal connector, enforcing a penalty for a participant who created an incorrect assembly since the connection must be loosened, the components moved and then the connection reconnected.

The nature of these socket-based connections prevents some of the challenges pipe fitters typically experience in assembling components to be flush with one another. This prompted the design of a spool with a more challenging geometry than normally experienced in an industrial piping project to help create an assembly that requires the level of planning and attention to detail that assembling a proper metal pipe spool would require.

Figure 7. Flexible elbow coupling used to simulate socket welds

The two-sided isometric drawing that was given to participants to convey design information is shown in Figure 8. A larger version of the drawing is provided in Appendix A.
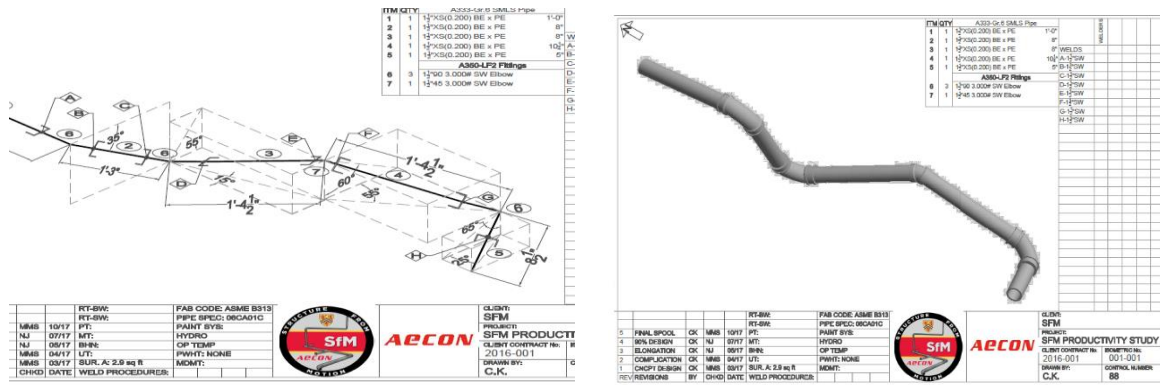
Figure 8. Both sides of the two-sided iso used in the experiment

3.1 Augmented Reality Application

An augmented reality application was developed by a team of researchers at the University of Waterloo working with Aecon Industrial West, to facilitate the process of assembling pipe spools for pipe fitters. The application focuses on making design information easier to interpret and providing a quick and accurate compliance check for completed or partially completed assemblies to facilitate the process of completing assemblies right the first time, thus increasing productivity and reducing rework.

The current workflow of the application is summarized in Figure 9 and features a series of screens that the worker can advance through as they assemble a pipe spool. Upon launching the app, the worker is presented with both sides of an augmented 2-sided iso: both a traditional isometric drawing and a fully manipulatable 3D model of the spool to be assembled. The worker can then move forward to the segmentation page where they can portion out the part of the assembly they are currently working on. The segmentation portions out the design model to show only the parts of the model that are currently being worked on. The worker is then taken to the scan acquisition page where there are several options for scan acquisition. For the purpose of this study all the scans were acquired using a Structure IO structured light scanner mounted on an iPad. Once the scan is acquired, a minimal amount of user input is required to overlay the scan over the 3D model. This process requires that a worker select 3 corresponding points on both the scan and the model to align the 2 point clouds. From there, an automatic clutter removal algorithm removes the points in the scan that are not a part of the pipe spool being investigated. The final output of the application is a heatmap that shows the compliance of the spool assembled with the model. If the heatmap indicates a compliant assembly, the user is prompted to return to the page with the 2-sided iso and to continue

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assembling the next component of the spool. In the event of an uncompliant assembly, the user is prompted to make corrections to the assembly and then to rescan the assembly.
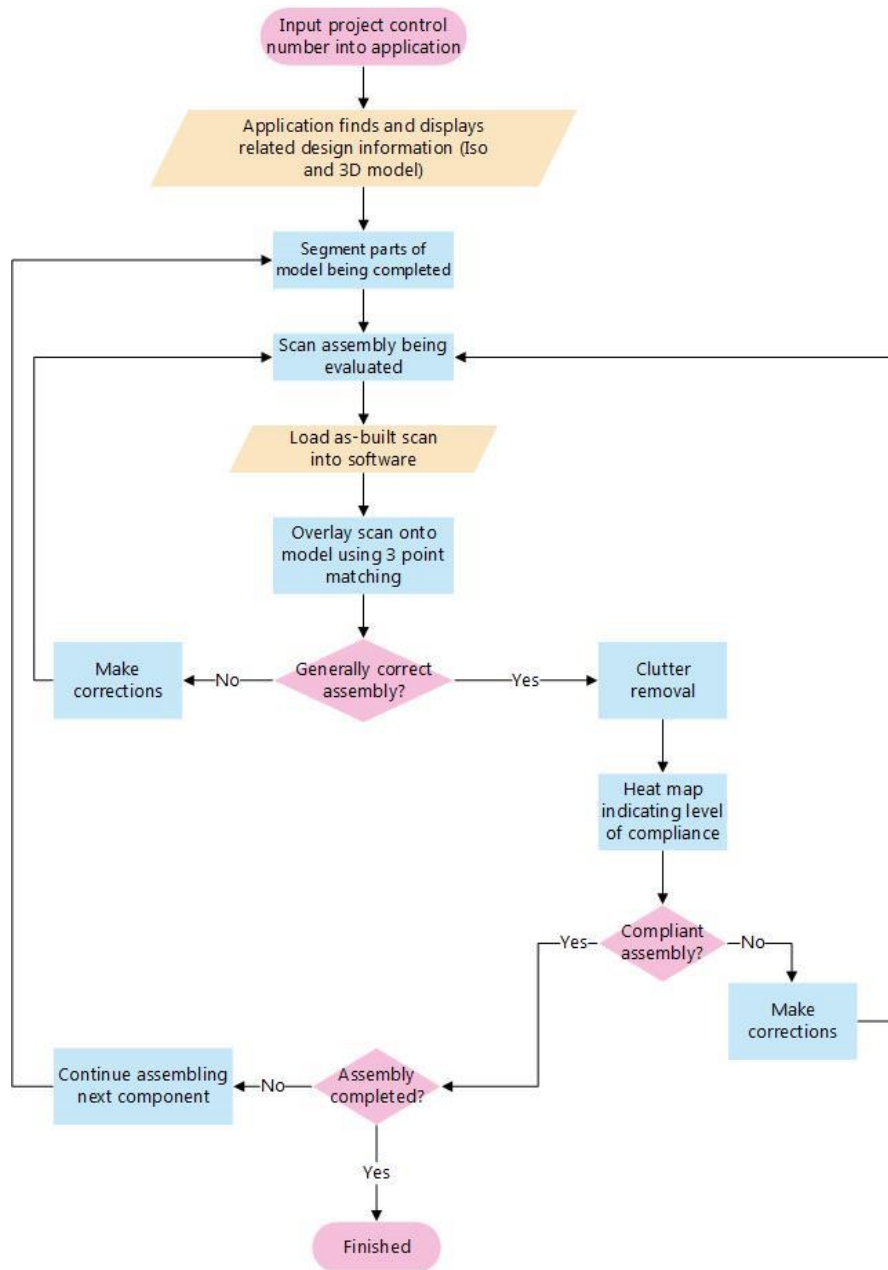
Figure 9. Augmented Reality Application Workflow

A proposed workflow that incorporates the augmented reality application into the pipe fitting process can be seen in Figure 10.
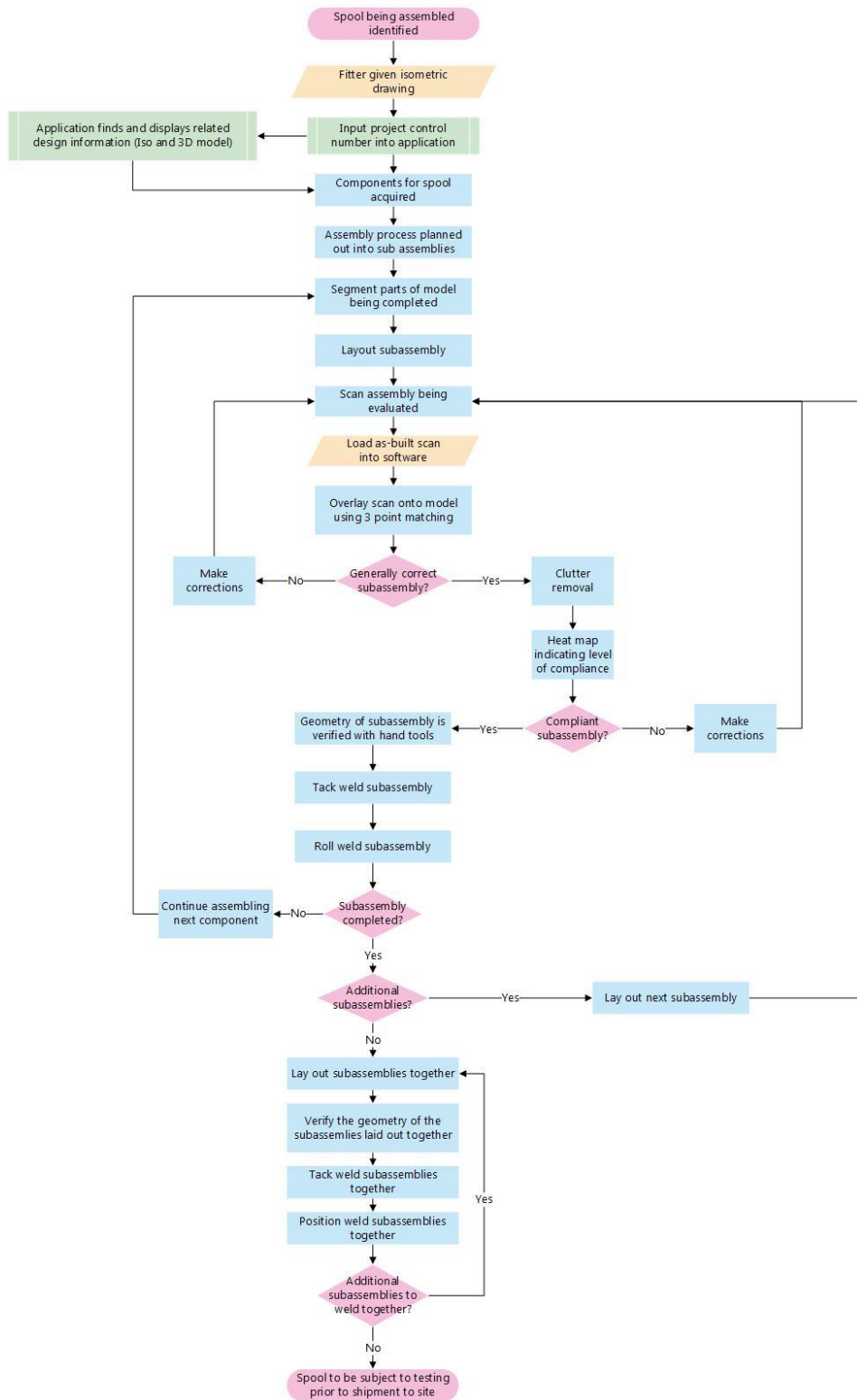
Figure 10. Proposed combined workflow for using the application to assemble pipe spools

It is proposed that the application can be used to facilitate the process of planning out subassemblies based on the design information by taking advantage of the model segmentation feature to help visualize the components in an effort to maximize the number of roll welds done in completing the assembly.

The application's 3D model could then be used to help the fitter with the interpretation of the geometry to facilitate and speed up the assembly process. The scanning feature could then be used to quickly verify that the geometry is close to accurate in the event of a particularly complicated spool design to avoid spending time adjusting an assembly that was incorrectly interpreted from the drawing. A fitter could then iterate through this process to complete all the sub-assemblies before the subassemblies are tacked together and then position welded together.

3.2 Design of Spool

An experiment was designed to validate that the augmented app will help increase productivity and reduce rework in assembling pipe spools. Because the experiment lacked the financial resources and means to run the experiment on a welded metal pipe assembly as would be the normal use scenario for the app once it is deployed, a PVC pipe spool was used as the experiment spool.

The design of this experiment spool was based on an existing PVC spool in the lab. This spool, known as the Cobra, is shown in Figure 1.
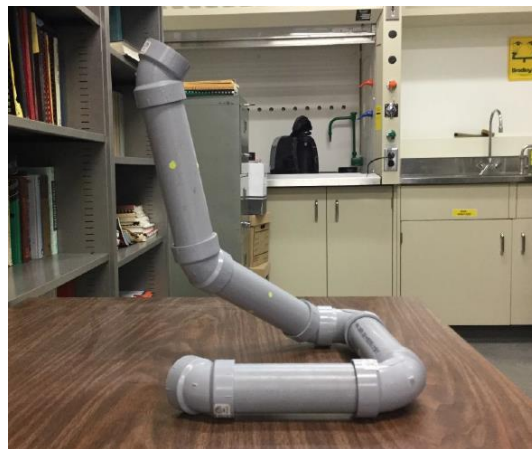
Figure 11. The cobra spool

The cobra was initially considered for the experiment as all the necessary files and documents needed to conduct the experiment were already available. However, as the experimental design based

on the cobra began, several issues were identified with the spool. The pieces fit together either too tightly which made adjustments without disrupting the rest of the spool challenging, or fit too loosely and wouldn't stay together.

It was also decided that the cobra was not a sufficient proxy for a real welded assembly, because there were no penalties for rework. If the assembly was incorrect, a participant could just apply some force to modify the component until the fit was perfect. Based on these problems, a new spool was designed.

The new spool was designed using 1.5" diameter black PVC pipes purchased at the hardware store. To help simulate the act of tack welding, the team purchased flexible coupling shown in Figure 12. The connections require the user to use a screwdriver to tighten the metal connector. This penalizes a participant for creating an incorrect assembly since the connection must be loosened, the components moved and then the connection reconnected. This was deemed to be an acceptable proxy for tack welding, where components tack welded incorrectly would have the tack weld cut out and filed down before the components could be reassembled correctly.

The first iteration of the experiment spool design consisted of five 8" long pieces of pipe connected in a sort of tapered C shape pattern using three 90° elbows. One of the elbows was placed at a 45° angle to elevate part of the spool. The assembly is shown in Figure 12.

Figure 12. First spool designed for the experiment

However, when the spool was assembled to the dimensions specified in the design file, it was determined that the spool was too simple for the purpose of the experiment. The 45° bend that was introduced to complicate the geometry was easily created and verified by using a geometric triangle. This made the spool too simple to assemble, eliminated many of the benefits of using the application

that was created and eliminated the penalty imposed by the coupling connections since the triangle could be used to hold the assembly in the correct position until it was tightened.

A second spool was then created. The second spool incorporated 45° rigid PVC bends to complicate the geometry. The 45° and 90°elbows were placed with centerline offsets at 5°, 10°, 15°, 20°, 30° and 50° angles that didn't have readily available geometric templates, making it more challenging to verify the geometry with conventional tools. This incorporated the most challenging aspect of the cobra spool. The second spool was also designed in a way that required the use of supports as the pieces were designed in a way that did not provide the assembly with a flat base. In addition to the 8" long straight pieces of pipe that were used in the original design, 2" and 5" long pieces were also incorporated to help eliminate symmetry. The assembly is shown in Figure 13.
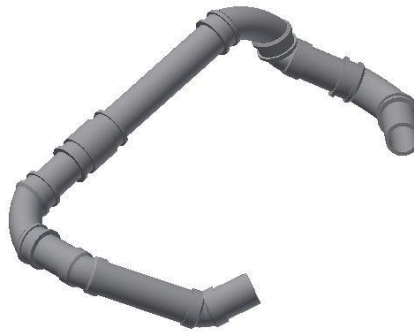
Figure 13. The second spool designed for the experiment

Upon constructing the assembly, it was decided that the second iteration was too challenging. Having 2 elbows directly connected made the geometry challenging to assemble. So challenging that it likely would have made the experiment too long for participants to willingly complete. The double angles also made it challenging to measure angular offsets for participants to assemble the spool. The shorter pipe lengths were deemed to be too small as they required that the supports be placed very close together which presented a logistical challenge of finding appropriate supports.

A third spool was then designed. It was similar to the second spool, but eliminated the use of elbows connected directly to other elbows and eliminated the use of 2" long straight pieces. Once the pieces were all prepared, the team decided that some of the components of the assembly could be permanently fixed to reduce the number of pieces that needed to be assembled and reduce the duration of the experiment. The third spool is shown in Figure 14.
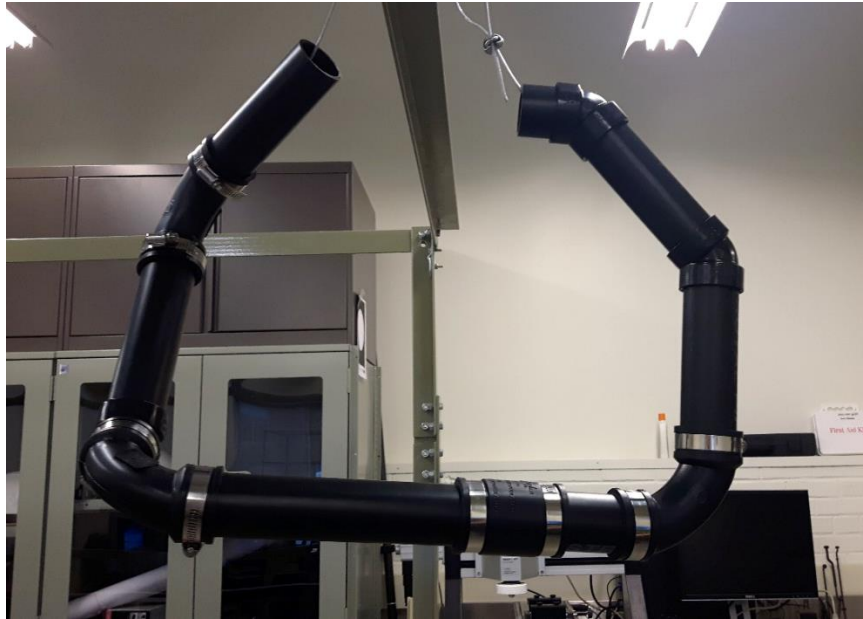
Figure 14. The third spool designed for the experiment

Upon trying to assemble the third spool and confirm the measurements, it was realized that the third spool still had some deficiencies, prompting the creation of a fourth design. The straight connection was removed as this connector did not adequately reflect the challenge of joining two straight pieces of pipe together. While this is a real challenge when tack welding pipes, a suitable proxy for this challenge that could be evaluated in the experiment was not found. The number of screw-tightened connections that the participants are required to complete was reduced from 8 to 5 to help control the length of the experiment. The new spool was designed to follow a path to make it feel like a more realistic assembly. The straight lengths of pipe were extended from 5 and 8 inch segments to 8 and 12 inch segments in the fourth design. Extending the pieces makes it easier for participants to measure the rise and run of components to determine the angles and increased the tolerance of acceptable measurements. The pieces were capped at 12 inches in length to ensure that the spool does not become too large which would make scanning it with the Structure IO challenging. The team decided that 3 components would be glued together (2 straight lengths of pipe that feed into a 45° elbow) as this is not a screw-tightened connection and may fall apart or shift during the installation of subsequent components. An Inventor™ model for the fourth spool is shown in Figure 15.

Figure 15: Inventor model for the fourth design

This fourth design was used in a trial experiment to see how challenging it was to assemble. Based on just the 3D model as a figure that could be rotated, without being given any dimensions, participants were able to assemble the spool. The spool was able to be assembled in under half an hour without the aid of tools and measurements, which seemed like a reasonable duration for this experiment as it would allow for training on the app itself, administration of spatial tests and verbal feedback from users in addition to completing the experiment itself.

This design was then shown to an engineer at Aecon who said that while the spool was more complicated than a typical spool assembly seen in their shop, it did not feel like an unreasonable design. This was deemed sufficient endorsement of the spool as this spool does not have the same challenges in making the components connect in a way where they are flush with one another and thus requires a more challenging geometry than the norm to help create a spool that requires the level of planning and attention to detail that assembling a proper metal pipe spool would require. While preliminary tests to debug any last issues with the designed experiment were conducted, one last piece of pipe was attached to the elbow that was previously the termination point of the spool to make it easier for participants to measure the angle at which that component was attached. The final design is shown in Figure 16.
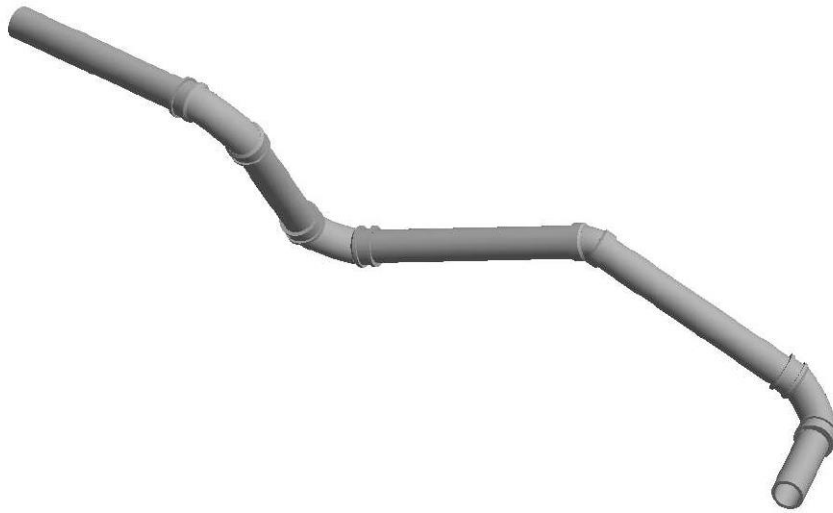
Figure 16: Final spool (Inventor^{TM} Model Rendering)

A later further endorsement of the spool and its many complicated angles was found through discussions with engineers in the nuclear power generation industry who commented that the feeder tubes used in nuclear power plants are often inclined at nontraditional angles, require many complicated spool assemblies be nested with one another and must be completed to very strict tolerances and safety guidelines. Figure 17 shows the face of a CANDU reactor core and the many feeder tubes that provide water for steam during operation.
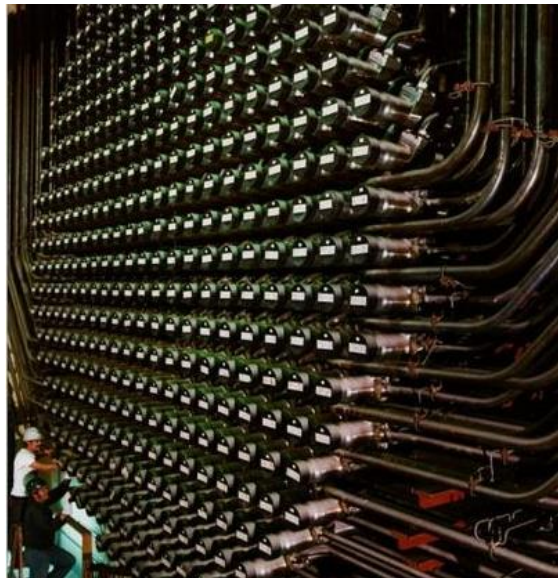
Figure 17. Face of a CANDU reactor core (Picture from [47]**)**

3.3 Evaluation of Inventor Model

To simulate welding in the experiment, flexible 90° elbows with metal clips were used. However, because no 3D model was readily available for this elbow, it was scanned using the FARO Arm scanner. The point cloud obtained is shown in Figure 18. This works well, because all 3D designs are converted in the application to point cloud equivalents in order to easily compare them with the scanned point clouds of assemblies.

Figure 18. Point cloud of the elbow obtained with the FARO Arm scanner

Because the team did not have access to a software that could easily fit geometric shapes to the scan point cloud, a caliper was used to measure the elbow. A 3D model was then created in Inventor. This model was exported as an STL file and was then repopulated using Meshlab to create the point cloud shown in Figure 19.
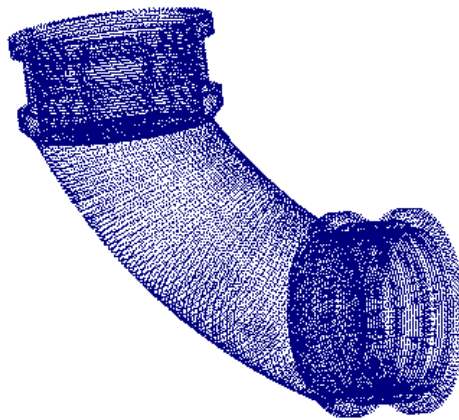
Figure 19: Point cloud of elbow generated using Inventor

The 2 point clouds were then overlayed in Meshlab to assess how closely the Inventor model reflected the scanned point cloud. The heat map obtained from overlaying the 2 point clouds is shown in Figure 20. Deviations greater than or equal to 3mm are shown in red.
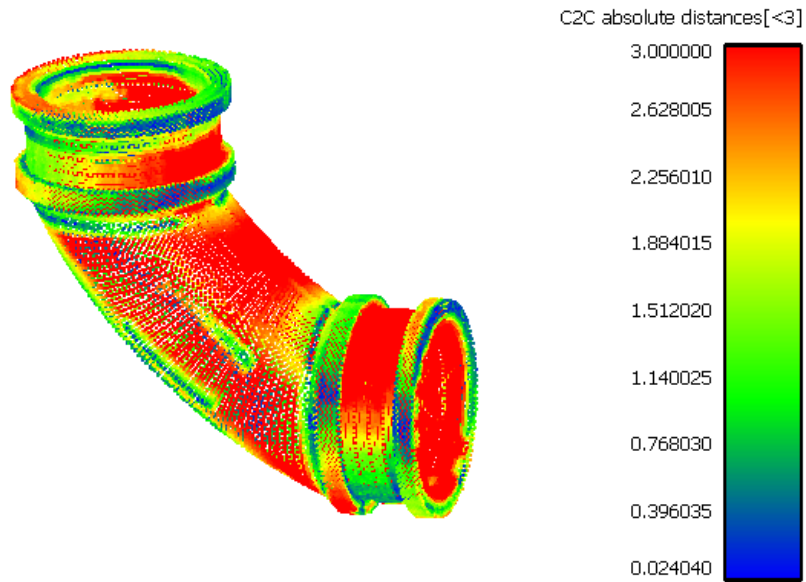
Figure 20. Overlay of FARO Arm scan onto Inventor model of elbow (3+ mm deviations)

A second heat map was then generated to show deviations of 5 or more millimeters in red. This heat map is shown in Figure 21.
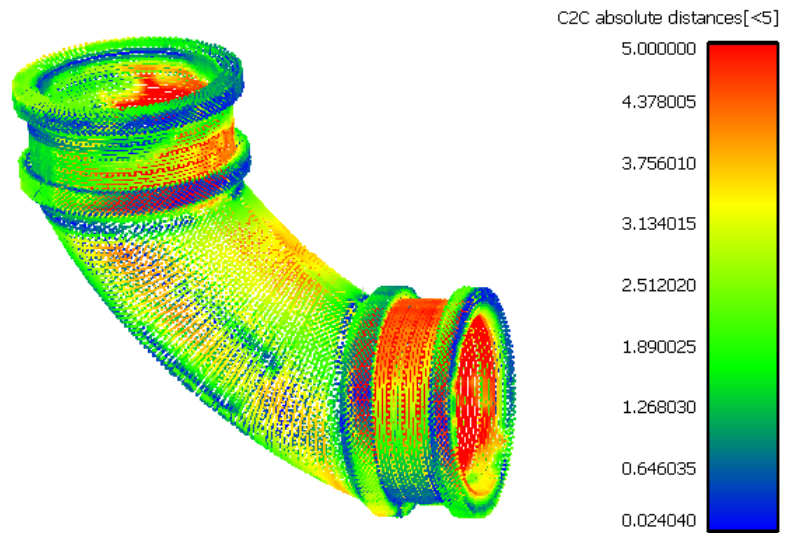
Figure 21. Overlay of FARO Arm scan onto Inventor model of elbow (5+mm deviations)

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While the radius of curvature in the elbow isn't perfect, it appears that the end points are sufficient to allow for use as the designed model proxy for the experiment.

The elbow was then scanned with the Structure IO mounted on an iPad and the point cloud obtained was superimposed on the point cloud obtained from the inventor model. The heat map shown in Figure 22 was generated to show the deviation between the 2 point clouds. Deviations of 2mm or more are shown in red.
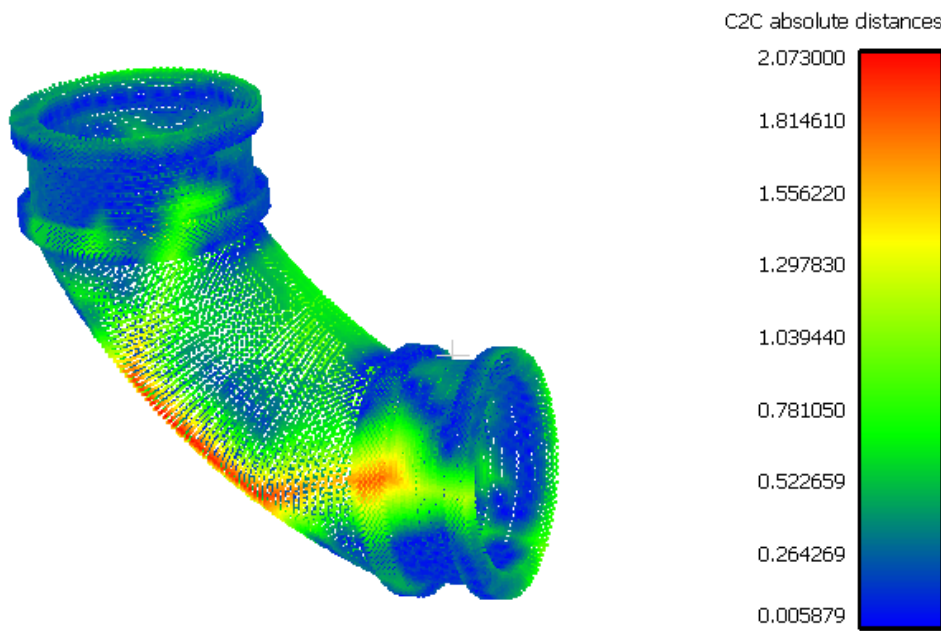
Figure 22. Overlay of Inventor model and a Structure IO scan (2+mm deviations)

This evaluation of the Inventor model was then expanded to consider the Inventor model for the whole spool and so see how it compares to a (mostly) compliant spool assembly. An almost perfectly compliant assembly was scanned with a Structure IO scanner mounted on an iPad and was superimposed onto a point cloud generated from the Inventor model of the spool. Two heat maps were generated to compare the as-built point cloud to the model. The heat map shown in Figure 23 shows deviations of 3 or more millimeters in red. The second heat map shown in Figure 24 shows deviations of 5 or more millimeters in red.
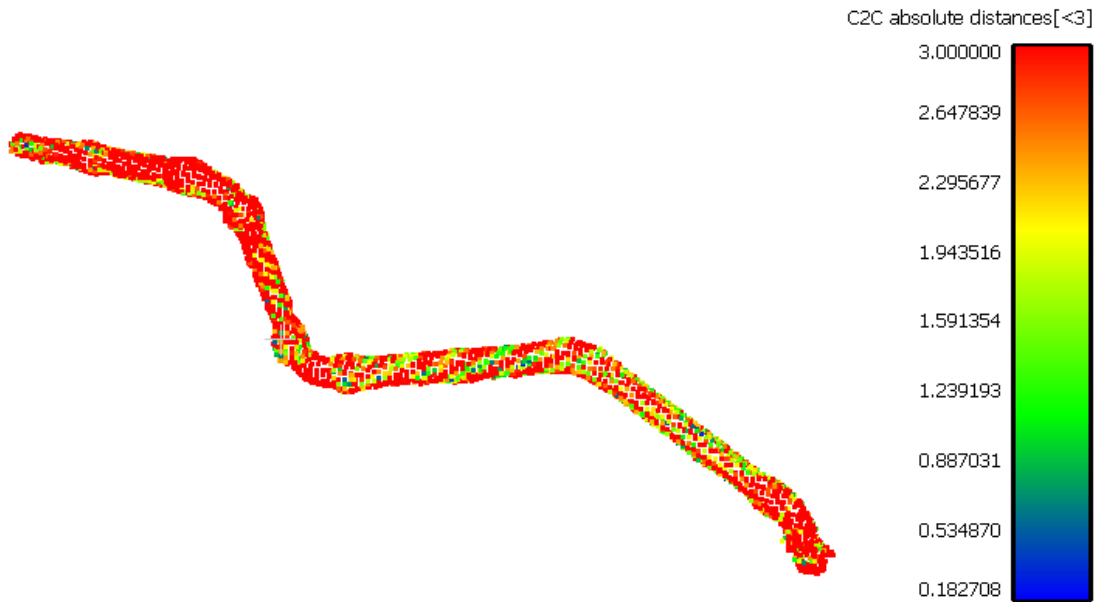
Figure 23: Heat map showing deviations of 3 or more millimeters in red
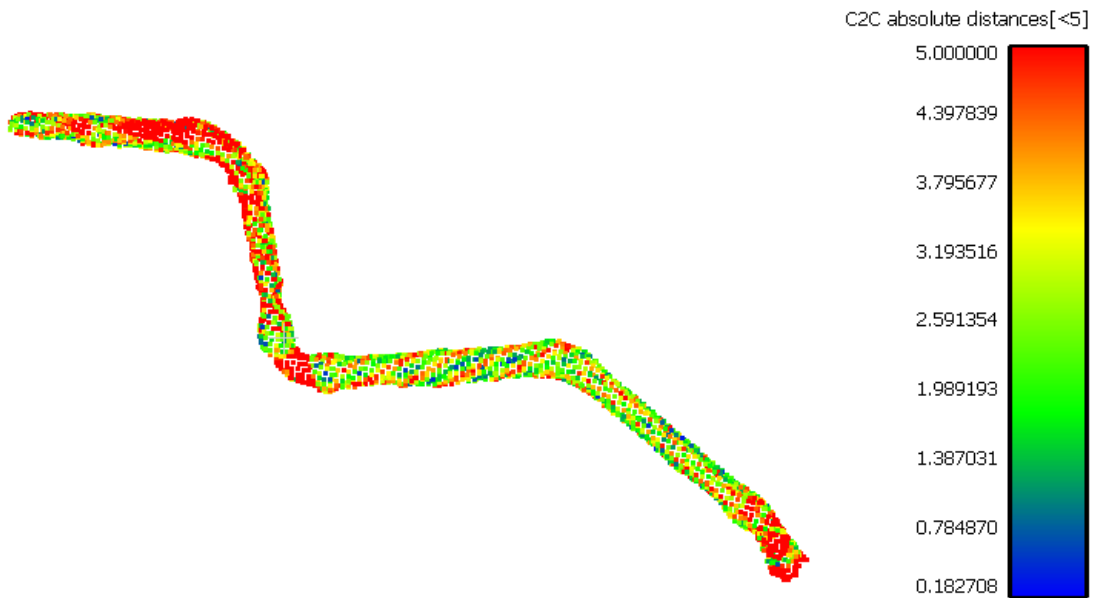
Figure 24: Heat map showing deviations of 5 or more millimeters in red

The scan shows that the inventor model is accurate within 5mm of a scan that can be obtained with a Structure IO scanner. It should be noted that the spool used in the overlay was not fine-tuned to be a completely, 100% compliant assembly.

Based on these findings, the Inventor model was deemed sufficient for use as the design model for the experiment. The Inventor model lends itself better to creating design drawings and provides a nicer visual for the 3D model on the 2-sided iso in the augmented reality application than an accurate laser scan point cloud would. Furthermore, using an actual model as the model for the experiment better simulates a real life application of the augmented reality application where a design is stipulated in engineering drawings and the required parts are then procured and assembled. Lastly, using the Inventor file will allow the user to actually select their own path for the step by step assembly by allowing them to use the segmentation feature of the augmented reality application.

3.4 Determining Accuracy of Scanners to Establish Experiment Tolerances

The third iteration of the PVC experiment spool was scanner with a FARO laser scanner and a Structure IO scanner mounted on an iPad. The technical specifications for both of these scanners can be found in Appendix B. The spool was first scanned using a laser scanner to obtain a dense, complete and highly reliable point cloud shown below. The spool was then scanned with the Structure IO scanner since this is the scanner that was used for the experiment.

The point cloud obtained with the laser scanner was compared with the point cloud obtained with the Structure IO on the IPad. In this case, both point clouds were measured in meters. The heat map shown in Figure 25 was then generated to show the deviation between the two point clouds. Deviations greater than or equal to 3mm are shown in red.
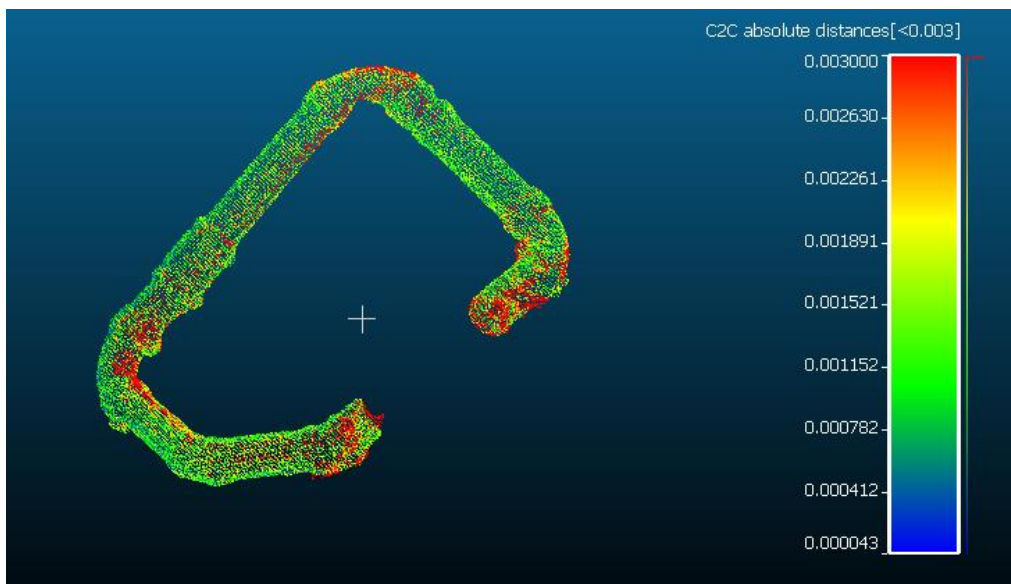
**Figure 25: Heat map showing deviations of 3+ mm between iPad and laser scanner point clouds**

Considering the accuracy of the Structure IO cited on the manufacturer's website and the results of overlaying a the laser scan of the assembly onto the Structure IO scan of the assembly as shown in Figure 25 it was decided that a 5mm tolerance was a realistic and acceptable threshold for the experiment.

Chapter 4
Methodology

The methodology outlined in this section addresses the execution of the experiment outlined in Chapter 3. The raw data collected in this experiment was a video of each participant assembling the spool. These videos had to be watched and divided into a series of generic activities that were both identified and defined so that they could be applied to all participants in a repeatable fashion in order to create a set of data that could be analyzed. Given the expectation that the participant's spatial skills will impact their performance, a means to evaluate these skills was established.

4.1 Office of Research Ethics Process

In order to conduct experiments with human participants, approval from the University of Waterloo's Office of Research Ethics had to be obtained. This process required the development of recruitment materials, information-consent forms to be signed by each participant and a formal means of thanking the participants for their time and effort. Because the experiment utilized an application that was developed for this research project a safety risk assessment review was also completed. This was an iterative process as the original submission was subjected to additional questioning.

4.2 Participant Recruitment Process

In designing the experiment, it was decided that 80 participants would be the recruitment goal, 40 participants with engineering backgrounds who would be drawing literate and 40 participants with welding and pipe fitting backgrounds who corresponded to the intended demographic for the application being developed. Splitting these two groups in half would allow for 20 participants from each demographic using the augmented reality process and 20 participants from each demographic using the two-sided isometric.

Participant recruitment was done through several avenues. Engineering participants were recruited using flyers and word of mouth at the University of Waterloo campus from October 2017 to February 2018 and during a visit to Aecon Industrial West in October 2017. The recruitment process allowed for engineers of all levels of experience, age and education to be recruited. The 40 engineering participants recruited varied in age from 18 to 57 years old and included undergraduate students, master's students, doctoral students, professors, engineers in training and licensed engineers from civil, chemical, electrical, mechatronics, systems design and mechanical engineering.

Recruiting trained pipe fitters was more challenging than recruiting engineers as they were less accessible than engineers were. Through the partnership with Aecon Industrial West in Edmonton, Alberta, 4 pipe fitters were recruited during an October 2017 visit. This working relationship extended the recruitment dialogue to Aecon Cambridge located in Cambridge, Ontario where an additional 12 fitters were recruited in April 2018. Recruitment efforts led to conversations with welding instructors at Conestoga College in Cambridge, Ontario where 4 welding and pipe fitting students were recruited in June 2018. One additional fitter was recruited through word of mouth in March 2018. Efforts to recruit participants through the local welders' union in Waterloo, Ontario were made but these attempts were ultimately unsuccessful. The 21 pipe fitters recruited varied in age from 19 to 54 years old and varied in experience level from students with internship placements to apprentices to those with 30 years of experience.

4.3 Participants

A total of 61 participants were recruited. 21 pipe fitters and 40 engineers and engineering students. Participants were split into two groups based on background (engineers and fitters) to account for the potential differences in exposure to computers, working with hand tools and completing assemblies based on design information. These two groups were further broken down into the two experiment cases, with one completing the experiment with a two-sided isometric drawing and having corrections verbally conveyed. The other group utilized the augmented reality process to complete the assembly and were actively involved in the quality control, utilizing the augmented reality process to obtain feedback on their work. As such, a total of 4 groups of participants were utilized in the experiment: engineers with drawings, engineers with the application, fitters with drawings and fitters with the application. A summary of the number of participants in each experiment case is presented in Table 1.

Table 1. Summary of the number of participants in each experiment case

	Assembly completed using application	Assembly completed using drawing
No. of fitters	18	3
No. of engineers	20	20

4.4 Experiment Process

The participant pools, the engineers and the pipe fitters, were divided into two groups: one group working with a standard two-sided isometric drawing and the other group working with the augmented reality process. Both groups were instructed to complete the same assembly. Figure 26 shows the set-up that participants who used the augmented reality process were given to begin the experiment.


Figure 26. Initial set up of experiment

Figure 27. Structure IO, structured light scanner used for experiment mounted on an iPad

Both groups were given the same traditional measuring tools and the same two-sided isometric drawing. In addition to the resources given to the participants who had information presented on only a static drawing, the participants using the augmented reality process had access to the 3D design model during the assembly process and were able to use a structured light scanner shown in Figure 27 to scan the assembly as they build it. This scanner is accurate up to 0.5 millimeters (mm) depending on how close the scanner is to the object being scanned [48]. A tolerance of 5 mm was set as the threshold for acceptance through multiple trials of scanning prefabricated components and comparing the scans to their actual dimensions. These participants were able to overlay the assembly, as they completed it, on the 3D design model to verify that what they had completed to that point was correct. These participants were also actively involved in the quality control process as they were the ones scanning the assembly, overlaying it on the model and doing the processing required to check if their assembly was compliant.

For participants using the static drawing, required rework was articulated and explained to the participant by the experiment administrator who completed the quality control on the assembly.

4.5 Participant Assessment

Participants were administered two spatial cognition tests: a Card Rotation Test and a Cube Rotation Test created by Educational Testing Service (ETS) in 1976 [45]. This was done primarily to ensure that participants with higher spatial cognitive skills were not all grouped into the same category and inflating the results by comparing a group with higher spatial cognition against a group with lower spatial cognition. This protocol was followed in related previous published studies [9], [15]. These tests were chosen as they were quick to administer, each having a time limit of up to 2 minutes The card rotation test serves to evaluate 2D rotation skills by having a participant compare a single key card against 8 potential matches. A sample question is provided in Figure 28. The cards are marked with an 'S' denoting them as being the same if the card being questioned can be obtained by rotating the key card. The cards are marked with a "D" denoting them as being different if they must be flipped in addition to any possible rotation to get the shape from the key card in question. The maximum score for this test was 40 points and the participants had 90 seconds to complete the assessment.

Figure 28. Sample card rotation test question

The cube rotation test serves to evaluate the 3D rotation skills of the participant by having them assess whether or not the pairs of cubes shown could be the same cube based on the orientations and uniqueness of the letters. A sample question is provided in Figure 29. The maximum score on this test was 14 and the participants were given a maximum of 2 minutes to complete this assessment.

Figure 29. Sample cube rotation test question

The scores of both types of participants, the engineers and the pipe fitters, were plotted to see how the overall scores were distributed and to see how the two groups compared to each other. The plot shown in Figure 30 shows the spatial scores on both tests for both groups of engineers. The ones who used the application to complete the assembly are shown in blue and the ones who used the two-sided iso to complete the assembly are shown in red. From the figure it can be seen that the scores are fairly distributed, with the engineers who used just the two-sided iso appearing to have slightly higher spatial skills. It appears that the engineers fared better on the card rotation test with all but three of them scoring at least 50% (20 out of a possible 40 points), while only about half of them scored at least 50% (7 out of a possible 14 points) on the cube rotation test. The range of these scores can be partially explained by the presence of both sexes in the engineering participants recruited for this study. The literature presented in Section 2.8 has found that women tend to score lower than men on spatial cognition assessments. Furthermore, some of the participants who scored particularly high on the tests administered mentioned that they had taken similar tests as children or teenagers and had thus been exposed to this question format. One could interpret having taken such a test previously as having some form of spatial cognitive training.
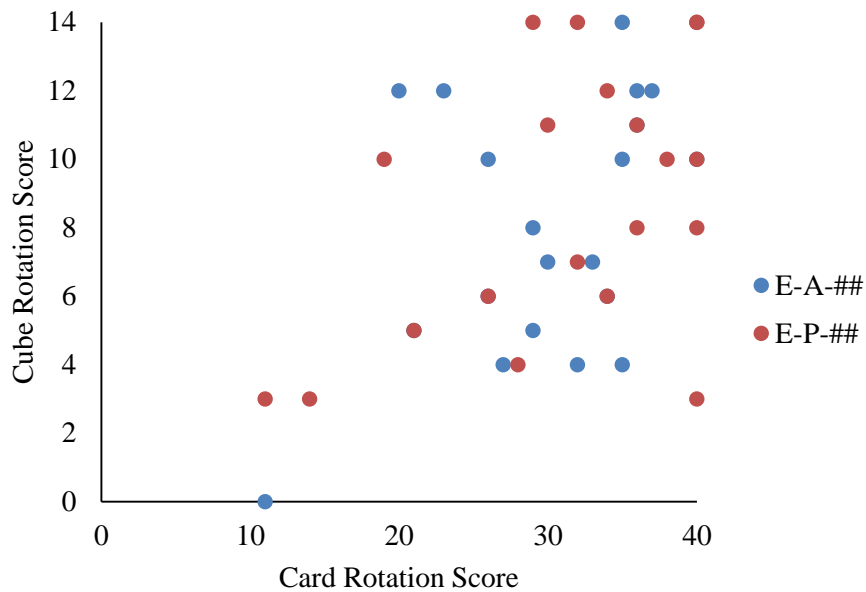
Figure 30. Spatial scores of both groups of engineering participants

Given the use of both a 2D isometric drawing and a 3D design model, it was decided that both 2D and 3D spatial skills were equally important to assess participants. The engineering participants were grouped into 3 categories based on the average the scores they obtained on the two tests. The categories were set as follows: participants with low spatial skills were deemed to be those who averaged below 0.6 on the two tests, participants who averaged over 0.8 on the two tests were deemed to have high spatial skills and those that averaged between 0.6 and 0.8 were deemed to have medium spatial skills. A fairly even distribution of scores was found across all the engineering participant groups as is shown in Table 2.

Table 2. Distribution of spatial scores of engineering participants

Score	App Participants	Drawing Participants
High (0.8-1.0)	5	8
Med. (0.6-0.79)	8	6
Low (0-0.59)	7	6

Figure 31 shows the spatial scores of the pipe fitters on the two spatial tests that were administered. The majority of the pipe fitters scored above 32 out of 40 on the card rotation test, outperforming the engineering participants but had a much greater range of scores on the cube rotation test. This can be partially explained by the participants' levels of exposure to different formats of visual information. The engineers may be more likely to have worked with 3D design formats from work with different design and drafting software. The craft workers would be more likely to be comfortable with 2D design formats since the industry standard for the information they work with is a 2D line drawing.
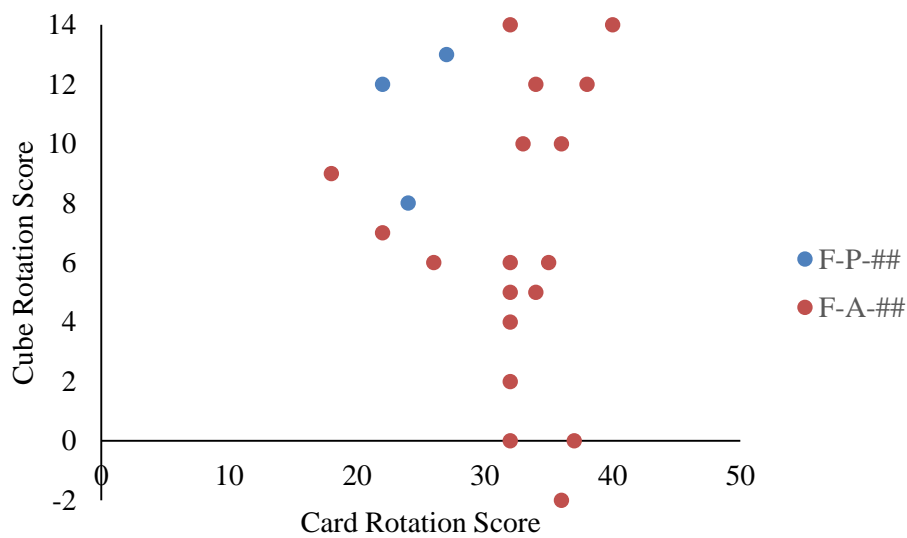
Figure 31. Spatial scores of both groups of pipe fitters

The sample of fitters used was approximately half the size of the sample of engineers used, so in lieu of the three categories used to group the engineers, only two categories were used to group the pipe fitters: low spatial skills and high spatial skills. The average spatial score of all the pipe fitters, 0.649, was used cutoff point to separate the high and low spatial groups. The distribution of scores is found in Table 3. This is provided to show that the distribution of spatial skills within participant group types was fairly equal. However, since the participants skew so heavily towards the version of the experiment that used the augmented reality application, it is not reasonable to conduct analysis on the two separate spatial skill levels.

Table 3. Distribution of spatial scores of pipe fitters

Score	App Participants	Drawing Participants
High (>0.649)	7	2
Low (<0.649)	11	1

4.6 Data Analysis

4.6.1 Activities Considered When Evaluating Participants

The participants in each experimental case were recorded as they completed the assembly and the videos were then watched and broken down into activities with their durations to analyze the work being done. Not all participants treated all activities in the same way, and thus evaluating the activities for each participant allows removal of bias and factors that did not constitute working on assembling the pipe spool. The two main variations in activities between participants that presented skew were the activities of chatting with the administrator of the experiment and adjusting clips. In the case of the chatting with administrator activity, some of the participants were more inquisitive about the research project or had feedback regarding how they felt the app could be improved. When participants were discussing these things with the experiment administrator, they were not working on assembling the assembly making this activity an unfair penalty against some of the participants. The second activity that creates a similar situation is adjusting clips. Some of the participants adjusted the clips to simulate tack welding as was outlined in the experimental design, however, not all did this and some were found to struggle more than others with this task.

4.6.1.1 App and Paper

The majority of the activities identified in the experimental videos applied to both participants who used the augmented reality process and those who used just the two-sided isometric. These activities are outlined in this section.

Interacting with Administrator: This is any time that the participant and the experiment administrator are talking, whether that be causal small talk, a participant providing feedback on the app or the experiment or clarification that needs to be provided in terms of app workflow or anything similar to that.

Assembling Assembly: This is any time that the participant is building the assembly. This includes mating pieces and attempts to get them in the right orientation.

Adjusting Clips: This is anytime that the participant is tightening or loosening the clips on the elbows. This is not being considered as assembling or rework, because not all participants felt the need to use the clips until they had the correct assembly confirmed by the experiment administrator. This time will be considered separately to assure that it does not bias the results.

Measuring Assembly: this is when the participants are measuring what they have assembled. Participants used a few different tools when measuring and sometimes this included tools they were not familiar with. Removing this from the analysis will help remove the fact that people didn't use the same measuring tools and that they didn't always have the tools that they were most accustomed to.

Checking Assembly: this is when the participant has completed the assembly and they are verifying that is it is correct prior to determining that the assembly is completed. In the case of using the app this is before the scanning is completed. In the case of a paper participant, this is before QC actions are undertaken. This is different from measuring because for whatever, reason not all participants feel obligated to check and this prevents participants who are more meticulous from being unfairly discriminated against.

Manipulating Stands: This is anytime that the participant is maneuvering the stands to help support the assembly as it is being completed

Adjusting Assembly: (undocumented rework) This is any spurious fidgeting that occurs as a result of checking

Assembly Layout: This is anytime that the participant spends getting the pieces in a general order. This is a little different from assembling since it does not consider getting actual positioning correct, just getting the components in the correct order.

Looking at Drawing: This is anytime that the participant is looking at the drawing that was provided to interpret the information being presented.

Completing Rework: This is anytime where the participant is correcting the assembly, having erroneously thought that it was correctly completed.

4.6.1.2 App Only

There are a few activities that are exclusively done by participants who used the augmented reality process as they relate to tasks done only when using the augmented reality process. These activities are as follows.

Model Segmentation: This is the time spent using the segmentation feature of the app. This is being identified as a separate component of using the app, because some people would struggle with this part of it from being unfamiliar with the interface. Sometimes the experiment administrator would complete this part for the participants. Once learned, almost no time is required for this step, thus the learning curve could bias analysis.

Looking at 3D Model: This is time where the participant is manipulating the 3D model. This time may be unnecessarily long for some participants, because they really struggled to rotate the 3D model into the orientation they wanted using the touch sensitive screen. Some younger participants found this part intuitive and easy. This was a really critical piece of user feedback from the experiment and was improved upon for future versions.

Scan Acquisition: This is the time where the participant is scanning the assembly they created. This is identified as a separate item because sometimes the wifi was unreliable and the scan took much longer than necessary to be sent from the scanner to the work station.

Scan Processing: This is the time where the participant (with help from the experiment administrator) is processing the scan for the purpose of comparing it to the 3D model. This includes, the 3 point matching, clutter removal and the one end lock.

Output Analysis: This is the time where the participant is looking at the scan overlain on the model to determine if the assembly is compliant and in the event of an incompliant assembly, the time where the participant is determining the error in the assembly and how to correct it.

4.6.1.3 Isometric Only

The activities done by the participants using only the two-sided isometric are activities associated with the inspection of the assembly by the experiment administrator.

QC: This stands for quality control; this is the time where the experiment administrator is verifying the assembly using the app.

Conveying corrections: this is the time where the experiment administrator is explaining to the participant how to correct the assembly.

4.6.2 Summary of Average Participant in Each Category

Participants were filmed while assembling the pipe spool. The videos were watched and segmented into activities and durations to assess the participants' progress during the experiment.

Figure 32 illustrates the average time spent on each activity for engineering experiment participants who only had the isometric drawing.
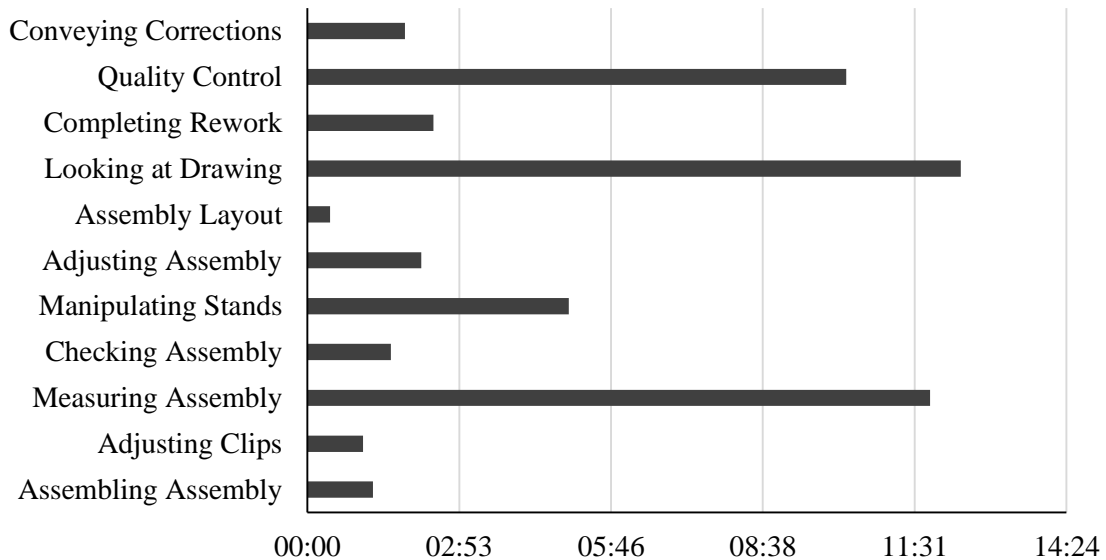

Figure 32. Average time spent on each activity by engineering participants using the isometric

Figure 33 shows the average time spent on each activity for engineering participants who used the app. For all the participants the activity of "chatting with experiment administrator" was removed from the analysis as it was not critical to the processes being evaluated. The difference between the two groups of engineering participants is seen in the "measuring assembly" activity. The engineers who used just the drawing spent on average over 11.5 minutes measuring the assembly compared to under 5 minutes for those engineers who used the application. The engineers who used the augmented reality application spend less time than their counterparts looking at the drawing since they also had a 3D model to interpret for design information as well and many of the engineers found that information format more intuitive to work with. In the case of the engineers with just the isometric, the "quality control" activity was essentially equivalent to the "scan acquisition" and "scan processing" activities completed by the engineers with the application. The sum of the two activities for the engineers with the application exceeds the time spent on the "quality control" activity for the engineers with just the isometric by close to 10 minutes. Some of this difference in time is accounted for in the experience of the users with the application. In the experiment trials with just the isometric drawing the experiment administrator completed these tasks and was intimately familiar with both the scan acquisition and scan processing whereas for the participants who used the application, they were

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completing these steps as independently as possible in what was their first instance of working with both the scanner and the application. Later analysis shows the presence of a learning curve for scan acquisition and processing, suggesting that the times shown in Figure 33 could be reduced if the learning curve were taken into account in the analysis.
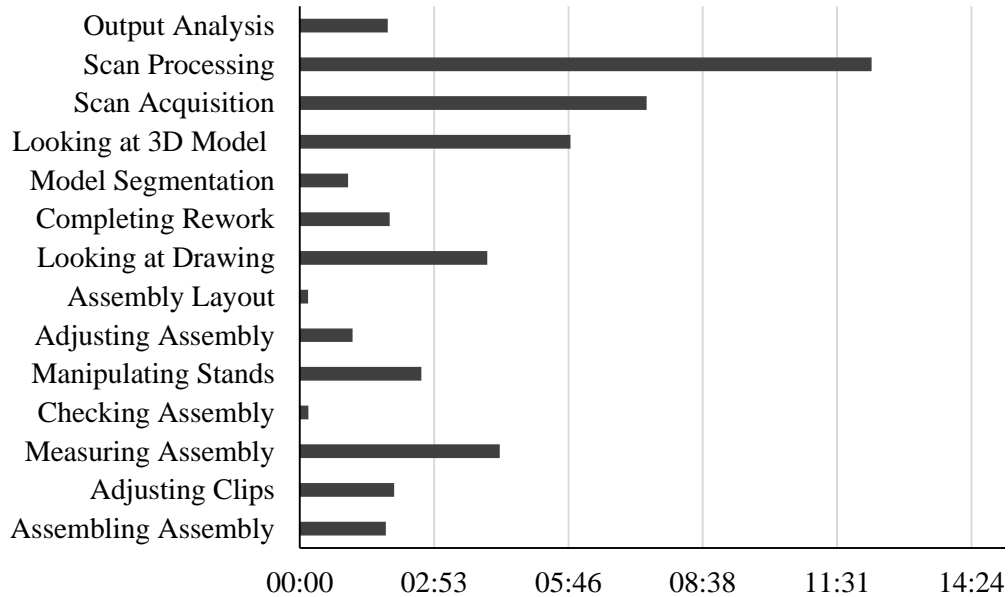

Figure 33. Average time spent on each activity by engineering participants using the application

The average times spent on each activity by the pipe fitters was also computed. Figure 34 presents the average time on the different activities recorded spent by pipe fitters who used the isometric only while Figure 35 shows the average time spent by the pipe fitters completing the assembly using the drawing. For the fitters using the drawing, the most time consuming activity was looking at the drawing and interpreting it with the average participant requiring almost 11 and a half minutes to absorb the information, while for the pipe fitters using the application this time was reduced to just over 4 minutes looking at the drawing plus an additional 3 minutes looking at the 3D model. This represents a reduction in time of about 50% spent interpreting design information. The next largest use of time by the pipe fitters with the isometric was time spent measuring the assembly which was the largest use of time for the pipe fitters who used the application. For both groups of pipe fitters this time was approximately 4 minutes.
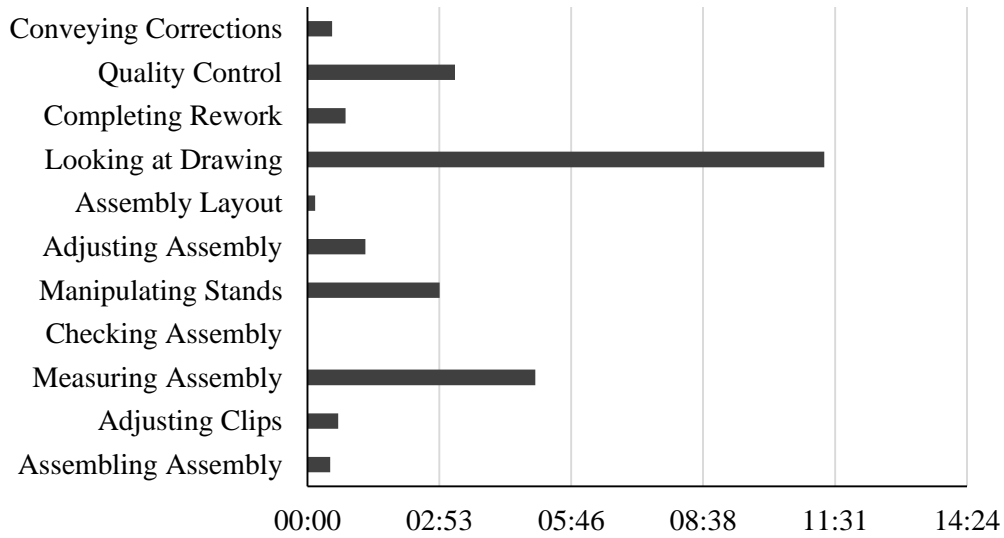
Figure 34. Average time spent on each activity by pipe fitter participants using the isometric
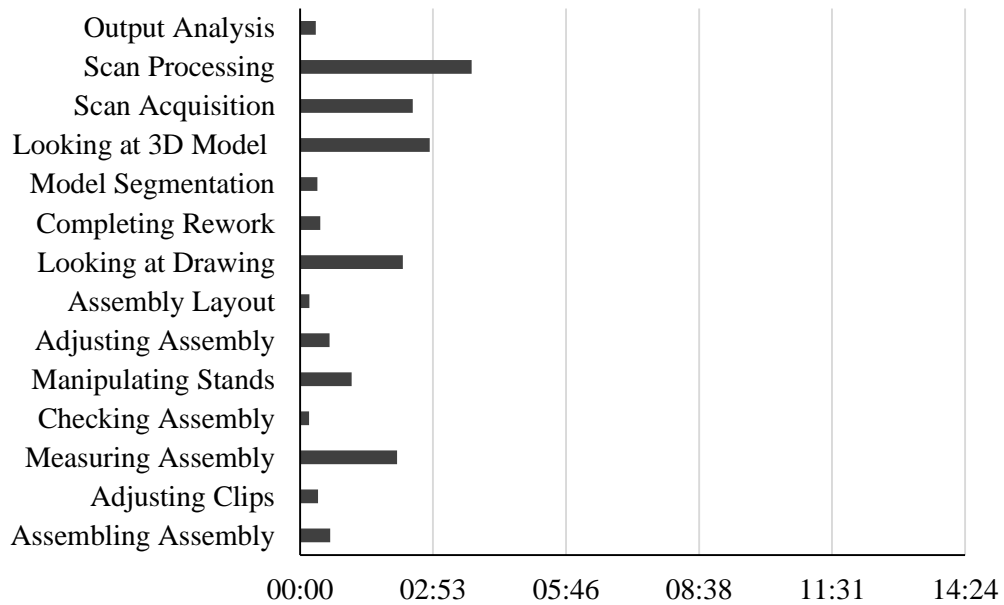

Figure 35. Average time spent on each activity by pipe fitter participants using the application

4.7 Productivity Data Analysis

To analyze the data for productivity, the activities outlined in 4.6.1 were combined to create new categories that were more reflective of the pipe spool assembly process. These categories were

created to allow a penalty to the time that was taken to assemble the spool for every instance of rework since the participants did not end up using the clips to simulate tack welding as was originally intended. The new categories were information absorption, assembling, processing and rework assembling. These categories were applied to both the participants who used the application and those who used the two-sided isometric to complete the experiment. The activities that were placed in each category are shown in Table 4.

Table 4: Activities lumped into each category

Category	Application Activities	Two-Sided Isometric Activities
Information absorption	• Looking at drawing • Looking at 3D model • Output analysis	• Looking at drawing • Conveying corrections
Assembling	• Assembling assembly • Measuring assembly • Checking assembly • Manipulating stands • Adjusting assembly • Assembly layout	• Assembling assembly • Measuring assembly • Checking assembly • Manipulating stands • Adjusting assembly • Assembly layout
Processing	• Model segmentation • Scan acquisition • Scan processing	• Quality control
Rework Assembling	• Completing rework • Measuring assembly • Checking assembly • Manipulating stands	• Completing rework • Measuring assembly • Checking assembly • Manipulating stands

The information absorption category encompasses all the activities that are linked to looking at the design and understanding it. Looking at the output from the application was also added to this category as it provided additional information regarding the geometry of the assembly and modifications that needed to be done to the assembly before it could be considered as completed. When considering the whole process, and especially when focusing on rework, the conveying corrections activity was also considered to be a part of this category.

The assembling category features all the activities that were active hands-on work by the participant to complete the assembly.

The processing category features the biggest differences between the two experiment cases as the case with the application features the participant interacting with the application in all capacities other than looking at the 3D model and two-sided isometric. This includes segmenting the model,

scanning the as built and comparing the scan to the model. With the participants using just the two-sided isometric, they never interact with the application, but the processing time is the time spent by the experiment administrator to verify the assembly. This time serves as data of an experienced person working with the application.

The rework assembling category considered the time manipulating the assembly after it was scanned or verified on the basis of the output of checking the assembly. These activities include completing rework, which is essentially the rework equivalent of assembling the assembly as well as measuring the assembly, checking the assembly and manipulating the stands.

Based on the size of the spool, a time of 5 minutes (00:05:00) was added to each tack weld that was completed. Based on the design of the spool and considering that each elbow was preassembled onto a piece of pipe at the start of each experiment iteration, a perfect assembly would have 00:15:00 added as only three tack welds would have been needed.

Similar to the tack welds, a penalty of 00:60:00 was added to each tack weld that needed to be cut as part of the time to complete the assembly of the rework. A second 00:05:00 penalty was then added to account for having to re-tack the weld that was cut. This meant that each instance of rework was penalized with a total of 00:65:00 to account for the weld needing to be cut, filed and re-tacked. These times were determined through discussions with experienced pipe fitters. This penalty was only added to the participants who were working with the two-sided isometric as their assemblies were only scanned and verified once they were deemed to be complete by the participant. The penalty was not added to the participants utilizing the application because they would scan the assembly on their own and were free to use it both as an additional measuring tool and to help facilitate their understanding of the assembly and as part of the process of fitting and fixing with clamps before tack welding. Through scanning their work thus far and overlaying it on the model they could see where their understanding of the design was erroneous. It was assumed that there was no rework for participants who worked with the application because they would not complete a tack weld until the feedback from the application indicated a compliant assembly. The rework assembly activity was applied to this group, because they would still have to move the assembly components if what they had assembled thus far was incorrect.

4.8 Rework Data Analysis

In evaluating the videos for rework process time, emphasis was placed primarily on tracking the activities of understanding the assembly issues that required rework and completing the rework

itself. The iterations of rework and were also tracked. Conveying rework was deemed to be any time where the administrator explained to the participant how their assembly failed to meet the required specifications in the case of participants using a traditional assembly and the time the participant spent assessing their own mistakes based on the overlay of the as built scan on the 3D model for a participant using the application. In both cases completing rework was deemed to be any time where the participants were modifying components that failed to meet the required specifications. The times were tracked for both activities as well as the iterations of rework.

The workflow associated with both iterations of the rework portion of the experiment is shown in Figure 36. The steps enclosed in the red boxes are the main focus of the rework study portion of this work.
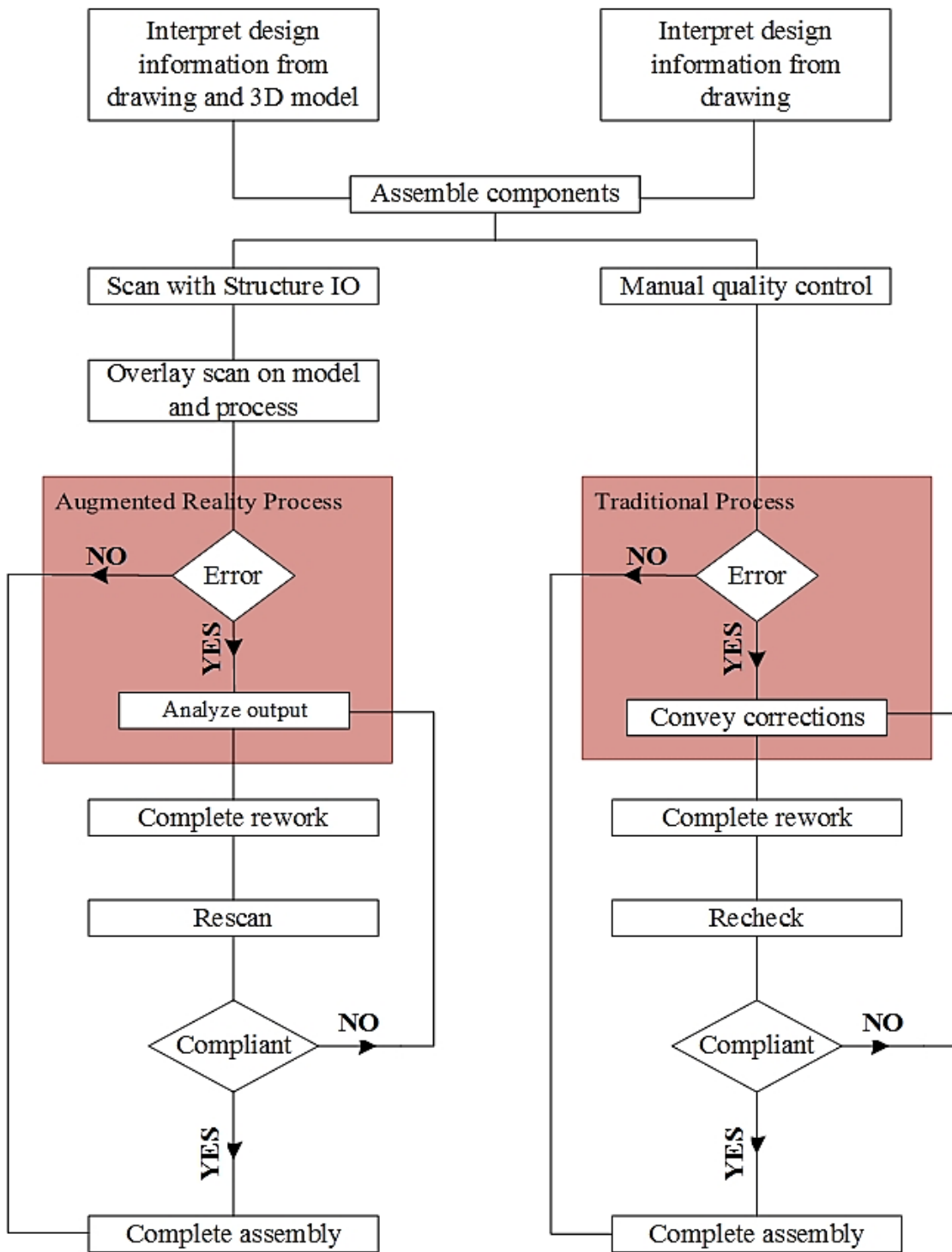
Figure 36. The workflows associate with both iterations of the experiment

Chapter 5
Results

A total of 61 experiment trials were run: 40 trials with engineers as the participants, where 20 used the augmented reality process, and 20 used the traditional drawing in addition to 21 trials that were run with the pipe fitters, where 18 used the augmented reality application, and 3 used the traditional drawing. Given the difference in expertise level in reading drawings, constructing pipe spool assemblies and working with hand tools, the engineering participants were evaluated separately from the pipe fitter participants. The population size of the engineering participants was large enough to justify creating sub groups based on spatial skills to consider the impact on performance of having low, medium or high spatial skills. The population size of the pipe fitters however was not deemed large enough to create groups based on spatial skills for the purpose of analysis, particularly as the distribution of participants between the two experiment types was heavily skewed towards the using the application.

5.1 Productivity

When evaluating the time required to complete the assembly, the penalty of 00:65:00 was not applied to the participants who used the application as the premise of using the applications is that scanning to identify any errors that would become rework would occur prior to tacking the assembly, meaning that traditional rework would essentially be eliminated. The times associated with the activities or rework were considered as they would still occur as erroneous first attempts at completing an assembly would still occur. An additional penalty of 00:15:00 was also applied to each participant regardless of experiment type, as completing the assembly requires 3 tack welds be completed.

Once these penalties were applied, it was found that the engineering students as a whole experienced a savings of 07:51:39 when they used the application compared to those who worked with the isometric drawing. The engineers who used the application needed an average of 00:59:53 to complete the assembly compared to 08:51:33 to complete the assembly for the students who worked with the drawing only. This is summarized in Table 5. A one-tail independent samples t-test was performed on this result and the time saved by using the application was found to be statistically significant at the 95% confidence level with p=0.000 and a lower confidence level bound of 00:10:21.

Table 5. Average time completing assembly for population of engineering participants

	Total time completing the assembly
Engineers with App	00:59:53
Engineers with Isometric only	08:51:33
Mean Time Difference	-07:51:39

This same analysis was then completed by dividing the participants into groups of high, medium and low spatial skills. The results of this analysis are summarized in Table 6. It was found that the use of the application has the least time savings on the group of engineers with high spatial skills with a savings of 05:18:30, followed by the group with medium spatial skills and then by the group with low spatial skills with a time saving of 07:01:38 and 12:07:20, respectively, both in hours. A one-tail independent samples t-test was completed on these results, and all three results were found to be statistically significant at the 95% confidence level. The high spatial skills group had a lower confidence level bound of 09:30:39 with a p-value of 0.022. The medium and low spatial skills groups had lower confidence level bounds of -00:10:06 and -00:17:42, respectively with p-values of 0.001 for both groups.

Table 6. Average time completing assembly for engineering participants grouped by spatial skills

	High Spatial	Medium Spatial	Low Spatial
Engineers with App	00:55:54	00:52:29	01:11:12
Engineers with Isometric only	06:14:24	07:54:07	13:18:32
Mean Time Difference	-05:18:30	-07:01:38	-12:07:20

A one-way analysis of covariance (ANCOVA) was conducted to compare the impact of using the application on the time required to complete the assembly while controlling for spatial skills. Levene's test and normality checks were carried out, and the assumptions were not met (this was likely because of the 3 participants who used the drawing and did not have rework). There was a significant difference in the time required to complete the assembly [$F(1,37) = 33.895$, $p = 0.000$] between the two groups of engineering participants. Comparing the estimated marginal means shows that the total time required for the participants using the drawing was 00:49:50 compared to 09:01:35

for those who used the application once the means were adjusted to reflect an average spatial score of 0.676.

The same analysis that was done for the engineering participants was completed for the pipe fitters, however because of the smaller sample size the analysis was run for the whole population. The results of this analysis can be found in Table 7. It was found that the fitters who used the application saved an average of 02:39:08 compared to their counterparts who used just the drawing with total times of 00:33:10 and 03:12:18 respectively. A one-tail independent samples t-test was completed and found this result to be statistically significant at the 95% confidence level with a p–value of 0.000 and a lower confidence level bounds of -03:27:21.

Table 7. Average time completing assembly for pipe fitter participants

	Total time completing the assembly
Pipe Fitters with App	00:33:10
Pipe Fitters with Isometric only	03:12:18
Mean Time Difference	-02:39:08

A one-way ANCOVA was conducted to compare the impact of using the application on the time required to complete the assembly while controlling for spatial skills. Levene's test and normality checks were carried out and the assumptions were not met. There was a significant difference in the time required to complete the assembly [F (1, 18) = 33.397, p = 0.000] between the two groups of pipe fitter participants. Comparing the estimated marginal means shows that the total time required for the participants using the application was 00:32:43 compared to 03:14:59 for those who used just the drawing once the means were adjusted to reflect an average spatial score of 0.649.

5.1.1 Impact on Information Absorption

One of the main advantages to the proposed augmented reality application is that it is expected to help reduce the time required to interpret and understand design information. This was assessed by comparing the time participants who worked with just the drawing spent absorbing the information presented on the drawing against the time that participants who used the augmented reality application spent looking at both the 3D model and the drawing. When the whole population of engineering participants was considered, it was found that an average of 00:02:20 was saved by participants who had access to the 3D model compared with their drawing-only counterparts. This

result was not found to be statistically significant at the 95% confidence level, with a p-value of 0.128 and a lower bound confidence interval of -00:05:45. These values are summarized in Table 8.

Table 8. Time spent absorbing information for the whole population of engineering participants

	Time absorbing information
Engineers with App	00:11:43
Engineers with Isometric only	00:14:03
Mean Time Difference	00:02:20

The time spent absorbing the information was then compared across the sub groups of spatial skills to evaluate how participants' skills at interpreting spatial information affected the impact of the additional design information. This information is summarized in Table 9. Summary of information absorption time for all spatial levels of engineering participants. It was found that none of the differences in the time the two groups took to interpret information were statistically significant at the 95% confidence level. For the participants with high spatial skills, using the application required an average of 18 seconds longer than relying on traditional drawing formats with participants using the application requiring 00:12:15 compared to 00:11:56 for the participants who used only the isometric. This difference has a p-value of 0.461 at the 95% confidence level and an upper bound confidence interval of +00:05:55. The participants with medium spatial skills saved an average of 00:04:30 interpreting design information when they used the application compared to using only the drawing. This result was approaching significance with a p-value of 0.085 at the 95% confidence level with a lower bound confidence interval of -00:09:59. Finally, the participants with low spatial skills saved an average of 00:02:56 when they used the application compared to working with just the drawing. This time savings has a p-value of 0.240 at the 95% confidence level and a lower bound confidence interval of -00:10:09.

Table 9. Summary of information absorption time for all spatial levels of engineering participants

	High Spatial Skills	Medium Spatial Skills	Low Spatial Skills
Engineers with app	00:12:15	00:08:40	00:14:49
Engineers with isometric only	00:11:56	00:13:10	00:17:46
Mean time difference	+00:00:18	-00:04:30	-00:02:56

The results for the whole population and for the spatially segmented groups indicated a general trend of time savings so a one-way ANCOVA was conducted to compare the impact of using the augmented reality process while controlling for the engineers' spatial skills to see if correcting for spatial skills while considering the entire population would lead to a statistically significant result. Levene's test and normality checks were carried out and the assumptions were met. There was no statistically significant difference in the time the two groups of engineering participants spent interpreting the design information [F (1,38) = 1.768, p = 0.192]. Comparing the estimated marginal means by adjusting the data for a spatial score of 0.676 shows that the average time for the participants using the application was 00:11:33 while the time for those using the isometric was 00:14:00.

The same analysis was completed on the results for the pipe fitters. It was found that the pipe fitters who used the application saved on average 00:06:12 compared to the pipe fitters who used the drawing, spending an average of 00:05:36 and 00:11:49 respectively. These values are summarized in Table 10. A one-tail independent sample t test found this difference to be statistically significant with a p-value of 0.015 and a lower bound confidence interval of -00:10:47.

Table 10. Mean time spent absorbing the information for pipe fitters

	Time absorbing information (minutes)
Fitters with App	00:05:36
Fitters with Isometric only	00:11:49
Mean Time Difference	-00:07:06

Given the range of spatial skills scores of the fitters and the insufficient sample size to create sub groups based on spatial skill, a one-way ANCOVA was conducted to compare the impact of using augmented reality application to reduce the time required to absorb the design information while controlling for spatial skills. Levene's test and normality checks were carried out and the assumptions were not met. There was a statistically significant difference, at the 95% confidence level, in the time required to absorb the design information [$F_{(1,18)} = 10.787$, $p = 0.004$] between the two groups of pipe fitter participants. Comparing the estimated marginal means determined by adjusting the results for a spatial score of 0.649, found that the pipe fitters using the application required 00:05:29 while the pipe fitters using the isometric required 00:12.32.

It is worth noting that the time required to interpret both sources of information was lower for the pipe fitters as they are more familiar with the information formats and have a better sense of the information they require from a drawing to complete an assembly. It is important to note that repeated use of the application would likely result in a greater intuition in interpreting the design model and would likely decrease the time required to absorb information further.

5.1.2 Mean Scan Acquisition and Processing Time

A common concern regarding the implementation of the augmented reality application is that acquiring and processing the scans will be too time consuming to reduce the overall time that the pipe fitters spend fitting assemblies. Over the course of conducting this study, 335 individual scan acquisition and processing cycles were completed with an average total time of 00:02:12 each. The longest recorded cycle took 00:06:56 while the shortest was 00:01:05. The spool used in the experiment required the completion of 3 fittings, requiring 3 scan acquisition and processing cycles in the case of a perfect assembly. Completing 3 average scan and processing cycles using the application required approximately 6 and a half minutes which is equal to the time saved in understanding the design information during the assembly process when the application was used. For this specific spool, completed with no rework by a pipe fitter, there would be a net zero difference in time overall comparing using the application to not using the application, however, using the application would add value by providing accurate as-built documentation of the completed spool.

5.2 Rework

When completing the analysis for the impact of the use of the application on understanding rework information, completing rework and the iterations of rework, three engineering participants

and three pipe fitter participants had to be removed from the data pool that used the drawing as those participants did not have any rework associated with their trials.

5.2.1 Understanding Rework

The first aspect of rework that was evaluated centered on how the use of the augmented reality application, through the visual feedback of the as-built scan superimposed on the 3D model, helped facilitate the understanding of the rework being completed and assisted the experiment participants in rectifying their own initial, incorrect, interpretation of the assembly.

First the whole population of engineering participants was evaluated for the time they required to interpret the rework information. This is summarized in Table 11. Completing a one-tail independent samples t-test found that the use of the augmented reality application actually increased the time required to interpret the rework information by 32 seconds from 00:04:17 for the participants using just the isometric to 00:04:49 for the participants using the application. The result had an upper confidence interval bound of +00:02:51 but was not found to be statistically significant at the 95% confidence level with a p-value of 0.349.

Table 11. Time required to interpret rework information by the engineering experiment population

	Time required to interpret rework information
Engineers with app	00:04:49
Engineers with isometric only	00:04:17
Mean time difference	+00:00:32

The time required to interpret the rework information was then considered by evaluating the engineering participants of different levels of spatial skills. This is summarized in Table 12. Using the application saved the participants with medium spatial skills an average of 00:02:55, with participants with the application requiring 00:03:30 compared to 00:06:26 for those with the isometric only. This was not statistically significant at the 95% confidence level with p-value of 0.171 and a lower confidence interval bound of -00:08:12. The high and low spatial skills engineering participants had average increases in time of 00:01:06 and 00:02:49 respectively when using the application. Neither of these results was found to be statistically significant at the 95% confidence level. The high spatial

skills group using the application had their time increase from 00:02:39 for those using just the application to 00:03:45, with a p-value of 0.264 and an upper confidence interval bound of +00:01:39. The low spatial skills group had the greatest increase in time required to interpret the rework information, increasing from 00:04:07 for those using the drawing to 00:06:57 for those using the application, with an upper confidence interval bound of +00:06:43 and a p-value of 0.111.

Table 12. Time required by the three levels of spatial skills of engineering participants to interpret rework information

	High Spatial	Medium Spatial	Low Spatial
Engineers with app	00:03:45	00:03:30	00:06:57
Engineers with isometric only	00:02:39	00:06:26	00:04:07
Mean time difference	+00:01:06	-00:02:55	+00:02:49

It is worth noting that the learning curve of interpreting the superimposed output of the scan onto the 3D model may be a factor in these results.

The same analysis was completed for the pipe fitter participants interpreting the rework information. This analysis is summarized in Table 13. It was found that, in contrast with the engineering students, the pipe fitters had a decrease in time required to interpret rework information from 00:08:56 for those using just the isometric to 00:01:06 for those using the application. This result was statistically significant at the 95% confidence level with a p-value of 0.000 and a lower confidence interval bound of -00:09:56 on the mean time saved of 00:07:49.

This difference in outcomes between the engineers and the pipe fitters could be rooted in how frustrated the two groups were in completing the assembly. Many of the engineers got frustrated by how long it was taking them or by how confused they got completing the assembly, and when they realized they had to continue and correct their assembly they were clearly disheartened. The pipe fitters, in contrast, were much more relaxed when completing the pipe spool assembly and were not disheartened when they had to iterate through additional assembly processes to correct their assembly. This might be because engineers typically work with only a few other people on drawings and are used to a specific style of presenting information while pipe fitters typically work with drawings created by engineers from a broader group and are thus more familiar with interpreting a range of drawing styles.

Table 13. Time required by the pipe fitters to interpret rework information

	Time required to interpret rework information
Pipe fitters with app	00:01:06
Pipe Fitters with isometric only	00:08:56
Mean time difference	-00:07:49

A one-way ANCOVA was conducted to compare the impact of using the application on interpreting rework information while controlling for spatial skills. Levene's test and normality checks were carried out and the assumptions were not met. There was a significant difference in the time required to interpret the rework information [$F(1,15)=38.918$, $p=0.000$] between the two groups of pipe fitter participants. Comparing the estimated marginal means adjusted for an average spatial score of 0.628 found that the pipe fitters using the isometric required 00:08:56 compared to just 00:01:06 for the pipe fitters using the application.

5.2.2 Completing Rework

The next aspect of rework that was evaluated was the actual time spent completing the rework, that is manipulating the erroneous assembly to make it compliant with the design. This is an extension of the time required to interpret the design, because a quicker interpretation without quicker assembly time would suggest that the participants were not actually understanding where their interpretation of the design was erroneous.

First the whole population of engineering participants was considered for the mean time required to complete the rework. This is summarized in Table 14. It was found that the participants with the application saved an average of 00:05:12, requiring 00:03:42 compared to their counterparts who used only the isometric and required 00:08:54. A one tail independent samples t-test was completed and the result was found to be significant at the 95% confidence level with a p-value of 0.018 and a lower confidence interval bound of -00:09:40.

Table 14. Mean times required by the engineering participants' population to complete rework

	Time required to complete rework
Engineers with app	00:03:42
Engineers with isometric only	00:08:54
Mean time difference	-00:05:12

The participants were then separated into groups based on high, medium and low spatial skills and the same analysis was then completed. This is summarized in Table 15. All three groups experienced a reduction in rework completion time, with the medium and low spatial skills groups experiencing a much greater reduction in time. The high spatial skills group saved on average 48 seconds when using the application, requiring 00:04:52 for the participants using the isometric and 00:04:04 for the participants using the application. This result was not found to be significant at the 95% confidence level with a p-value of 0.377. The medium and low spatial skills groups saved on average 00:06:44 and 00:07:54 respectively. An independent samples one-tail t test was completed on these data sets and the results were found to be approaching significance. The t test results for the medium spatial skills engineering participants indicated a p-value of 0.099 with a lower confidence interval bound of -00:15:33 and the test results for the low spatial skills engineering participants indicated a p-value of 0.056 with a lower confidence interval bound of -00:16:05.

Table 15. Mean times required by the different spatial skill groups of engineers to complete rework

	High Spatial	Medium Spatial	Low Spatial
Engineers with app	00:04:04	00:03:38	00:03:49
Engineers with isometric only	00:04:52	00:10:22	00:11:43
Mean time difference	-00:00:48	-00:6:44	-00:07:54

Since the results for the difference spatial groups were approaching significance, a one-way ANCOVA was conducted to compare the impact of using the application on the time required to complete the rework while controlling for spatial skills. Levene's test and normality checks were carried out and the assumptions were not met. There was a significant difference in the time required to complete the assembly [$F_{(1, 34)}=4.896$, $p=0.034$] between the two groups of engineering participants. Comparing the estimated marginal means shows that the average time spent decreased

from 00:08:59 when using the isometric to 00:03:39 when using the application once the results were adjusted to reflect a mean spatial score of 0.668.

This same analysis was then repeated for the pipe fitters who had rework as part of their trials. These results are summarized in Table 16. It was found that the participants working with just the isometric required 00:02:46 to complete the rework compared to 00:01:12 for those using the application, resulting in 00:01:33 being saved. A one tail independent samples t-test was performed and found that the results were approaching significance at the 95% confidence level with a p-value of 0.069 and a lower confidence interval bound of -00:03:18.

Table 16. Mean times required by the pipe fitter participants to complete rework

	Time required to complete rework
Pipe fitters with app	00:01:12
Pipe fitters with isometric only	00:02:46
Mean time difference	-00:01:33

Since the results were approaching significance, a one-way ANCOVA was conducted to compare the impact of using the application on the time required to complete the rework while controlling for spatial skills. Levene's test and normality checks were carried out and the assumptions were met. The test did not find a statistically significant difference in the time required to complete the assembly [$F(1, 15)=2.275$, $p=0.152$] between the two groups of engineering participants. Comparing the estimated marginal means shows that the average time spent decreased from 00:02:45 when using the isometric to 00:01:12 when using the application once the results were adjusted to reflect a mean spatial score of 0.628.

5.2.3 Amount of rework

The last consideration into the analysis of rework that was considered is the amount of rework that had to be completed. For this analysis, the number of components that were erroneously deemed correctly completed was evaluated. This represents the number of erroneously mated pieces that would have been tacked together and would have to be cut out and filed down to rectify the assembly in the event of using the just the isometric drawing and the number of erroneously mated pieces that would have been detected prior to tacking by using the application.

First the whole population of engineering participants was considered for the mean number of erroneously mated components. This is summarized in Table 17. It was found that the participants with the application eliminated an average of 0.759 erroneously mated components, with participants using the application generating an average of 7.3 erroneously mated components compared to 8.06 for their counterparts who used only the isometric. A one tail independent samples t-test was completed and the result was not found to be significant at the 95% confidence level with a p-value of 0.353 and a lower confidence interval bound of 4.128 errors eliminated.

Table 17. Number of times a piece was erroneously mated by engineering participants

	Number of erroneously mated components
Engineers with app	7.3
Engineers with isometric only	8.06
Mean difference	-0.759

The same analysis was then completed on the engineering participants divided into groups based on spatial skill. A summary is presented in Table 18. It was found that the application had the biggest reduction on participants with medium spatial skills resulting in a reduction of 1.975 erroneously mated components followed by the participants with high spatial skills who had a reduction of 1.833 erroneously mated components. The low spatial skills group was found to only have a reduction of 0.167 erroneously mated components. A one tail independent samples t test was completed on the means of the different groups. None of the results were found to be statistically significant at the 95% confidence interval. For the group with high spatial skills the reduction from 5.33 to 3.5 erroneous components when using the application had a p-value of 0.136 and a lower confidence interval bound of -4.722. For the group with medium spatial skills the reduction from 5.63 to 7.6 erroneously mated components had a p-value of 0.220 and a lower confidence interval bound of -6.396. For the group with low spatial skills the reduction from 11.17 to 11 erroneously mated components had a p-value of 0.486 and a lower confidence interval bound of -8.366.

Table 18. Average number of erroneously mated components based on engineers' spatial skills

	High Spatial	Medium Spatial	Low Spatial
Engineers with app	3.5	5.63	11
Engineers with isometric only	5.33	7.6	11.17
Mean error reduction	-1.833	-1.975	-0.167

Since the results for the difference spatial groups suggested a trend based on the participants' spatial cognitive skills, a one-way ANCOVA was conducted to compare the impact of using the application on the number of erroneously mated components while controlling for spatial skills. Levene's test and normality checks were carried out and the assumptions were met. The test did not find a statistically significant difference in the number of erroneously mated components [$F(1, 34)=0.754$, $p=0.574$] between the two groups of engineering participants. Comparing the estimated marginal means shows that the average number of erroneously mated components decreased from 8.222 when using the isometric to 7.161 when using the application once the results were adjusted to reflect a mean spatial score of 0.668.

This same analysis was then completed on the pipe fitters who had rework and is summarized in Table 19. It was found that an average of 1.0 erroneously installed components were avoided by using the application compared to using just the isometric drawing. A one tail independent sample t test was conducted to evaluate the means but it did not find the reduction from 3.5 to 2.5 to be statistically significant at the 95% confidence level with a p-value of 0.167 and a lower confidence interval bound of -2.748

Table 19. Average number of erroneously mated components by pipe fitters

	Number of erroneously mated components
Pipe fitters with app	2.5
Pipe fitters with isometric only	3.5
Mean error reduction	-1.0

Since the results suggested that there is trend towards reductions in erroneously mated components, a one-way ANCOVA was conducted to compare the impact of using the application on the number of erroneously mated components while controlling for spatial skills. Levene's test and normality checks were carried out and the assumptions were met. The test did not find a statistically

significant difference in the number of erroneously mated components [$F_{(1, 15)}=0.919$, $p=0.353$] between the two groups of pipe fitter participants. Comparing the estimated marginal means shows that the average number of erroneously mated components decreased from 3.484 when using the isometric to 2.310 when using the application once the results were adjusted to reflect a mean spatial score of 0.628.

While this was considered as rework for both groups of participants, there were many participants, particularly those who struggled to complete the experiment, who used the application as a measuring tool and scanned assemblies without verifying their compliance. These participants realized that if would be quicker for them to scan the assembly without verifying its compliance with traditional tools. This explains why the number of erroneously mated components does not vary much between the groups of participants. The engineering participants had an average decrease of 0.759 erroneously mated components and while the pipe fitters had an average decrease of 1 erroneously mated component.

5.3 Attitudes About Technology

The craft workers were asked about their opinions regarding technology to help understand how to facilitate the implementation of such technology into the work environment. It was speculated that with the proliferation of hand-held technology over the last decade and the ubiquity of smartphones that trades workers in 2018 are more open to technology than in previous decades. All the trades workers who participated reported daily use of smartphones, however the use of tablets and personal computers was highly varied among the participants. The craft workers were asked about their interest in using technology at work and in their personal lives on a spectrum from very interested to very disinterested. To assess these results, each value on the spectrum was assigned a value, and the values for the answers to the two questions were summed together for each participant. The spectrum and the associated values are presented in Table 20. The ages of the fitters were plotted against their interest in technology score and can be found in Figure 37.

Table 20. Spectrum and associated values to assess participants' interest in technology

Response	Associated Value
Very interested	+3
Somewhat interested	+1
Neutral	0
Somewhat disinterested	-1
Very disinterested	-3
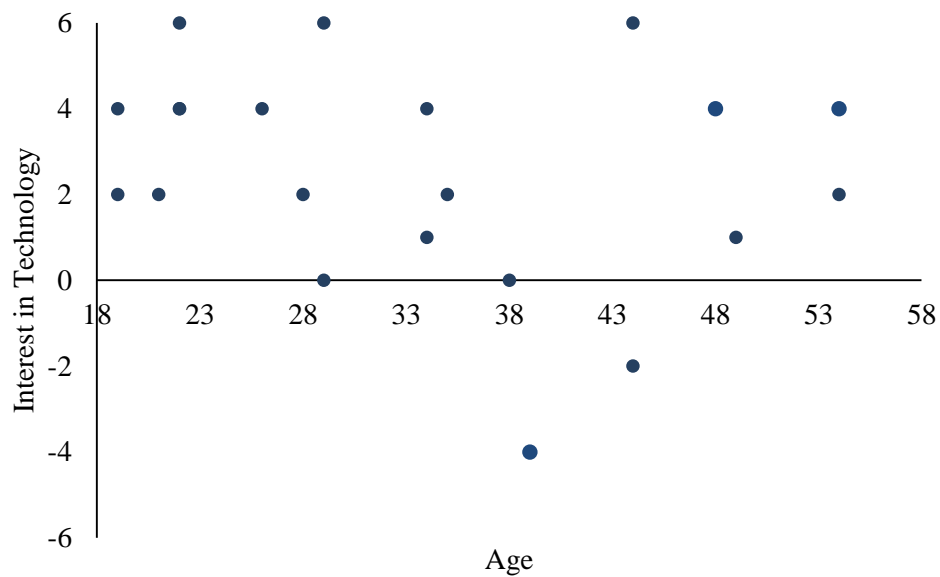
Figure 37. Fitters' age compared to their interest in technology

It can be seen that the age of the craft workers does not appear to have an impact on their level of interest in using technology in their lives. With the exception of two participants who were vehemently opposed to the use of technology, the remaining participants were at best neutral to the idea of using technology in their lives.

The workers were also asked about their biggest apprehension about using technology at work and what could be done to make them feel more comfortable using technology at work. The participants were permitted to select more than one response so the number of responses exceeds the number of participants. Figure 38 presents a summary of the craft workers' reported biggest apprehensions about using new technology at work. The biggest reported apprehension was

technology creating additional tasks to be done with 8 of the 24 responses identifying this issue. Change to routine and less time for direct work were the second most popular responses with each one receiving 6 votes.
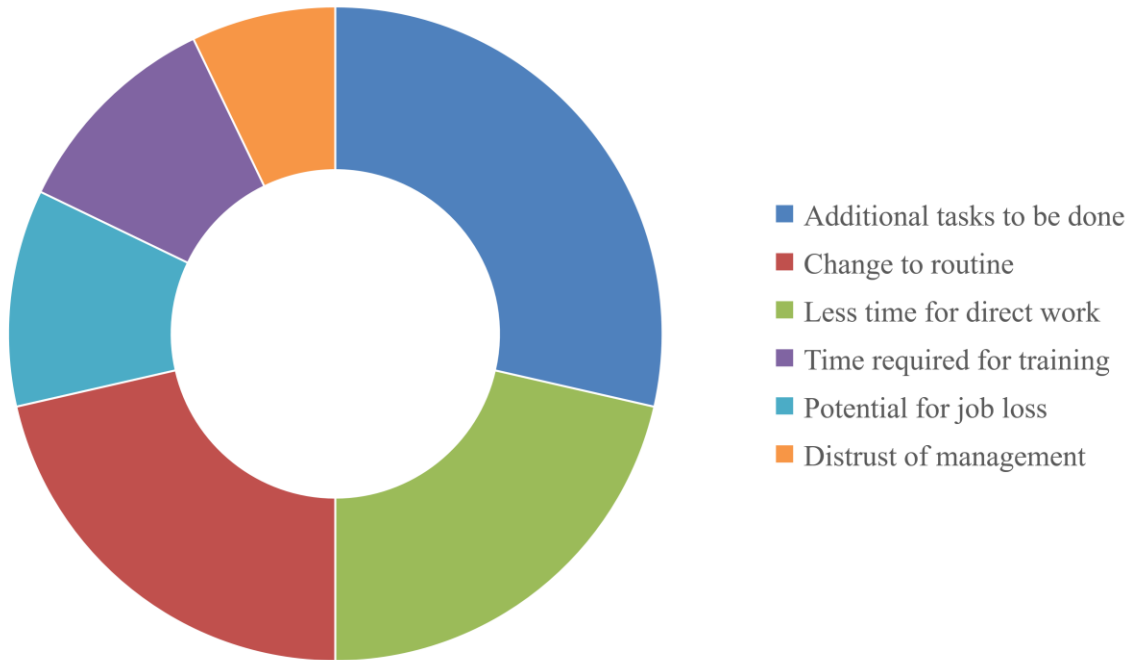
Figure 38. Craft workers' biggest apprehensions about using new technology at work

Figure 39 presents a summary of the factors that would make craft workers more comfortable with using new technology at work. Sufficient training was the most popular response receiving 11 of the total votes. Simplification of annoying tasks was the second most popular response.
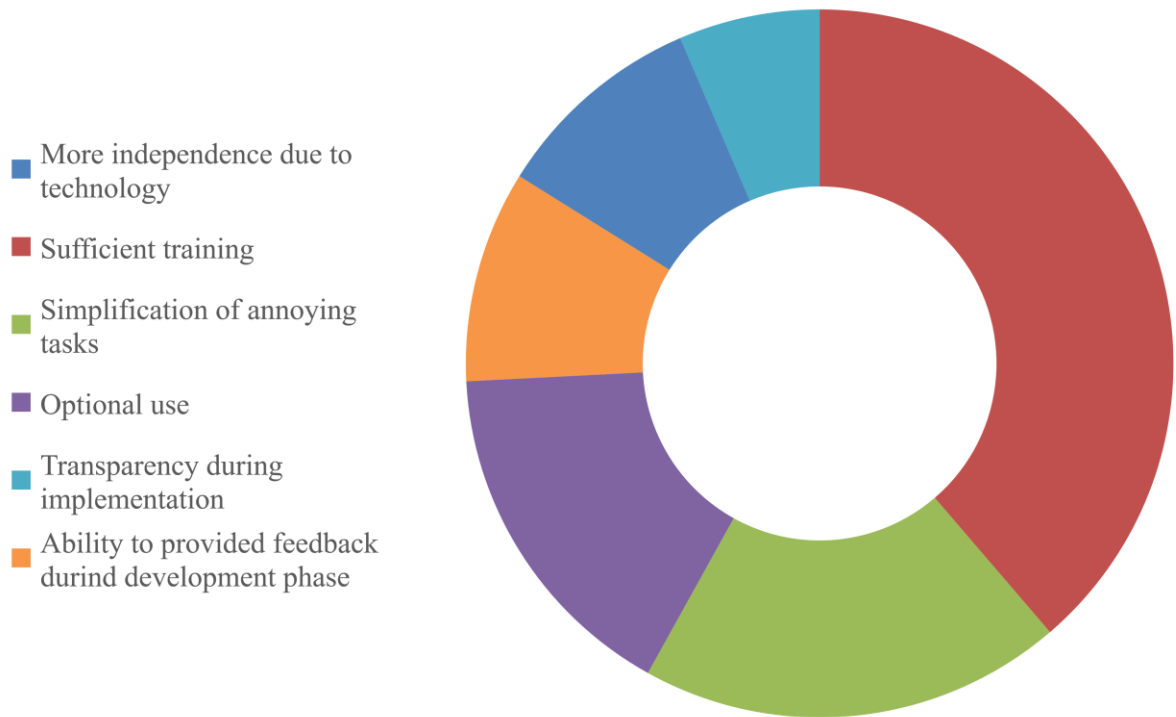
Figure 39. Factors that increase craft workers' comfort with using new technology at work

From the data collected from the craft workers regarding their attitudes about technology, it appears that craft workers are not opposed to working with new technology, regardless of their age, so long as they feel that the technology adds value by making the work simpler and that they are able to receive adequate training prior to implementation. If the technology minimizes the additional processes or replaces existing tasks with minimal impact to their routine, craft workers are far more likely to be receptive to it.

Chapter 6
Summary Conclusions and Recommendations

6.1 Productivity

It was observed that the use of the application reduced the total simulated time required to complete the assembly for both the pipe fitters and the engineers. In both of these groups the impact of spatial cognitive skills on the participants was found to impact the benefit that the participants received from using the augmented reality application.

For the engineers the reduction in total time required to complete the assembly reduced from 08:51:53 to 00:59:53 when the use of the application and its revised workflow was utilized. This result was found to be statistically significant at the 95% confidence level, and the impact of the engineering participant's spatial skills was found to be significant, with those engineering participants who had low spatial skills benefitting twice as much as their counterparts with high spatial skills.

Furthermore, it was found that the engineering participants had a decrease in the time required to interpret and understand the design information when using the application from 00:14:03 when using a standard isometric to 00:11:43 when using the application. This result was not found to be significant at the 95% confidence level and was likely impacted by the varying experience the engineering participants had in completing assemblies by following instructions.

Of greater consequence was the finding that the application had a positive impact on the productivity of the pipe fitters when completing the assembly. When using the revised workflow coupled with the application, the pipe fitters were able to complete the assembly with an average time of 00:32:43 compared to 03:12:18 for those who worked with just the isometric drawing. When corrected for spatial cognitive skills these results were found to be statistically significant at the 95% confidence level.

Furthermore, it was found that the use of the application reduced the amount of time needed by the pipe fitters to interpret and understand the design information from 00:11:49 for those using just the isometric drawing to 00:05:36 for those who used the application featuring the 3D model. This result was also found to be statistically significant when corrected for the participant's spatial skills.

In completing the study, it was found that an average scan acquisition and scan processing cycle requires 00:02:12 on the basis of the over 300 cycles that were completed in conducting this experimental study. The added value of having accurate as-built data for the pipe spools leaving a fabrication shop coupled with the reduction in time required to complete the assembly through the elimination of rework and the reduced time required to interpret and understand design information suggests that the use of an augmented reality application can have a positive impact on the productivity of pipe spool fabrication.

6.2 Rework

It was observed that the use of the augmented reality application reduced the impact of rework on the completion of a pipe spool assembly. The benefit that the participants received from using the application in completing their rework was also impacted by the participant's spatial skills, with those who had weaker spatial skills receiving greater benefits.

In evaluating the engineering participants, it was noted that the time required to complete the rework on an assembly was reduced from 00:08:54 for the participants using an isometric to 00:03:42 for the participants using the application. This reduction in time was significant at the 95% confidence level. The impact of spatial skills was particularly substantial in this area of assessment with the participants with low spatial skills receiving approximately 8 times the benefit of their counterparts with high spatial skills. This may be because the participants with lower spatial skills struggled more with completing the assembly and thus had more rework to complete.

Additionally, it was observed that the slight increase in time required to correct the initial erroneous interpretation of the design from 00:04:17 for those using the isometric to 00:04:49 for those using the application was not statistically significant.

In the assessment of the number of erroneously mated components for both groups of engineering participants, the reduction from 8.06 errors to 7.3 errors when using the application was found to be approaching significance while the impact of the engineers' spatial skills on this reduction in errors was noted.

Of greater consequence once again was the impact of the augmented reality application on the pipe fitters. The pipe fitters saved an average of 00:01:33 in completing rework, reducing the time from 00:02:46 for those using the isometric to 00:01:12 for those using the augmented reality application. This result was approaching significance.

The pipe fitters experienced a decrease in the time required to interpret and understand the rework to be completed from 00:08:56 when using just the isometric to 00:01:06 when using the augmented reality application. This decrease in time was found to be statistically significant at the 95% confidence level and was found to be statistically significant when corrected to reflect the participant's spatial skills.

Lastly, the pipe fitters reduced the number of erroneously mated components from 3.5 when using the isometric to 2.5 when they used the application.

Overall, the reduction in time spent completing rework, understanding rework information and the decrease in the number of components requiring rework for the pipe fitters presents the potential for the application to decrease rework in a pipe spool fabrication facility.

6.3 Participant Habits

It was observed, in evaluating the number of erroneously mated components, that participants who had access to the augmented reality app utilized the app as a measuring tool in favor of actually measuring. It appears that participants realized that they would be able to verify the assembly with the application quicker than they would be able to actually perform the measurements with traditional measuring tools.

Fitters who used the application were confident in their abilities to measure the assembly efficiently and accurately resulting in their main use of the application being to break down the complicated assembly into smaller more manageable components. However, a few of the fitters did adopt the engineers' idea to use the scanning as a measuring tool, or at least to confirm the general layout before they put in the effort to measure the complicated assembly.

Participants with the application, both engineers and fitters, appeared more comfortable checking assemblies they were less confident in. Participants with the drawing were more inclined to spend time checking the assembly before telling the experiment administrator that it was complete, whereas participants using the application were more likely to check it and modify the same piece multiple times. This may be because for the participants using the application the feedback on the rework to be done was self-given whereas the participants who had only the drawing to complete the assembly were being told by someone else that their work was wrong, lowering their morale.

One of the primary objections to incorporating this type of technology into a fabrication shop is the concern that in a harsh shop environment, with heavy equipment and many hard objects, the computing technology would get damaged from workers not being careful with the computing

equipment. While the experiments were conducted in a controlled office setting, participants were highly conscientious of how they treated the computing equipment. Almost every single participant performed an awkward handoff of the scanning device to the experiment administrator upon completion of the scan to free their hands to process the scan. Towards the end of the experiment a simple inexpensive stand was purchased to provide the participants with a docking location for the scanner. It is assumed that because the participants were working with technology (an iPad tablet) that they had purchased for themselves or for their child (depending on the age of the participant) that they emotionally identified with the cost of the equipment and were careful with how they treated it.

6.4 Feedback from Participants

At the end of the experiment, participants were briefly presented the format of the other version of the experiment. Participants with the drawing often expressed that they would have found the visualization of the rework to be more conducive to their ability to complete it while several participants who used the augmented reality process expressed that they did not think they would be able to complete the assembly without the aid of the 3D model. The value in providing the 3D design data to help facilitate the assembly process was identified by both engineers and fitters.

Multiple fitters commented on how when completing more complicated assemblies they would bend a wire at their work station based on the information they absorbed from the isometric drawings they were presented with, essentially creating their own 3D models. Many of the fitters acknowledged that while their jobs didn't require the daily use of computers, the proliferation of smartphones and other technologies into their lives did provide them with greater familiarity with technology compared to trades workers as little as a decade earlier.

Many of the best ideas for how to improve the augmented reality application were from the fitters. While engineers enjoyed using the technology and found the overall process to be interesting, it was the fitters who had the most practical and innovative ideas for implementing the technology. To facilitate the use of the application for completing an assembly, it was suggested that the 3D model would be far more useful to the craft workers if they could easily align any part of it with a principle axis. For example, to align a specific piece of pipe with the horizontal axis by selecting the piece and then being able to click a button that automatically aligned that piece and the model. This idea was furthered by the suggestion that the application recalculate and present the new angles resulting from realigning the assembly. To facilitate the completion of rework, it was suggested that the application

compute the angle by which the erroneously installed component needed to be modified to rectify the assembly.

Both the engineers and the fitters acknowledged that the flow of steps/pages in the application could be streamlined. The biggest challenge for using the application was often navigating to find the page that was most useful at any given time. The original application was designed as a sequence with the assumption that the information needed would progress linearly from the first page to the last page. What was found however, is that to best utilize the information presented, users must be able to switch between multiple different steps repeatedly without having to complete the processing each time they wish to switch pages.

Many of the more senior participants, both engineers employed in a management position and more experienced pipe fitters suggested that this augmented reality process would be a valuable training tool for onboarding apprentice pipe fitters. This sentiment was echoed by the apprentice pipe fitters who were recruited for the experiment.

6.5 Recommendations

Based on the study that was completed, the following recommendations are made:

- The application should be revised based on the feedback from the experiment participants to provide increased functionalities and a more intuitive, user-friendly experience.

- Further testing should be completed on a simpler model that is more representative of the types of issues encountered with completing a pipe spool assembly, including the potential for mating errors and erroneous components being provided to complete an assembly. This would likely have to be done with a real fabrication project by craft workers in a shop environment.

- There would be value in monitoring the progress a worker made over time in using the application and the learning curve required to reach high proficiency in using the application.

- There would also be value in using the application to assemble a pipe spool that was not easily manipulated given its size and weight to see how the augmented reality application's use is different when the assembly cannot be picked up and spun around easily, requiring a greater mental load to visualize the design information for the purpose of assembly.

- To fully benefit from the value presented by the utilization of the augmented reality application, the adaptation of the proposed application and process would have to be accepted from the upper

management level and proliferated through the practices of the company wishing to deploy the system. One of the greatest value propositions presented through the workflow of the presented application is the acquisition of accurate, detailed, as-built data for each spool manufactured in the fabrication shop facility.   In the event of a dispute between parties collaborating on a project as to who made the error responsible for an issue encountered on site, the availability of accurate as-built information would be valuable to a pipe spool fabricator to prove that the error was not their fault. This value is most felt by upper management. Individual workers are most concerned with their own total production on any given day, and shop foremen are used to pressuring their workers to produce as much as possible as their own evaluation is dependent on their shop's production. To allow for an effective implementation of this kind of work flow, a top-down approach is required.

Bibliography

[1]   J. Song, W. R. Fagerlund, C. T. Haas, C. B. Tatum, and J. A. Vanegas, "Considering Prework on Industrial Projects," *J. Constr. Eng. Manag.*, vol. 131, no. 6, pp. 723–733, 2005.

[2]   H. Yu, M. Al-Hussein, S. Al-Jibouri, and A. Telyas, "Lean Transformation in a Modular Building Company: A Case for Implementation," *J. Manag. Eng.*, vol. 29, no. 1, pp. 103–111, 2013.

[3]   Y. Shahtaheri, C. Rausch, J. West, C. Haas, and M. Nahangi, "Risk Mitigation through Tolerance Strategies for Design in Modularization," 2015.

[4]   C. Rausch, M. Nahangi, M. Perreault, C. T. Haas, and J. West, "Optimum Assembly Planning for Modular Construction Components," *J. Comput. Civ. Eng.*, p. 4016039, 2016.

[5]   R. Kurzweil, *Age Of Spiritual Machines*. New York: Penguin Books, 2000.

[6]   J. Irizarry, M. Gheisari, G. Williams, and B. N. Walker, "InfoSPOT: A mobile Augmented Reality method for accessing building information through a situation awareness approach," *Autom. Constr.*, vol. 33, pp. 11–23, 2013.

[7]   W. Yi and A. P. C. Chan, "Critical Review of Labor Productivity Research in Construction Journals," vol. 30, no. APRIL, pp. 214–225, 2014.

[8]   A. A. Tsehayae and A. R. Fayek, "Identification and comparative analysis of key parameters influencing construction labour productivity in building and industrial projects," vol. 891, no. September, pp. 878–891, 2014.

[9]   P. M. Goodrum, J. Miller, J. Sweany, and O. Alruwaythi, "Influence of the Format of Engineering Information and Spatial Cognition on Craft-Worker Performance," *Am. Soc. Civ. Eng.*, vol. 142, no. 9, pp. 1–10, 2016.

[10]   M. Nahangi and C. T. Haas, "Automated 3D compliance checking in pipe spool fabrication," *Adv. Eng. Informatics*, vol. 28, no. 4, pp. 360–369, 2014.

[11]   D. Zhang, C. T. Haas, P. M. Goodrum, C. H. Caldas, and R. Granger, "Construction Small-Projects Rework Reduction for Capital Facilities," *J. Constr. Eng. Manag.*, vol. 252, no. December, p. 415, 2012.

[12]   B. Akinci *et al.*, "A Formalism for Utilization of Sensor Systems and Integrated Project

Models for Active Construction Quality Control," pp. 1–25.

[13] P. E. D. Love, H. Li, and P. Mandal, "Rework: a symptom of a dysfunctional supply-chain," *Eur. J. Purch. Supply Manag.*, vol. 5, no. 1, pp. 1–11, 1999.

[14] P. E. D. Love and D. J. Edwards, "Forensic project management: The underlying causes of rework in construction projects," *Civ. Eng. Environ. Syst.*, vol. 21, no. 3, pp. 207–228, 2004.

[15] G. B. Dadi, T. R. B. Taylor, P. M. Goodrum, and W. F. Maloney, "Performance of 3D computers and 3D printed models as a fundamental means for spatial engineering information visualization," vol. 877, no. September, pp. 869–877, 2014.

[16] P. Wang, Y. Mohamed, S. M. Abourizk, M. Asce, and A. R. T. Rawa, "Flow Production of Pipe Spool Fabrication : Simulation to Support Implementation of Lean Technique," vol. 135, no. October, pp. 1027–1038, 2009.

[17] P. E. D. Love and H. Li, "Quantifying the causes and costs of rework in construction.," *Constr. Manag. Econ.*, vol. 18, no. 4, pp. 479–490, 2000.

[18] J. Dai, P. M. Goodrum, W. F. Maloney, and C. Sayers, "Analysis of focus group data regarding construction craft workers' perspective of the factors affecting their productivity," *Constr. Res. Congr. 2005*, pp. 1–10, 2005.

[19] P. E. D. Love, "Auditing the indirect consequences of rework in construction: a case based approach," *Manag. Audit. J.*, vol. 17, pp. 138–146, 2002.

[20] L. Hou, X. Wang, and M. Truijens, "Using Augmented Reality to Facilitate Piping Assembly : An Experiment-Based Evaluation," vol. 29, no. 1, pp. 1–12, 2015.

[21] V. Pətrəucean, I. Armeni, M. Nahangi, J. Yeung, I. Brilakis, and C. Haas, "State of research in automatic as-built modelling," *Adv. Eng. Informatics*, vol. 29, no. 2, pp. 162–171, 2015.

[22] B. Becerik-Gerber and S. Rice, "The perceived value of building information modeling in the US building industry," *J. Inf. Technol. Constr.*, vol. 15, no. February, pp. 185–201, 2010.

[23] T. Hartmann and M. Fischer, "Applications of BIM and Hurdles for Widespread Adoption of BIM," 2007.

[24] B.-G. Hwang, S. R. Thomas, C. T. Haas, and C. H. Caldas, "Measuring the impact of rework on construction cost performance," *J. Constr. Eng. Manag.*, vol. 135, no. 3, pp. 187–198,

2009.

[25]   C. H. Oglesby, H. W. Parker, and G. A. Howell, *Productivity Improvment in Construction*. New York: Mcgraw-Hill, 1989.

[26]   F. Bosché, M. Ahmed, Y. Turkan, C. T. Haas, and R. Haas, "The value of integrating Scan-to-BIM and Scan-vs-BIM techniques for construction monitoring using laser scanning and BIM: The case of cylindrical MEP components," *Autom. Constr.*, vol. 49, pp. 201–213, 2015.

[27]   T. Czerniawski *et al.*, "Automating measurement process to improve quality management for piping fabrication," *Autom. Constr.*, vol. 13, no. 1, pp. 67–81, 2015.

[28]   H. Son, C. Kim, and C. Kim, "Fully Automated As-Built 3D Pipeline Extraction Method from Laser-Scanned Data Based on Curvature Computation," *J. Comput. Civ. Eng.*, vol. 29, no. 4, p. B4014003, 2015.

[29]   Y. Turkan, F. Bosche, C. T. Haas, and R. Haas, "Automation in Construction Automated progress tracking using 4D schedule and 3D sensing technologies," *Autom. Constr.*, vol. 22, pp. 414–421, 2012.

[30]   Y. Turkan, F. N. Bosche, C. Haas, and R. Haas, "Towards Automated Progress Tracking of Erection of Concrete Structures," in *6th Annual International AEC Innovation Conference*, 2010.

[31]   A. V Yadhukrishnan and A. Shetty, "A Review on GIS based Construction Project Management," vol. 2, no. 6, pp. 137–141, 2015.

[32]   P. Vähä, T. Heikkilä, P. Kilpeläinen, M. Järviluoma, and E. Gambao, "Extending automation of building construction — Survey on potential sensor technologies and robotic applications," *Autom. Constr.*, vol. 36, pp. 168–178, 2013.

[33]   H. Son, F. Bosché, and C. Kim, "As-built data acquisition and its use in production monitoring and automated layout of civil infrastructure: A survey," *Adv. Eng. Informatics*, vol. 29, no. 2, pp. 172–183, 2015.

[34]   M. Nahangi, L. Chanudhary, J. Yeung, C. T. Haas, and S. Walbridge, "Skeleton-Based Registration of 3D Laser Scans for Automated Quality Assurance of Industrial Facilities," *Comput. Civ. Eng.*, p. 1, 2015.

[35]   J. Chen, Y. Fang, Y. K. Cho, and C. Kim, "Principal Axes Descriptor for Automated

Construction-Equipment Classification from Point Clouds," *J. Comput. Civ. Eng.*, p. 4016058, Sep. 2016.

[36] M. Nahangi and C. T. Haas, "Skeleton-based discrepancy feedback for automated realignment of industrial assemblies," *Autom. Constr.*, vol. 61, pp. 147–161, 2016.

[37] A. Sehgal, D. Cernea, and M. Makaveeva, "Real-time scale invariant 3D range point cloud registration," *Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)*, vol. 6111 LNCS, no. PART 1, pp. 220–229, 2010.

[38] T. Rabbani and R. Sensing, "3D Industrial Reconstruction By Fitting Csg Models To a," *Optimization*.

[39] D. Nistér, "Preemptive RANSAC for live structure and motion estimation," *Mach. Vis. Appl.*, vol. 16, no. 5, pp. 321–329, 2005.

[40] T. Jebara, A. Azarbayejani, and A. Pentland, "3D Structure from 2D Motion."

[41] L. A. Tartre, "Spatial Orientation Skill and Mathematical Problem Solving," *J. Res. Math. Educ.*, vol. 21, no. 3, pp. 216–229, 1990.

[42] O. Ha and N. Fang, "Spatial Ability in Learning Engineering Mechanics : Critical Review," *J. Prof. Issues Eng. Educ. Pract.*, vol. 142, no. 2, pp. 1–11, 2016.

[43] R. Gorska and S. Sorby, "AC 2008-2727 : TESTING INSTRUMENTS FOR THE ASSESSMENT OF 3-D Renata Gorska , Cracow University of Technology Sheryl A . Sorby is a Professor of Civil and Environmental Engineering andis the former University . She is currentlyserving as a Program Director," 2008.

[44] I. D. Cherney, "Mom, Let Me Play More Computer Games : They Improve My Mental Rotation Skills," *Sex Roll.*, pp. 776–786, 2008.

[45] R. B. Ekstrom, J. W. French, H. H. Harman, and D. Dermen, "Manual for Kit of of Factor-Referenced Cognitive Tests," 1976.

[46] J. A. Bratton and J. A. Bratton, "Why workers are reluctant learners : the case of the Canadian pulp and paper industry," *J. Work. Learn.*, vol. 13, no. 7/8, pp. 333–343, 2001.

[47] J. Hanania, K. Stenhouse, and J. Donev, "CANDU Reactor." .

[48] Occipital, "Precise 3D Vision for Embedded Applications." 2018.

Appendix A
Full Size Two-Sided Isometric
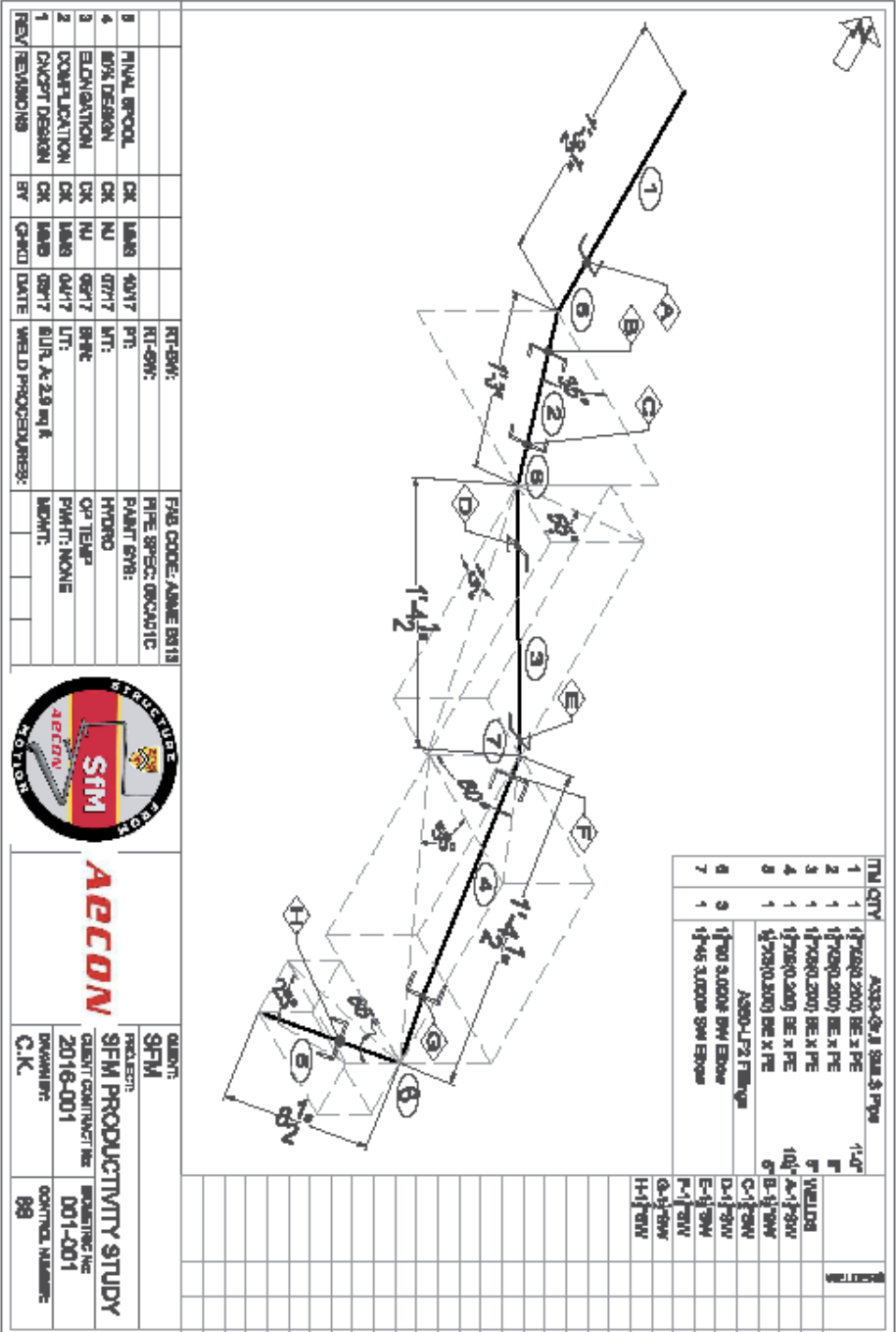
AECON

SfM — STRUCTURE FROM MOTION

CLIENT: SFM
PROJECT: SFM PRODUCTIVITY STUDY
CLIENT CONTRACT No: 2016-001
DRAWN BY: C.K.
CONTROL NUMBER: 89
ISOMETRIC No: D01-001

FAB CODE: ASME B31.1
PIPE SPEC: 8SA01C
PAINT SYS:
RT-BW:
RT-SW:
PT:
MT:
RFHC:
LT:
BUR. A: 2.9 sq ft
HYDRO
OP TEMP
PWHT: NONE
MDMT:
WELD PROCEDURES:

		BY	CHKD	DATE	
5	FINAL SPOOL	CK	MMG	10/17	
4	90% DESIGN	CK	NJ	07/17	
3	ELONGATION	CK	NJ	06/17	
2	COMPLICATION	CK	MMG	04/17	
1	CONCEPT DESIGN	CK	MMG	03/17	
REV	REVISIONS				

ITM QTY

ITM	QTY		
1	1	1" x 8.0 3000LB BE x PE	A-1¾"BW
2	1	1" x 8.0 3000LB BE x PE	B-1¾"BW
3	1	1" x 8.0 3000LB BE x PE	C-1¾"BW
4	1	1" x 8.0 3000LB BE x PE	D-1¾"BW
5	1	¾" 3000LB BE x PE	E-1¾"BW
6	1	ASME LF2 Flange	F-1¾"BW
7	1	1" 90 3000R BW Elbow	G-1¾"BW
8	1	1" x 45 3000R BW Elbow	H-1¾"BW

WELDERS

Appendix B
Technical Specifications of Scanners Used

Structure IO Technical Specifications:

Technical Specifications

Dimensions
119.2 mm
29 mm
28 mm

Weight
95g

Maximum Recommended Range
3.5m+

Minimum Recommended Range
40cm

Precision
0.5mm at 40cm (0.15%),
30mm at 3m (1%)
More detail

Resolution
VGA (640 x 480),
QVGA (320 x 240)

Framerate
30 / 60 frames per second

Battery Life
3-4 hours of active sensing,
1000+ hours of standby

Illumination
Infrared structured light projector, uniform infrared LEDs

Field of View
Horizontal: 58 degrees,
Vertical: 45 degrees

Operating Temperature
0° to 35° C (32° to 95° F)

FARO® Focus™ 70 Laser Scanner
Short-range Professional Grade Laser Scanner

FARO

Laser Scanner for Short Range Applications

The FARO Focus™ 70 Laser Scanner is a powerful 3D laser scanner specifically designed for both indoor and outdoor applications that require scanning up to 70 meters.

The ultra-portable device enables fast, straight-forward and accurate measurements of construction sites, small-scale facades, complex structures, production and supply facilities and crime and crash scenes. Combining professional grade scanning technology with portability and ease-of-use, the new device offers reliability, flexibility and real-time views of recorded data. The 3D scan data can easily be imported into all commonly used software solutions for architecture and construction, forensics and accident reconstruction or industrial manufacturing.

FARO Focus™ 70 Laser Scanner is equipped with recognizable features from the industry's most trusted laser scanner product line.

Short range scanning - up to 70m
The Focus™ 70 can record data up to 70 meters, making it ideal for short-range measurements and small area job applications.

Compact and Portable
The Focus™ 70 is compact and lightweight with dimensions of just 9.05" x 7.2" x 4.05" (230mm x 183mm x 103mm) and a weight of only 9.26 lbs (4.2kg). An included waterproof, ergonomic carrying case gives the device true portability.

HDR Photo Overlay
The HDR camera easily captures detailed imagery while providing a natural color overlay to the scan data captured under extreme brightness gradients.

Best Value For Money
The FARO Focus™ 70, coupled with FARO SCENE, is the first professional grade scanner solution to be offered for under $27,000 that does not compromise on the industrial grade performance of the award winning FARO Focus Laser Scanner portfolio.

IP Rating - Class 54
With the sealed design and IP54 Ingress Protection Rating, the Focus™ 70 can be used in high particulate and wet weather conditions.

Temperature
Extended temperature range allows scanning in challenging environments. The Focus™ 70 can operate in temperatures as low as -4°F (-20°C) and up to 131°F (55°C).

Benefits

- Scan in challenging environments while providing protection from dust, debris and water splashes
- The FocusM 70 delivers full scanning capability with the quickest return on invest in the market
- Be confident in performance using the FocusM 70 from the award-winning Focus Laser Scanner portfolio
- Easily navigate the scanner controls using the large and luminous touch-screen

Performance Specifications

Range Unit

Reflectivity	90% (white)	10% (dark-grey)	2% (black)
Range[1]	2' – 230' (0.6–70m)	2' – 230' (0.6–70m)	2' – 164' (0.6–50m)

Ranging noise[2]	@10m	@10m noise reduction[3]	@25m	@25m noise reduction[3]
90% reflectivity	0.7mm	0.4mm	0.7mm	0.4mm
10% reflectivity	0.5mm	0.4mm	0.9mm	0.4mm
2% reflectivity	1.5mm	0.3mm	2.1mm	1.1mm

Measurement speed (pts/sec): 122,000 / 244,000 / 488,000
Ranging error[2]: ±3mm

Color Unit
* **Resolution:** Up to 165 megapixel color
* **High Dynamic Range (HDR):** Exposure Bracketing 2x, 3x, 5x
* **Parallax:** Minimized due to co-axial design

Deflection Unit
* **Field of View (vertical/horizontal):** 300° / 360°
* **Step Size (vertical/horizontal):** 0.009° (40,960 3D-Pixel on 360°) / 0.009° (40,960 3D-Pixel on 360°)
* **Max. Vertical Scan Speed:** 97Hz

Data Handling and Control
Data Storage: SD, SDHC™, SDXC™; 32GB card

Scanner Control: Via touchscreen display and WLAN connection. Access by mobile devices with HTML5

Laser (Optical Transmitter)
* **Laser Class:** Laser class 1
* **Wavelength:** 1550nm
* **Beam divergence:** 0.3mrad (1/e)
* **Beam diameter at exit:** 0.085" (2.12mm) (1/e)

Interface Connection
* WLAN: 802.11n (150Mbit/s), as Access Point or client in existing networks

Integrated Sensors

Dual Axis Compensator:	Performs leveling of each scan within accuracy of 19 arcsec valid within ±2°
Height Sensor:	The height relative to a fixed point can be detected and added to a scan via an electronic barometer.
Compass[4]:	The electric compass provides each scan with orientation.
GNSS:	Integrated GPS & GLONASS

General

* **Power Supply Voltage:** 19V (external supply) / 14.4V (internal battery)
* **Power consumption:** 15W idle, 25W scanning, 80W charging
* **Battery Service Life:** 4.5 hours
* **Operating Temperature:** 41° – 104°F (5° – 40°C)
* **Extended Operating Temperature[5]:** -4° – 131°F (-20° – 55°C)
* **Storage Temperature:** 14° – 140°F (10° – 60°C)

* **Ingress Protection:** P54
* **Humidity:** Non-condensing
* **Weight Including Battery:** 9.26 lbs (4.2kg)
* **Size:** 9.05" x 7.2" x 4.05" (230mm x 183mm x 103mm)
* **Maintenance / calibration:** Annual

For more information,
call 800.736.0234 or visit www.faro.com

Contract Holder

Appendix C
Pipe Spool Design Process Details

The proxy pipe spool used in this experiment was designed in Inventor. To develop the Inventor model of the assembly, the individual parts had to be created and then mated in Inventor.

The most complicated part that needed to be created was the flexible 90º elbow. This part had an atypical radius of curvature and its flexible nature made taking accurate caliper measurements difficult. For this reason, a scan was taken with the FARO Arm scanner to compare it against the model drawn in Inventor.

First, the scan of the actual elbow was opened in Meshlab to ensure it was complete.
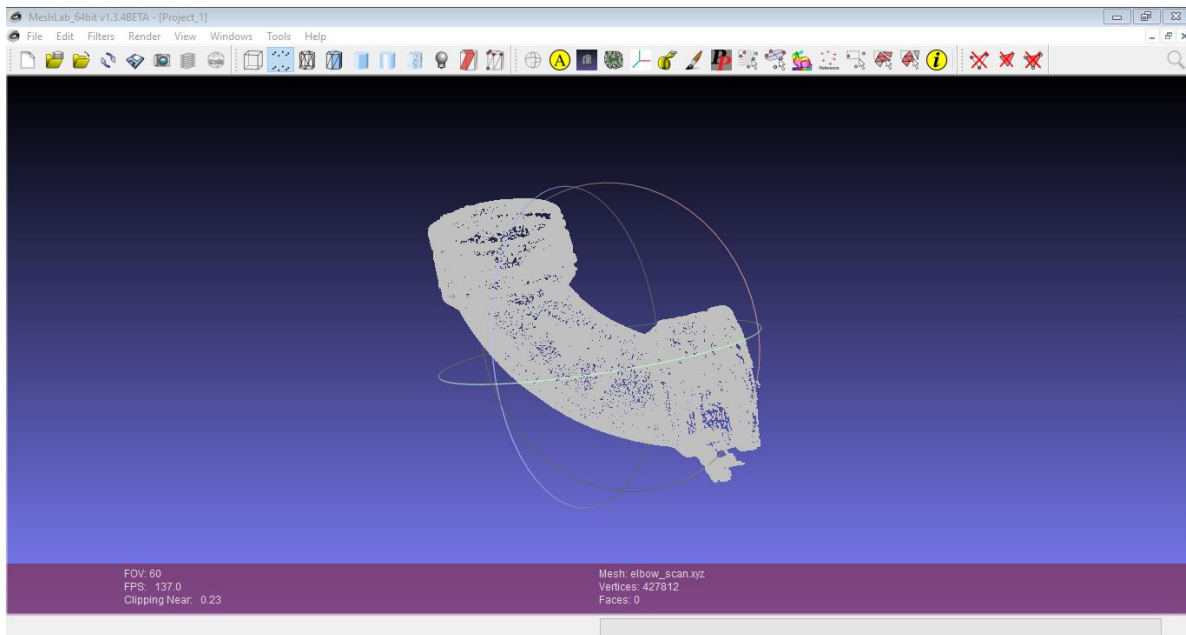
The elbow was then drawn in 3D in Inventor.
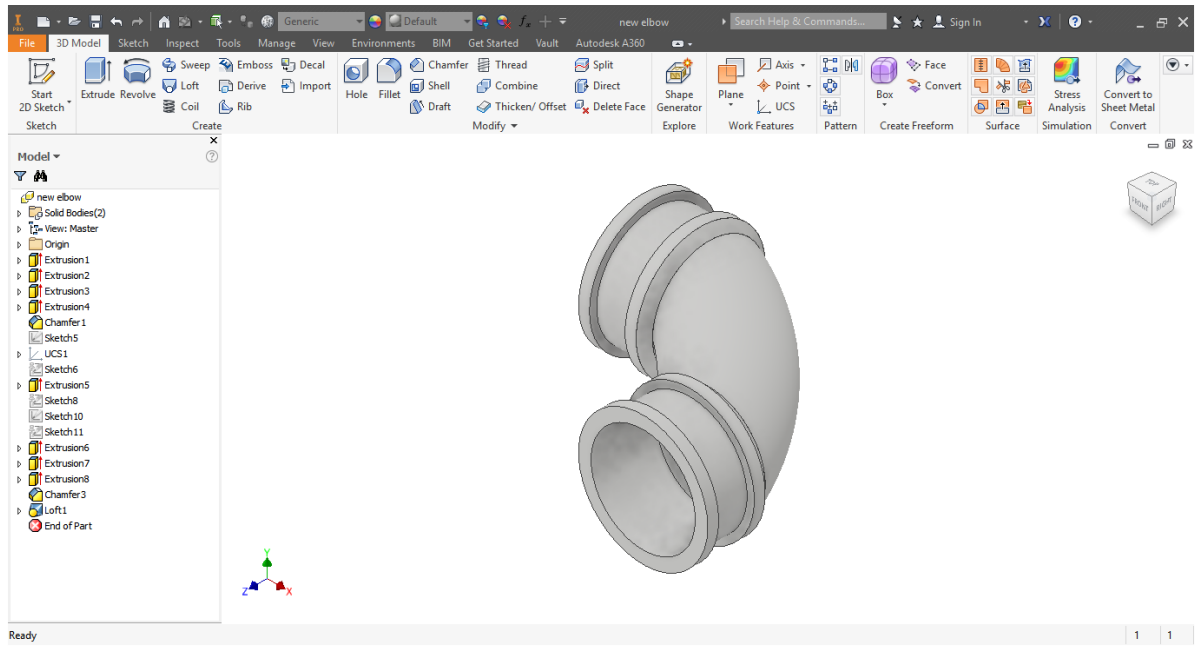
The Inventor model was then exported as an STL file.
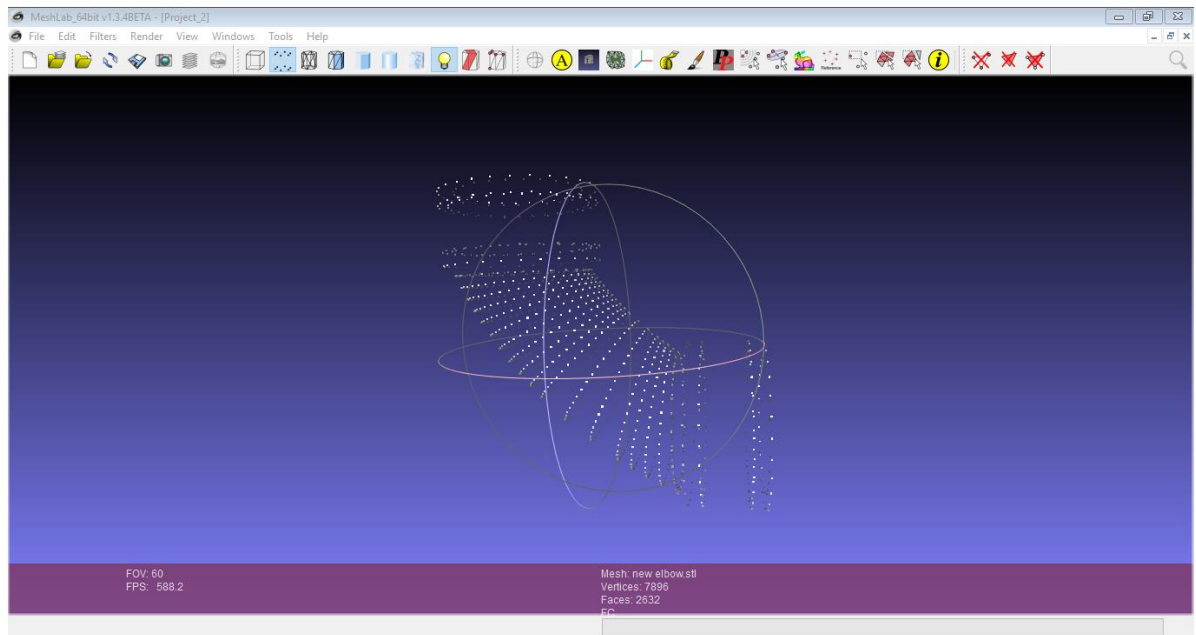
The STL file was then and repopulated in Meshlab to generate a point cloud.
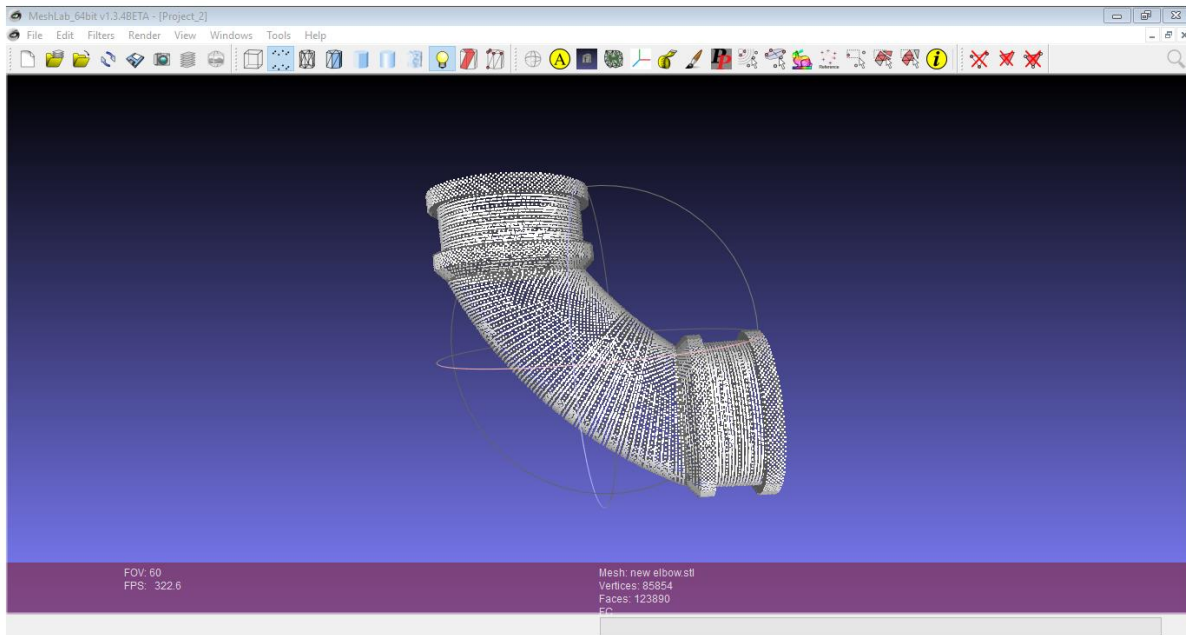
In order to verify that the model elbow was sufficient for use in the experiment, the point cloud generated in Meshlab was superimposed on the point cloud obtained by the FARO Arm scanner using CloudCompare. The cloud-to-cloud distance was then computed.
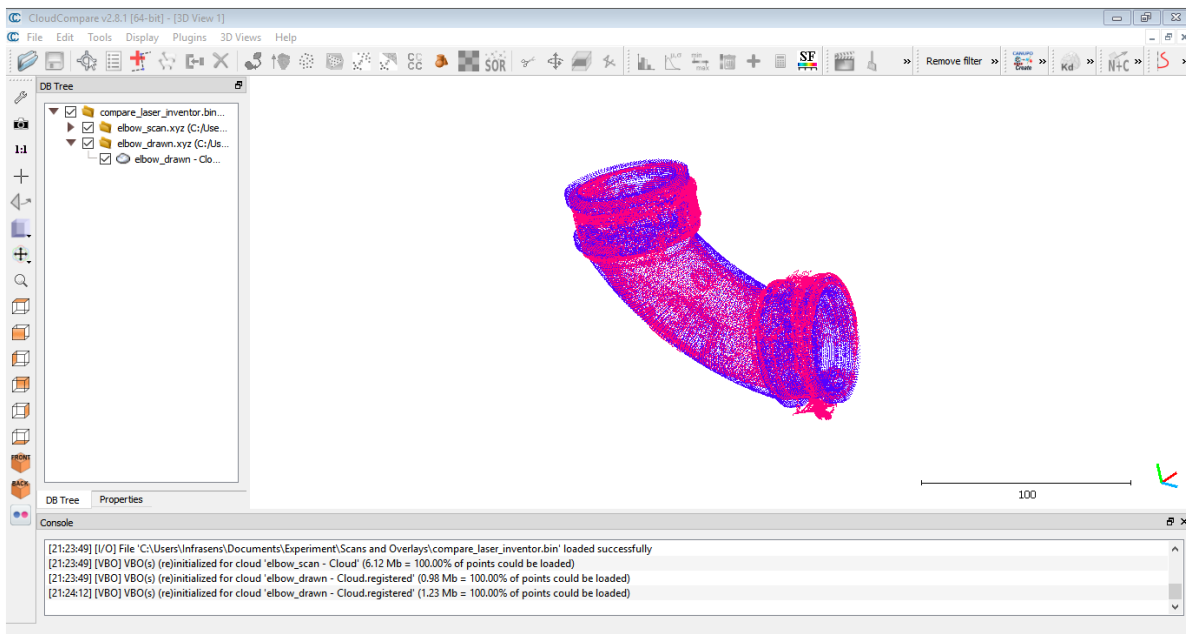
This process was repeated for the 45º elbow used as well.

In total, 2 different elbow shapes and 3 different pipe lengths had to be drawn in Inventor. Once these parts were completed they were used to create an assembly in Inventor.
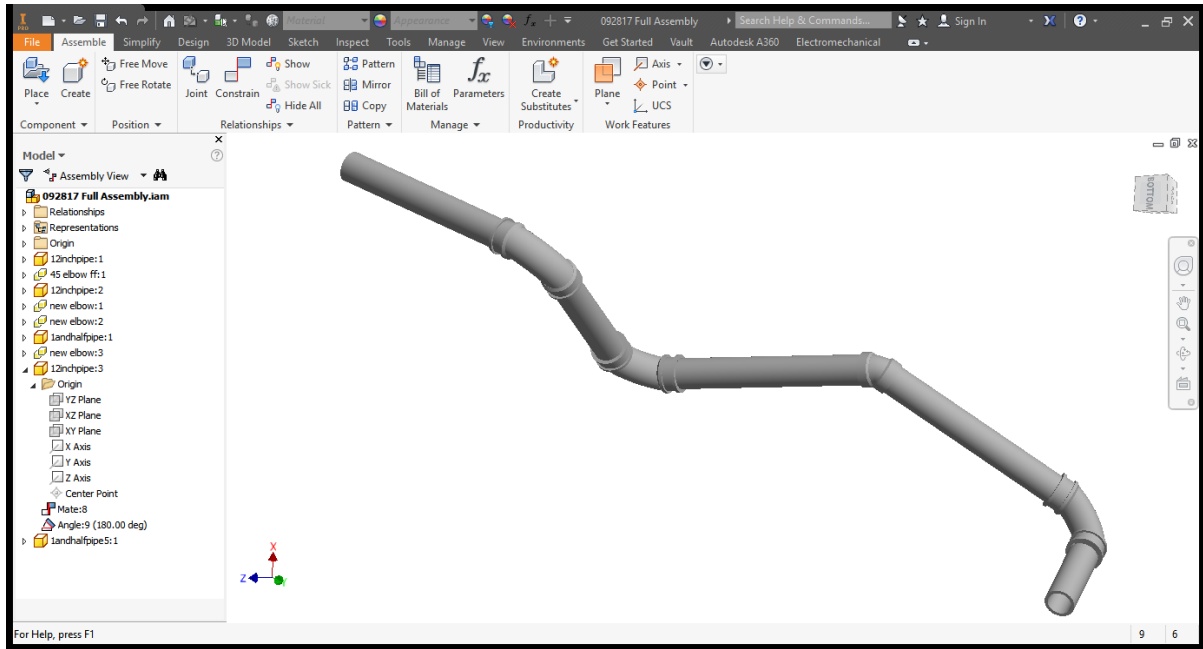
Once the Inventor Model was completed, the coordinates of the components needed to be recorded and transformed to align the first pipe segment with the x-axis.

These transformed coordinates were then used to create an isometric drawing in AutoCAD.
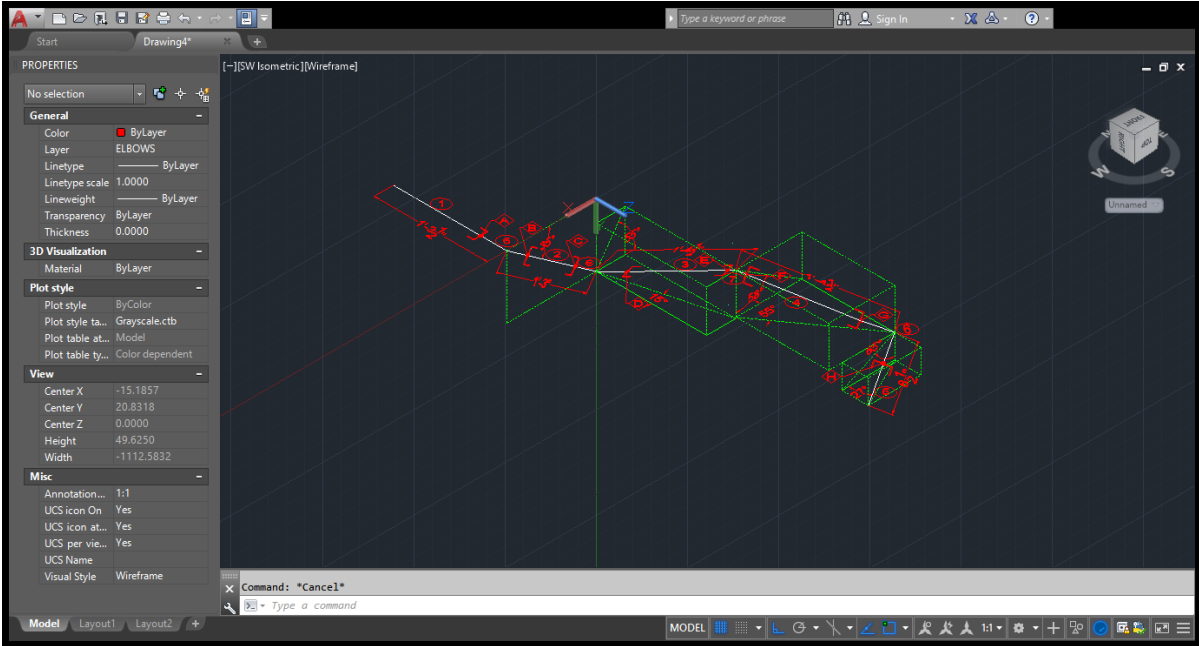
Appendix D

Engineers with App Raw Data

				E-A-01	

Cycle	Start	End	Duration	Category	Note
1	00:00	00:33	00:33	Chatting with Administrator	
1	00:33	00:47	00:14	Looking at Drawing	
1	00:47	01:10	00:23	Assembly Layout	
1	01:10	01:35	00:25	Looking at Drawing	
1	01:35	02:03	00:28	Looking at 3D Model	
1	02:03	02:08	00:05	Looking at Drawing	
1	02:08	02:22	00:14	Chatting with Administrator	
1	02:22	02:48	00:26	Model Segmentation	
1	02:48	03:02	00:14	Chatting with Administrator	.
2	03:02	03:44	00:42	Scan Acquisition	For some reason piece 1 was scanned
2	03:44	04:48	01:04	Scan Processing	
2	04:48	04:50	00:02	Output Analysis	
2	04:50	04:56	00:06	Chatting with Administrator	
2	04:56	05:18	00:22	Model Segmentation	
2	05:18	05:42	00:24	Assembling Assembly	
2	05:42	05:53	00:11	Looking at 3D Model	
2	05:53	06:04	00:11	Measuring Assembly	
2	06:04	06:12	00:08	Assembling Assembly	
2	06:12	06:22	00:10	Looking at 3D Model	
2	06:22	06:49	00:27	Measuring Assembly	
3	06:49	07:30	00:41	Scan Acquisition	
3	07:30	08:40	01:10	Scan Processing	
3	08:40	08:42	00:02	Output Analysis	
3	08:42	09:40	00:58	Scan Processing	
3	09:40	09:57	00:17	Output Analysis	
3	09:57	10:05	00:08	Completing Rework	Part 2
3	10:05	10:12	00:07	Chatting with Administrator	
3	10:12	10:40	00:28	Model Segmentation	
3	10:40	11:14	00:34	Adjusting Clips	
3	11:14	11:27	00:13	Looking at 3D Model	
3	11:27	11:37	00:10	Assembling Assembly	pt 4
3	11:37	12:12	00:35	Manipulating Stands	
3	12:12	13:22	01:10	Looking at 3D Model	
4	13:22	15:15	01:53	Scan Acquisition	
4	15:15	16:58	01:43	Scan Processing	
4	16:58	17:07	00:09	Output Analysis	
4	17:07	17:18	00:11	Completing Rework	Part 4
4	17:18	17:42	00:24	Looking at Drawing	
4	17:42	17:48	00:06	Completing Rework	Part 4
5	17:48	18:20	00:32	Scan Acquisition	
5	18:20	20:18	01:58	Scan Processing	
5	20:18	20:22	00:04	Output Analysis	
5	20:22	20:42	00:20	Adjusting Clips	
5	20:42	21:04	00:22	Completing Rework	Part 4
5	21:04	21:14	00:10	Looking at 3D Model	
5	21:14	21:27	00:13	Completing Rework	Part 4
5	21:27	21:32	00:05	Chatting with Administrator	
5	21:32	21:42	00:10	Completing Rework	Part 4
5	21:42	21:55	00:13	Chatting with Administrator	
6	21:55	23:35	01:40	Scan Acquisition	
6	23:35	24:16	00:41	Scan Processing	
6	24:16	24:18	00:02	Output Analysis	
6	24:18	24:58	00:40	Adjusting Clips	
6	24:58	25:17	00:19	Model Segmentation	
6	25:17	25:26	00:09	Looking at 3D Model	
6	25:26	25:35	00:09	Assembling Assembly	pt 5
6	25:35	26:07	00:32	Manipulating Stands	
6	26:07	26:27	00:20	Adjusting Assembly	
7	26:27	27:43	01:16	Scan Acquisition	
7	27:43	28:38	00:55	Scan Processing	

Totals	
Chatting with Administrator	01:38
Assembling Assembly	00:51
Adjusting Clips	01:34
Measuring Assembly	00:38
Checking Assembly	00:00
Manipulating Stands	01:07
Adjusting Assembly	00:20
Assembly Layout	00:23
Looking at Drawing	01:08
Completing Rework	01:17
Model Segmentation	01:35
Looking at 3D Model	02:31
Scan Acquisition	08:04
Scan Processing	09:12
Output Analysis	00:49
Total	31:07

Cycle	Start	End	Duration	Category	Note
7	28:38	28:48	00:10	Output Analysis	
7	28:48	28:55	00:07	Completing Rework	Part 5
8	28:55	30:15	01:20	Scan Acquisition	
8	30:15	30:58	00:43	Scan Processing	
8	30:58	31:01	00:03	Output Analysis	
8	31:01	31:07	00:06	Chatting with Administrator	

E-A-02

Cycle	Start	End	Duration	Category	Note
1	00:00	00:25	00:25	Looking at Drawing	
1	00:25	00:35	00:10	Chatting with Administrator	
1	00:35	01:40	01:05	Looking at Drawing	
1	01:40	02:40	01:00	Chatting with Administrator	Exp dwg
1	02:40	03:15	00:35	Looking at Drawing	
1	03:15	03:35	00:20	Assembling Assembly	
1	03:35	03:50	00:15	Checking Assembly	
1	03:50	04:25	00:35	Assembling Assembly	
1	04:25	05:10	00:45	Model Segmentation	.
1	05:10	05:45	00:35	Looking at 3D Model	
1	05:45	06:25	00:40	Assembling Assembly	pt5
1	06:25	06:40	00:15	Checking Assembly	
1	06:40	06:48	00:08	Adjusting Clips	
1	06:48	06:56	00:08	Chatting with Administrator	
1	06:56	07:16	00:20	Chatting with Administrator	
2	07:16	08:34	01:18	Scan Acquisition	
2	08:34	11:20	02:46	Scan Processing	
2	11:20	11:56	00:36	Chatting with Administrator	
2	11:56	12:07	00:11	Output Analysis	
2	12:07	13:35	01:28	Scan Processing	
2	13:35	14:32	00:57	Adjusting Clips	
2	14:32	14:55	00:23	Completing Rework	pt5
2	14:55	15:09	00:14	Adjusting Clips	
2	15:09	15:17	00:08	Manipulating Stands	
3	15:17	16:45	01:28	Scan Acquisition	
3	16:45	17:50	01:05	Scan Processing	
3	17:50	18:05	00:15	Output Analysis	
3	18:05	18:16	00:11	Chatting with Administrator	
3	18:16	18:33	00:17	Chatting with Administrator	
3	18:33	19:46	01:13	Model Segmentation	
3	19:46	20:30	00:44	Looking at 3D Model	
3	20:30	20:45	00:15	Assembling Assembly	pt4
3	20:45	20:58	00:13	Looking at 3D Model	
3	20:58	21:12	00:14	Adjusting Assembly	
3	21:12	21:35	00:23	Looking at Drawing	
3	21:35	21:51	00:16	Chatting with Administrator	
3	21:51	22:11	00:20	Measuring Assembly	
3	22:11	22:20	00:09	Adjusting Assembly	
3	22:20	22:26	00:06	Chatting with Administrator	
3	22:26	22:42	00:16	Adjusting Clips	
3	22:42	22:56	00:14	Manipulating Stands	
4	22:56	24:09	01:13	Scan Acquisition	
4	24:09	25:10	01:01	Scan Processing	
4	25:10	25:20	00:10	Output Analysis	
4	25:20	25:49	00:29	Chatting with Administrator	
4	25:49	26:22	00:33	Model Segmentation	
4	26:22	27:50	01:28	Looking at 3D Model	
4	27:50	28:07	00:17	Assembling Assembly	pt2
4	28:07	28:30	00:23	Looking at 3D Model	
4	28:30	28:36	00:06	Chatting with Administrator	
4	28:36	28:48	00:12	Looking at 3D Model	
4	28:48	28:52	00:04	Looking at Drawing	
4	28:52	29:14	00:22	Assembling Assembly	
4	29:14	30:20	01:06	Measuring Assembly	
4	30:20	30:22	00:02	Adjusting Assembly	
4	30:22	30:35	00:13	Measuring Assembly	
4	30:35	30:53	00:18	Adjusting Clips	
5	30:53	32:10	01:17	Scan Acquisition	
5	32:10	33:10	01:00	Scan Processing	

Totals	
Chatting with Administrator	04:16
Assembling Assembly	02:29
Adjusting Clips	01:53
Measuring Assembly	01:39
Checking Assembly	00:30
Manipulating Stands	00:22
Adjusting Assembly	00:25
Assembly Layout	00:00
Looking at Drawing	02:32
Completing Rework	00:23
Model Segmentation	02:31
Looking at 3D Model	03:35
Scan Acquisition	05:16
Scan Processing	07:20
Output Analysis	00:51
Total	34:02

Cycle	Start	End	Duration	Category	Note
5	33:10	33:25	00:15	Output Analysis	
5	33:25	34:02	00:37	Chatting with Administrator	

E-A-03

Cycle	Start	End	Duration	Category	Note
1	00:00	01:48	01:48	Chatting with Administrator	
1	01:48	02:20	00:32	Model Segmentation	
1	02:20	02:39	00:19	Looking at 3D Model	
1	02:39	02:55	00:16	Assembling Assembly	PT 2 PT 4
1	02:55	03:06	00:11	Adjusting Clips	
1	03:06	03:17	00:11	Adjusting Assembly	
1	03:17	03:37	00:20	Adjusting Clips	
1	03:37	03:46	00:09	Assembling Assembly	
1	03:46	03:56	00:10	Adjusting Clips	.
1	03:56	04:04	00:08	Adjusting Assembly	
1	04:04	04:28	00:24	Chatting with Administrator	
1	04:28	04:56	00:28	Chatting with Administrator	
2	04:56	05:42	00:46	Scan Acquisition	
2	05:42	07:05	01:23	Scan Processing	
2	07:05	07:22	00:17	Chatting with Administrator	
2	07:22	08:00	00:38	Scan Processing	
2	08:00	08:08	00:08	Output Analysis	
2	08:08	08:15	00:07	Chatting with Administrator	
2	08:15	08:25	00:10	Looking at 3D Model	
2	08:25	08:40	00:15	Completing Rework	RW 4
3	08:40	09:39	00:59	Scan Acquisition	
3	09:39	12:20	02:41	Scan Processing	
3	12:20	12:38	00:18	Output Analysis	
3	12:38	13:07	00:29	Chatting with Administrator	
3	13:07	13:35	00:28	Model Segmentation	
3	13:35	13:45	00:10	Chatting with Administrator	
3	13:45	14:05	00:20	Looking at 3D Model	
3	14:05	14:10	00:05	Assembling Assembly	PT 5
3	14:10	14:23	00:13	Looking at 3D Model	
3	14:23	14:57	00:34	Assembling Assembly	
3	14:57	15:20	00:23	Adjusting Clips	
3	15:20	15:29	00:09	Adjusting Assembly	
3	15:29	16:12	00:43	Chatting with Administrator	
4	16:12	17:09	00:57	Scan Acquisition	
4	17:09	17:17	00:08	Chatting with Administrator	
4	17:17	19:00	01:43	Scan Processing	
4	19:00	19:20	00:20	Chatting with Administrator	
4	19:20	19:30	00:10	Scan Processing	
4	19:30	19:40	00:10	Output Analysis	
4	19:40	20:00	00:20	Chatting with Administrator	
4	20:00	20:30	00:30	Manipulating Stands	
4	20:30	21:51	01:21	Adjusting Clips	
4	21:51	22:07	00:16	Completing Rework	dis 4
4	22:07	22:12	00:05	Looking at 3D Model	ass 4
4	22:12	22:28	00:16	Completing Rework	
4	22:28	22:30	00:02	Looking at 3D Model	
4	22:30	22:46	00:16	Completing Rework	rw 4
4	22:46	23:23	00:37	Chatting with Administrator	
4	23:23	23:57	00:34	Looking at 3D Model	
4	23:57	24:07	00:10	Assembling Assembly	
4	24:07	24:39	00:32	Completing Rework	rw 4
4	24:39	24:45	00:06	Looking at 3D Model	
4	24:45	25:00	00:15	Chatting with Administrator	
4	25:00	25:15	00:15	Manipulating Stands	
4	25:15	25:37	00:22	Looking at 3D Model	
4	25:37	26:11	00:34	Completing Rework	rw 4
4	26:11	27:13	01:02	Adjusting Clips	
4	27:13	27:53	00:40	Chatting with Administrator	bad scan
4	27:53	28:42	00:49	Chatting with Administrator	bad scan
5	28:42	29:50	01:08	Scan Acquisition	
5	29:50	30:20	00:30	Scan Processing	
5	30:20	30:39	00:19	Chatting with Administrator	
5	30:39	31:15	00:36	Scan Processing	

Totals	
Chatting with Administrator	21:44
Assembling Assembly	02:00
Adjusting Clips	06:39
Measuring Assembly	00:00
Checking Assembly	00:00
Manipulating Stands	04:04
Adjusting Assembly	00:40
Assembly Layout	00:00
Looking at Drawing	00:00
Completing Rework	06:16
Model Segmentation	01:54
Looking at 3D Model	09:17
Scan Acquisition	09:23
Scan Processing	19:31
Output Analysis	02:34
Total	1:24:02

5	31:15	31:30	00:15	Output Analysis	
5	31:30	31:44	00:14	Looking at 3D Model	
5	31:44	32:08	00:24	Adjusting Clips	
5	32:08	32:23	00:15	Completing Rework	
5	32:23	32:30	00:07	Looking at 3D Model	
5	32:30	32:40	00:10	Manipulating Stands	
5	32:40	32:47	00:07	Looking at 3D Model	
5	32:47	33:00	00:13	Chatting with Administrator	
5	33:00	33:38	00:38	Manipulating Stands	
5	33:38	34:08	00:30	Chatting with Administrator	
5	34:08	34:25	00:17	Adjusting Clips	
5	34:25	34:35	00:10	Chatting with Administrator	
5	34:35	35:34	00:59	Adjusting Clips	
5	35:34	35:53	00:19	Completing Rework	
5	35:53	36:20	00:27	Looking at 3D Model	
5	36:20	36:27	00:07	Completing Rework	
5	36:27	37:00	00:33	Looking at 3D Model	
5	37:00	37:38	00:38	Adjusting Clips	
5	37:38	37:45	00:07	Completing Rework	
5	37:45	37:56	00:11	Adjusting Clips	
5	37:56	38:08	00:12	Manipulating Stands	
5	38:08	38:29	00:21	Model Segmentation	
6	38:29	39:07	00:38	Scan Acquisition	
6	39:07	41:40	02:33	Scan Processing	
6	41:40	41:58	00:18	Output Analysis	
6	41:58	42:46	00:48	Looking at 3D Model	
6	42:46	43:05	00:19	Chatting with Administrator	
6	43:05	43:32	00:27	Chatting with Administrator	
6	43:32	43:46	00:14	Adjusting Clips	
6	43:46	44:25	00:39	Completing Rework	RW 2
6	44:25	44:36	00:11	Adjusting Clips	
6	44:36	45:00	00:24	Chatting with Administrator	
6	45:00	45:18	00:18	Adjusting Clips	
7	45:18	45:54	00:36	Scan Acquisition	
7	45:54	46:45	00:51	Scan Processing	
7	46:45	47:00	00:15	Chatting with Administrator	about rotation
7	47:00	48:01	01:01	Scan Processing	
7	48:01	48:09	00:08	Output Analysis	
7	48:09	48:30	00:21	Model Segmentation	
7	48:30	49:10	00:40	Looking at 3D Model	
7	49:10	49:30	00:20	Manipulating Stands	
7	49:30	49:43	00:13	Assembling Assembly	
7	49:43	49:52	00:09	Manipulating Stands	
7	49:52	50:10	00:18	Assembling Assembly	
7	50:10	51:00	00:50	Chatting with Administrator	
7	51:00	51:47	00:47	Chatting with Administrator	bad scan
7	51:47	51:58	00:11	Chatting with Administrator	
7	51:58	53:02	01:04	Chatting with Administrator	bad scan
8	53:02	53:35	00:33	Scan Acquisition	
8	53:35	54:09	00:34	Chatting with Administrator	
8	54:09	55:31	01:22	Scan Processing	
8	55:31	56:50	01:19	Chatting with Administrator	CRASH
8	56:50	56:57	00:07	Output Analysis	
8	56:57	57:20	00:23	Looking at 3D Model	
8	57:20	57:38	00:18	Chatting with Administrator	
8	57:38	57:50	00:12	Looking at 3D Model	
8	57:50	58:20	00:30	Completing Rework	RW 4
8	58:20	58:40	00:20	Chatting with Administrator	
8	58:40	59:38	00:58	Looking at 3D Model	
8	59:38	59:58	00:20	Completing Rework	
8	59:58	1:00:22	00:24	Manipulating Stands	
9	1:00:22	1:01:02	00:40	Scan Acquisition	
9	1:01:02	1:01:54	00:52	Scan Processing	
9	1:01:54	1:02:20	00:26	Output Analysis	
9	1:02:20	1:02:40	00:20	Completing Rework	RW 4
9	1:02:40	1:02:50	00:10	Manipulating Stands	
9	1:02:50	1:03:10	00:20	Chatting with Administrator	
10	1:03:10	1:03:57	00:47	Scan Acquisition	
10	1:03:57	1:04:20	00:23	Scan Processing	
10	1:04:20	1:04:49	00:29	Chatting with Administrator	
10	1:04:49	1:05:15	00:26	Scan Processing	

10	1:05:15	1:05:28	00:13	Output Analysis	
10	1:05:28	1:06:07	00:39	Looking at 3D Model	
10	1:06:07	1:06:23	00:16	Completing Rework	RW 4
10	1:06:23	1:06:30	00:07	Manipulating Stands	
10	1:06:30	1:07:05	00:35	Completing Rework	
10	1:07:05	1:07:15	00:10	Looking at 3D Model	
10	1:07:15	1:07:53	00:38	Manipulating Stands	
10	1:07:53	1:08:38	00:45	Chatting with Administrator	
10	1:08:38	1:09:30	00:52	Chatting with Administrator	
10	1:09:30	1:09:37	00:07	Chatting with Administrator	
11	1:09:37	1:10:23	00:46	Scan Acquisition	
11	1:10:23	1:11:02	00:39	Scan Processing	
11	1:11:02	1:11:07	00:05	Output Analysis	
11	1:11:07	1:11:36	00:29	Chatting with Administrator	
11	1:11:36	1:11:45	00:09	Completing Rework	RW 4
12	1:11:45	1:12:08	00:23	Scan Acquisition	
12	1:12:08	1:12:48	00:40	Scan Processing	
12	1:12:48	1:12:56	00:08	Output Analysis	
12	1:12:56	1:13:17	00:21	Chatting with Administrator	
12	1:13:17	1:13:26	00:09	Looking at 3D Model	
12	1:13:26	1:13:30	00:04	Completing Rework	RW 4
12	1:13:30	1:13:46	00:16	Chatting with Administrator	
12	1:13:46	1:13:58	00:12	Model Segmentation	
12	1:13:58	1:14:46	00:48	Looking at 3D Model	
12	1:14:46	1:14:49	00:03	Manipulating Stands	
12	1:14:49	1:15:15	00:26	Looking at 3D Model	
12	1:15:15	1:15:30	00:15	Assembling Assembly	
12	1:15:30	1:15:40	00:10	Looking at 3D Model	
12	1:15:40	1:15:52	00:12	Adjusting Assembly	
12	1:15:52	1:16:07	00:15	Looking at 3D Model	
13	1:16:07	1:16:46	00:39	Scan Acquisition	
13	1:16:46	1:17:35	00:49	Scan Processing	
13	1:17:35	1:17:49	00:14	Output Analysis	
13	1:17:49	1:18:15	00:26	Completing Rework	RW 1 RW 4
13	1:18:15	1:18:25	00:10	Manipulating Stands	
14	1:18:25	1:18:56	00:31	Scan Acquisition	
14	1:18:56	1:20:00	01:04	Scan Processing	
14	1:20:00	1:20:13	00:13	Chatting with Administrator	
14	1:20:13	1:21:28	01:15	Chatting with Administrator	
14	1:21:28	1:21:46	00:18	Manipulating Stands	
14	1:21:46	1:22:08	00:22	Chatting with Administrator	
14	1:22:08	1:23:00	00:52	Scan Processing	
14	1:23:00	1:23:40	00:40	Chatting with Administrator	CRASH
14	1:23:40	1:23:58	00:18	Scan Processing	
14	1:23:58	1:24:02	00:04	Output Analysis	

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:45	00:45	Chatting with Administrator	
1	00:45	01:00	00:15	Model Segmentation	
1	01:00	01:15	00:15	Looking at 3D Model	
1	01:15	01:35	00:20	Assembling Assembly	pt 2
1	01:35	01:50	00:15	Looking at Drawing	
1	01:50	03:00	01:10	Chatting with Administrator	
1	03:00	03:10	00:10	Assembling Assembly	
2	03:10	03:44	00:34	Scan Acquisition	
2	03:44	05:20	01:36	Scan Processing	.
2	05:20	05:25	00:05	Output Analysis	
2	05:25	05:47	00:22	Model Segmentation	
2	05:47	06:12	00:25	Assembling Assembly	pt 4
2	06:12	06:20	00:08	Looking at Drawing	
2	06:20	06:25	00:05	Manipulating Stands	
2	06:25	06:45	00:20	Chatting with Administrator	
2	06:45	07:10	00:25	Model Segmentation	
2	07:10	07:25	00:15	Looking at 3D Model	
2	07:25	07:45	00:20	Adjusting Assembly	
2	07:45	07:58	00:13	Looking at 3D Model	
2	07:58	08:08	00:10	Adjusting Assembly	

Totals	
Chatting with Administrator	06:18
Assembling Assembly	01:05
Adjusting Clips	02:27
Measuring Assembly	00:00
Checking Assembly	00:00
Manipulating Stands	00:26
Adjusting Assembly	00:51
Assembly Layout	00:00
Looking at Drawing	00:46
Completing Rework	02:10
Model Segmentation	01:24
Looking at 3D Model	04:12
Scan Acquisition	07:12
Scan Processing	22:39
Output Analysis	05:34
Total	55:04

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2	08:08	08:10	00:02	Looking at 3D Model	
2	08:10	08:16	00:06	Adjusting Assembly	
3	08:16	09:02	00:46	Scan Acquisition	
3	09:02	11:48	02:46	Scan Processing	
3	11:48	12:12	00:24	Output Analysis	
3	12:12	12:25	00:13	Manipulating Stands	
3	12:25	12:33	00:08	Completing Rework	rw4
4	12:33	13:15	00:42	Scan Acquisition	
4	13:15	14:52	01:37	Scan Processing	
4	14:52	15:07	00:15	Output Analysis	
4	15:07	15:20	00:13	Completing Rework	
4	15:20	15:35	00:15	Chatting with Administrator	rw4
4	15:35	16:00	00:25	Adjusting Clips	
4	16:00	16:19	00:19	Looking at 3D Model	
4	16:19	16:30	00:11	Adjusting Clips	
4	16:30	16:40	00:10	Looking at 3D Model	rw2
4	16:40	16:50	00:10	Completing Rework	
4	16:50	16:55	00:05	Adjusting Clips	
4	16:55	17:25	00:30	Completing Rework	rw4 rw2
5	17:25	18:00	00:35	Scan Acquisition	
5	18:00	20:40	02:40	Scan Processing	
5	20:40	21:32	00:52	Output Analysis	
5	21:32	21:43	00:11	Completing Rework	rw1
5	21:43	21:51	00:08	Manipulating Stands	
5	21:51	22:09	00:18	Chatting with Administrator	
5	22:09	22:35	00:26	Looking at 3D Model	
6	22:35	23:13	00:38	Scan Acquisition	
6	23:13	25:20	02:07	Scan Processing	
6	25:20	25:25	00:05	Output Analysis	
6	25:25	25:33	00:08	Completing Rework	rw4
6	25:33	25:40	00:07	Chatting with Administrator	
7	25:40	26:12	00:32	Scan Acquisition	
7	26:12	27:00	00:48	Scan Processing	
7	27:00	27:28	00:28	Chatting with Administrator	
7	27:28	27:38	00:10	Scan Processing	
7	27:38	28:17	00:39	Output Analysis	
7	28:17	29:01	00:44	Adjusting Clips	
7	29:01	29:10	00:09	Looking at 3D Model	
7	29:10	29:18	00:08	Completing Rework	rw3
8	29:18	29:48	00:30	Scan Acquisition	
8	29:48	30:42	00:54	Scan Processing	
8	30:42	32:09	01:27	Chatting with Administrator	CRASH
8	32:09	32:55	00:46	Scan Processing	
8	32:55	33:16	00:21	Output Analysis	
8	33:16	33:26	00:10	Chatting with Administrator	
8	33:26	33:33	00:07	Completing Rework	rw3
9	33:33	34:00	00:27	Scan Acquisition	
9	34:00	35:30	01:30	Scan Processing	
9	35:30	36:10	00:40	Output Analysis	
9	36:10	37:00	00:50	Looking at 3D Model	
9	37:00	37:10	00:10	Chatting with Administrator	
9	37:10	37:25	00:15	Completing Rework	st1
10	37:25	37:50	00:25	Scan Acquisition	
10	37:50	39:00	01:10	Scan Processing	
10	39:00	39:36	00:36	Output Analysis	
10	39:36	39:44	00:08	Completing Rework	rw1
11	39:44	40:16	00:32	Scan Acquisition	
11	40:16	41:17	01:01	Scan Processing	
11	41:17	42:00	00:43	Output Analysis	
11	42:00	43:02	01:02	Adjusting Clips	
11	43:02	43:25	00:23	Looking at Drawing	
11	43:25	43:40	00:15	Looking at 3D Model	
11	43:40	43:50	00:10	Assembling Assembly	pt 5
11	43:50	44:25	00:35	Looking at 3D Model	
11	44:25	44:30	00:05	Adjusting Assembly	
11	44:30	44:40	00:10	Looking at 3D Model	
11	44:40	44:50	00:10	Adjusting Assembly	
11	44:50	45:23	00:33	Looking at 3D Model	
11	45:23	45:45	00:22	Model Segmentation	
12	45:45	46:10	00:25	Scan Acquisition	
12	46:10	47:50	01:40	Scan Processing	

Cycle	Start	End	Duration	Category	Note
12	47:50	48:03	00:13	Output Analysis	
12	48:03	48:09	00:06	Completing Rework	rw5
13	48:09	48:46	00:37	Scan Acquisition	
13	48:46	51:25	02:39	Scan Processing	(screwey)
13	51:25	52:29	01:04	Chatting with Administrator	(crash)
13	52:29	52:58	00:29	Scan Processing	
13	52:58	53:34	00:36	Output Analysis	
13	53:34	53:40	00:06	Completing Rework	rw5
14	53:40	54:09	00:29	Scan Acquisition	
14	54:09	54:55	00:46	Scan Processing	
14	54:55	55:00	00:05	Output Analysis	
14	55:00	55:04	00:04	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:11	02:11	Chatting with Administrator	
1	02:11	02:23	00:12	Looking at 3D Model	
1	02:23	02:48	00:25	Assembling Assembly	Piecing together parts 2
1	02:48	02:52	00:04	Looking at 3D Model	
1	02:52	03:41	00:49	Assembling Assembly	pieces 4 5
1	03:41	03:56	00:15	Looking at 3D Model	
1	03:56	04:06	00:10	Looking at Drawing	
1	04:06	04:37	00:31	Measuring Assembly	
1	04:37	04:47	00:10	Assembling Assembly	Adjusting orientation
1	04:47	04:57	00:10	Looking at Drawing	
1	04:57	05:01	00:04	Assembling Assembly	Adjusting orientation
1	05:01	05:13	00:12	Looking at Drawing	
1	05:13	05:30	00:17	Measuring Assembly	
1	05:30	05:33	00:03	Assembling Assembly	
1	05:33	05:41	00:08	Chatting with Administrator	Clarifying drawing info
1	05:41	05:50	00:09	Assembling Assembly	Adjusting orientation
1	05:50	05:56	00:06	Measuring Assembly	
1	05:56	06:01	00:05	Assembling Assembly	
1	06:01	06:05	00:04	Looking at Drawing	
1	06:05	06:17	00:12	Looking at 3D Model	
1	06:17	06:25	00:08	Looking at Drawing	
1	06:25	07:15	00:50	Assembling Assembly	
1	07:15	07:19	00:04	Adjusting Clips	Tightening clip on elbow 1
1	07:19	07:21	00:02	Looking at 3D Model	
1	07:21	07:30	00:09	Assembling Assembly	
1	07:30	07:46	00:16	Chatting with Administrator	
1	07:46	08:02	00:16	Assembling Assembly	
1	08:02	08:10	00:08	Chatting with Administrator	
1	08:10	08:13	00:03	Assembling Assembly	
1	08:13	08:18	00:05	Looking at Drawing	
1	08:18	08:30	00:12	Assembling Assembly	
1	08:30	08:38	00:08	Chatting with Administrator	
1	08:38	08:41	00:03	Looking at Drawing	
1	08:41	09:21	00:40	Assembling Assembly	
1	09:21	09:30	00:09	Looking at Drawing	
1	09:30	09:37	00:07	Assembling Assembly	
1	09:37	09:50	00:13	Looking at 3D Model	
1	09:50	10:01	00:11	Assembling Assembly	Observing Assembly
1	10:01	10:11	00:10	Looking at Drawing	
1	10:11	10:14	00:03	Assembling Assembly	Moving the entire assembly
1	10:14	10:25	00:11	Checking Assembly	Observing Assembly
1	10:25	10:30	00:05	Measuring Assembly	
1	10:30	10:33	00:03	Looking at Drawing	
1	10:33	10:42	00:09	Measuring Assembly	
1	10:42	10:48	00:06	Adjusting Assembly	
1	10:48	10:51	00:03	Looking at Drawing	
1	10:51	10:56	00:05	Adjusting Assembly	
1	10:56	11:00	00:04	Checking Assembly	Observing Assembly
1	11:00	11:41	00:41	Chatting with Administrator	Explaination of scanning process
2	11:41	12:40	00:59	Scan Acquisition	
2	12:40	12:48	00:08	Chatting with Administrator	Idle time
2	12:48	14:28	01:40	Scan Processing	
2	14:28	14:52	00:24	Output Analysis	

Totals	
Chatting with Administrator	09:07
Assembling Assembly	04:16
Adjusting Clips	00:12
Measuring Assembly	01:08
Checking Assembly	00:24
Manipulating Stands	00:38
Adjusting Assembly	00:11
Assembly Layout	00:00
Looking at Drawing	01:17
Completing Rework	05:55
Model Segmentation	00:00
Looking at 3D Model	07:04
Scan Acquisition	09:46
Scan Processing	36:50
Output Analysis	03:59
Total	1:20:47

2	14:52	14:57	00:05	Completing Rework	RW 1
2	14:57	15:01	00:04	Looking at 3D Model	
2	15:01	15:25	00:24	Completing Rework	RW 1
2	15:25	15:41	00:16	Looking at 3D Model	
2	15:41	15:45	00:04	Completing Rework	RW 1
2	15:45	16:06	00:21	Looking at 3D Model	
2	16:06	16:10	00:04	Chatting with Administrator	
2	16:10	16:35	00:25	Chatting with Administrator	Ready for second scan
3	16:35	17:15	00:40	Scan Acquisition	
3	17:15	19:45	02:30	Scan Processing	
3	19:45	19:55	00:10	Chatting with Administrator	
3	19:55	20:07	00:12	Output Analysis	
3	20:07	20:12	00:05	Completing Rework	RW 1
3	20:12	20:25	00:13	Looking at 3D Model	
3	20:25	20:42	00:17	Chatting with Administrator	Computer fell
3	20:42	21:04	00:22	Looking at 3D Model	
3	21:04	21:14	00:10	Completing Rework	RW 2
3	21:14	21:27	00:13	Looking at 3D Model	
3	21:27	21:54	00:27	Completing Rework	RW 1
3	21:54	21:58	00:04	Checking Assembly	Idle time; getting ready for scan
4	21:58	22:25	00:27	Scan Acquisition	
4	22:25	24:20	01:55	Scan Processing	
4	24:20	24:35	00:15	Output Analysis	
4	24:35	25:05	00:30	Looking at 3D Model	
4	25:05	25:16	00:11	Chatting with Administrator	
4	25:16	25:38	00:22	Completing Rework	RW 2
4	25:38	25:46	00:08	Completing Rework	RW 3
4	25:46	25:59	00:13	Manipulating Stands	Placing assembly on stand
4	25:59	26:04	00:05	Checking Assembly	Idle time; getting ready for scan
5	26:04	26:52	00:48	Scan Acquisition	
5	26:52	29:50	02:58	Scan Processing	Did not proceed to scan overlain
5	29:50	30:04	00:14	Completing Rework	RW 2
5	30:04	30:08	00:04	Looking at 3D Model	App still in the scan process step
5	30:08	30:16	00:08	Completing Rework	RW 2
5	30:16	30:29	00:13	Chatting with Administrator	Idle time; getting ready for scan
6	30:29	30:54	00:25	Scan Acquisition	
6	30:54	32:07	01:13	Scan Processing	
6	32:07	32:14	00:07	Output Analysis	RW 2
6	32:14	32:20	00:06	Completing Rework	
6	32:20	32:40	00:20	Manipulating Stands	
6	32:40	32:45	00:05	Chatting with Administrator	Idle time; getting ready for scan
7	32:45	33:12	00:27	Scan Acquisition	
7	33:12	35:17	02:05	Scan Processing	Did not proceed to scan overlain
7	35:17	35:24	00:07	Completing Rework	RW 3
7	35:24	35:29	00:05	Looking at 3D Model	App still in the scan process step
7	35:29	35:34	00:05	Completing Rework	RW 5
7	35:34	36:10	00:36	Looking at 3D Model	App still in the scan process step
7	36:10	36:22	00:12	Chatting with Administrator	Idle time; getting ready for scan
8	36:22	36:46	00:24	Scan Acquisition	
8	36:46	40:29	03:43	Scan Processing	
8	40:29	40:41	00:12	Output Analysis	
8	40:41	40:45	00:04	Completing Rework	RW 5
8	40:45	40:58	00:13	Looking at 3D Model	Relooking at scan overlain
8	40:58	41:17	00:19	Completing Rework	RW 1
8	41:17	41:27	00:10	Chatting with Administrator	Idle time; getting ready for scan
9	41:27	41:51	00:24	Scan Acquisition	
9	41:51	43:20	01:29	Scan Processing	
9	43:20	43:35	00:15	Output Analysis	
9	43:35	43:43	00:08	Completing Rework	RW 1
9	43:43	43:46	00:03	Completing Rework	RW 5
9	43:46	43:49	00:03	Chatting with Administrator	Idle time; getting ready for scan
10	43:49	44:21	00:32	Scan Acquisition	
10	44:21	45:15	00:54	Scan Processing	
10	45:15	45:45	00:30	Chatting with Administrator	Program crashed, resetting app
10	45:45	46:33	00:48	Scan Processing	
10	46:33	46:45	00:12	Looking at 3D Model	
10	46:45	47:14	00:29	Output Analysis	
10	47:14	47:19	00:05	Completing Rework	RW 1
10	47:19	47:27	00:08	Looking at 3D Model	Relooking at scan overlain
10	47:27	47:45	00:18	Completing Rework	RW 1
10	47:45	47:59	00:14	Chatting with Administrator	Idle time; getting ready for scan

11	47:59	48:26	00:27	Scan Acquisition	
11	48:26	49:40	01:14	Scan Processing	
11	49:40	49:48	00:08	Output Analysis	
11	49:48	49:53	00:05	Completing Rework	RW 1
11	49:53	50:03	00:10	Looking at 3D Model	Relooking at scan overlain
11	50:03	50:10	00:07	Completing Rework	RW 4
11	50:10	50:12	00:02	Chatting with Administrator	Idle time; getting ready for scan
12	50:12	50:40	00:28	Scan Acquisition	
12	50:40	51:30	00:50	Scan Processing	
12	51:30	51:40	00:10	Output Analysis	
12	51:40	51:49	00:09	Looking at 3D Model	
12	51:49	51:53	00:04	Completing Rework	RW 1
12	51:53	51:59	00:06	Chatting with Administrator	Idle time; getting ready for scan
13	51:59	52:17	00:18	Scan Acquisition	
13	52:17	53:16	00:59	Scan Processing	
13	53:16	53:27	00:11	Output Analysis	
13	53:27	53:53	00:26	Completing Rework	RW 2
13	53:53	54:03	00:10	Looking at 3D Model	Relooking at scan overlain
13	54:03	54:07	00:04	Completing Rework	RW 1
13	54:07	54:12	00:05	Chatting with Administrator	Idle time; getting ready for scan
14	54:12	54:32	00:20	Scan Acquisition	
14	54:32	55:30	00:58	Scan Processing	
14	55:30	55:45	00:15	Output Analysis	
14	55:45	55:54	00:09	Completing Rework	RW 2
14	55:54	56:14	00:20	Looking at 3D Model	Relooking at scan overlain
15	56:14	56:33	00:19	Scan Acquisition	
15	56:33	57:18	00:45	Scan Processing	
15	57:18	57:43	00:25	Output Analysis	
15	57:43	57:59	00:16	Completing Rework	rw 2
16	57:59	58:26	00:27	Scan Acquisition	
16	58:26	59:26	01:00	Scan Processing	
16	59:26	59:30	00:04	Output Analysis	
16	59:30	59:43	00:13	Looking at 3D Model	
16	59:43	59:53	00:10	Completing Rework	RW 2
16	59:53	59:57	00:04	Chatting with Administrator	Idle time; getting ready for scan
17	59:57	1:00:18	00:21	Scan Acquisition	
17	1:00:18	1:02:24	02:06	Scan Processing	
17	1:02:24	1:02:51	00:27	Chatting with Administrator	Program crashed, resetting app
17	1:02:51	1:03:20	00:29	Scan Processing	
17	1:03:20	1:03:30	00:10	Output Analysis	
17	1:03:30	1:03:36	00:06	Looking at 3D Model	
17	1:03:36	1:03:50	00:14	Completing Rework	RW 2
17	1:03:50	1:03:58	00:08	Adjusting Clips	
17	1:03:58	1:04:05	00:07	Completing Rework	RW 2
17	1:04:05	1:04:12	00:07	Chatting with Administrator	Idle time; getting ready for scan
18	1:04:12	1:04:28	00:16	Scan Acquisition	
18	1:04:28	1:05:22	00:54	Scan Processing	Did not proceed to scan overlain
18	1:05:22	1:05:23	00:01	Output Analysis	
18	1:05:23	1:05:27	00:04	Completing Rework	RW 2
18	1:05:27	1:05:33	00:06	Chatting with Administrator	Idle time; getting ready for scan
19	1:05:33	1:05:49	00:16	Scan Acquisition	
19	1:05:49	1:07:30	01:41	Scan Processing	
19	1:07:30	1:07:40	00:10	Output Analysis	
19	1:07:40	1:08:13	00:33	Looking at 3D Model	
19	1:08:13	1:08:52	00:39	Looking at 3D Model	
19	1:08:52	1:09:01	00:09	Completing Rework	RW 5
20	1:09:01	1:09:27	00:26	Scan Acquisition	
20	1:09:27	1:10:51	01:24	Scan Processing	
20	1:10:51	1:11:06	00:15	Output Analysis	
20	1:11:06	1:11:13	00:07	Completing Rework	RW 2
20	1:11:13	1:11:40	00:27	Chatting with Administrator	Figuring out program
20	1:11:40	1:11:49	00:09	Looking at 3D Model	
20	1:11:49	1:11:57	00:08	Completing Rework	RW 2
20	1:11:57	1:12:06	00:09	Looking at 3D Model	
20	1:12:06	1:12:14	00:08	Completing Rework	RW 5
20	1:12:14	1:12:25	00:11	Chatting with Administrator	Idle time; getting ready for scan
21	1:12:25	1:12:46	00:21	Scan Acquisition	
21	1:12:46	1:14:10	01:24	Scan Processing	
21	1:14:10	1:14:21	00:11	Chatting with Administrator	Program crashed, resetting app
21	1:14:21	1:15:00	00:39	Scan Processing	
21	1:15:00	1:15:10	00:10	Output Analysis	

21	1:15:10	1:15:19	00:09	Chatting with Administrator	
21	1:15:19	1:15:29	00:10	Completing Rework	RW 3
21	1:15:29	1:15:33	00:04	Chatting with Administrator	Idle time; getting ready for scan
22	1:15:33	1:15:54	00:21	Scan Acquisition	
22	1:15:54	1:17:37	01:43	Scan Processing	
22	1:17:37	1:17:43	00:06	Output Analysis	
22	1:17:43	1:18:00	00:17	Scan Processing	
22	1:18:00	1:18:03	00:03	Completing Rework	RW 1
22	1:18:03	1:18:06	00:03	Looking at 3D Model	Relooking at scan overlain
22	1:18:06	1:18:08	00:02	Completing Rework	RW 1
22	1:18:08	1:18:25	00:17	Looking at 3D Model	Relooking at scan overlain
22	1:18:25	1:18:30	00:05	Manipulating Stands	
23	1:18:30	1:18:50	00:20	Scan Acquisition	
23	1:18:50	1:19:42	00:52	Scan Processing	
23	1:19:42	1:20:02	00:20	Scan Processing	
23	1:20:02	1:20:56	00:54	Chatting with Administrator	Participant gives up

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:37	02:37	Chatting with Administrator	
1	02:37	02:58	00:21	Looking at Drawing	
1	02:58	03:30	00:32	Chatting with Administrator	
1	03:30	03:45	00:15	Model Segmentation	
1	03:45	03:50	00:05	Chatting with Administrator	
1	03:50	04:45	00:55	Model Segmentation	
1	04:45	05:05	00:20	Looking at 3D Model	
1	05:05	05:20	00:15	Assembling Assembly	PT 2
1	05:20	05:35	00:15	Looking at Drawing	.
1	05:35	06:25	00:50	Chatting with Administrator	
1	06:25	06:35	00:10	Looking at Drawing	
1	06:35	06:59	00:24	Looking at 3D Model	
1	06:59	07:10	00:11	Looking at Drawing	
1	07:10	07:54	00:44	Chatting with Administrator	
1	07:54	09:23	01:29	Looking at Drawing	
1	09:23	09:33	00:10	Looking at 3D Model	
1	09:33	10:00	00:27	Measuring Assembly	
1	10:00	10:05	00:05	Adjusting Assembly	
1	10:05	10:10	00:05	Measuring Assembly	
1	10:10	10:13	00:03	Adjusting Assembly	
1	10:13	10:20	00:07	Measuring Assembly	
1	10:20	10:25	00:05	Adjusting Assembly	
1	10:25	10:32	00:07	Measuring Assembly	
1	10:32	10:44	00:12	Looking at 3D Model	
1	10:44	11:07	00:23	Looking at Drawing	
1	11:07	11:32	00:25	Chatting with Administrator	
1	11:32	12:10	00:38	Chatting with Administrator	BAD SCAN
1	12:10	12:19	00:09	Chatting with Administrator	
1	12:19	13:35	01:16	Scan Processing	
2	13:35	14:15	00:40	Scan Acquisition	
2	14:15	15:40	01:25	Scan Processing	
2	15:40	15:49	00:09	Output Analysis	
2	15:49	15:55	00:06	Chatting with Administrator	
2	15:55	16:01	00:06	Output Analysis	
2	16:01	16:06	00:05	Checking Assembly	
3	16:06	16:57	00:51	Scan Acquisition	
3	16:57	17:17	00:20	Chatting with Administrator	
3	17:17	18:18	01:01	Scan Processing	
3	18:18	18:20	00:02	Output Analysis	
3	18:20	19:00	00:40	Adjusting Clips	
3	19:00	19:30	00:30	Model Segmentation	
3	19:30	19:50	00:20	Looking at 3D Model	
3	19:50	20:12	00:22	Assembling Assembly	PT 3
3	20:12	20:55	00:43	Looking at 3D Model	
3	20:55	21:12	00:17	Chatting with Administrator	
3	21:12	21:40	00:28	Looking at 3D Model	
3	21:40	21:52	00:12	Adjusting Assembly	
3	21:52	22:00	00:08	Looking at 3D Model	
3	22:00	22:05	00:05	Adjusting Assembly	
3	22:05	22:25	00:20	Looking at 3D Model	

Totals	
Chatting with Administrator	11:26
Assembling Assembly	00:55
Adjusting Clips	01:25
Measuring Assembly	00:46
Checking Assembly	00:05
Manipulating Stands	00:28
Adjusting Assembly	00:46
Assembly Layout	00:00
Looking at Drawing	02:49
Completing Rework	01:25
Model Segmentation	02:24
Looking at 3D Model	10:12
Scan Acquisition	06:12
Scan Processing	14:28
Output Analysis	02:39
Total	56:00

Cycle	Start	End	Duration	Category	Note
3	22:25	22:35	00:10	Chatting with Administrator	
3	22:35	22:48	00:13	Manipulating Stands	
4	22:48	23:35	00:47	Scan Acquisition	
4	23:35	24:20	00:45	Chatting with Administrator	
4	24:20	25:30	01:10	Scan Processing	
4	25:30	25:47	00:17	Chatting with Administrator	
4	25:47	26:05	00:18	Scan Processing	
4	26:05	26:30	00:25	Output Analysis	
4	26:30	26:50	00:20	Looking at 3D Model	
4	26:50	27:10	00:20	Completing Rework	
4	27:10	27:22	00:12	Chatting with Administrator	rw4
4	27:22	28:40	01:18	Looking at 3D Model	
4	28:40	28:50	00:10	Completing Rework	rw4
4	28:50	29:00	00:10	Looking at 3D Model	
4	29:00	29:22	00:22	Chatting with Administrator	
4	29:22	30:46	01:24	Scan Processing	Rematching last scan
4	30:46	31:38	00:52	Output Analysis	
5	31:38	32:30	00:52	Scan Acquisition	
5	32:30	34:20	01:50	Scan Processing	
5	34:20	34:40	00:20	Output Analysis	
5	34:40	0:35:03	00:23	Looking at 3D Model	
5	35:03	36:26	01:23	Chatting with Administrator	
5	36:26	37:15	00:49	Looking at 3D Model	
5	37:15	37:36	00:21	Completing Rework	rw4
6	37:36	38:15	00:39	Scan Acquisition	
6	38:15	39:45	01:30	Scan Processing	
6	39:45	39:50	00:05	Output Analysis	
6	39:50	40:00	00:10	Chatting with Administrator	
6	40:00	40:45	00:45	Adjusting Clips	
6	40:45	41:30	00:45	Looking at 3D Model	
6	41:30	41:40	00:10	Assembling Assembly	PT 5
6	41:40	41:55	00:15	Manipulating Stands	
6	41:55	42:03	00:08	Assembling Assembly	
6	42:03	42:33	00:30	Looking at 3D Model	
6	42:33	42:39	00:06	Adjusting Assembly	
6	42:39	43:00	00:21	Looking at 3D Model	
6	43:00	43:10	00:10	Adjusting Assembly	
6	43:10	43:54	00:44	Model Segmentation	
7	43:54	44:47	00:53	Scan Acquisition	
7	44:47	45:18	00:31	Scan Processing	
7	45:18	46:42	01:24	Chatting with Administrator	CRASH
7	46:42	48:00	01:18	Scan Processing	
7	48:00	48:10	00:10	Output Analysis	
7	48:10	48:51	00:41	Looking at 3D Model	rw5
7	48:51	49:05	00:14	Completing Rework	
8	49:05	49:50	00:45	Scan Acquisition	
8	49:50	50:50	01:00	Scan Processing	
8	50:50	51:00	00:10	Output Analysis	
8	51:00	52:30	01:30	Looking at 3D Model	
8	52:30	52:40	00:10	Completing Rework	nothing
8	52:40	53:00	00:20	Looking at 3D Model	
8	53:00	53:20	00:20	Output Analysis	
8	53:20	53:30	00:10	Completing Rework	rw5
9	53:30	54:15	00:45	Scan Acquisition	
9	54:15	56:00	01:45	Scan Processing	

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:56	02:56	Chatting with Administrator	
1	02:56	03:31	00:35	Assembling Assembly	
1	03:31	03:55	00:24	Adjusting Clips	
1	03:55	04:05	00:10	Looking at Drawing	
1	04:05	04:20	00:15	Assembling Assembly	
1	04:20	04:30	00:10	Chatting with Administrator	
1	04:30	05:30	01:00	Looking at 3D Model	
1	05:30	05:40	00:10	Looking at Drawing	
1	05:40	06:17	00:37	Assembling Assembly	pt 2 4
1	06:17	06:22	00:05	Adjusting Clips	
1	06:22	06:45	00:23	Looking at Drawing	

Totals	
Chatting with Administrator	07:35
Assembling Assembly	01:58
Adjusting Clips	04:17
Measuring Assembly	00:00
Checking Assembly	00:00
Manipulating Stands	01:03
Adjusting Assembly	00:00
Assembly Layout	00:00
Looking at Drawing	01:00
Completing Rework	01:17

1	06:45	07:30	00:45	Model Segmentation			Model Segmentation	00:55
1	07:30	07:45	00:15	Looking at 3D Model			Looking at 3D Model	02:26
1	07:45	08:20	00:35	Chatting with Administrator			Scan Acquisition	07:00
2	08:20	09:09	00:49	Scan Acquisition			Scan Processing	12:00
2	09:09	12:47	03:38	Scan Processing			Output Analysis	01:27
2	12:47	12:57	00:10	Output Analysis			Total	40:58
2	12:57	13:10	00:13	Chatting with Administrator				
2	13:10	13:22	00:12	Adjusting Clips				
2	13:22	13:42	00:20	Completing Rework	rw1			
2	13:42	14:00	00:18	Looking at 3D Model				
2	14:00	14:20	00:20	Completing Rework	rw1			
2	14:20	14:50	00:30	Adjusting Clips				
2	14:50	15:10	00:20	Looking at 3D Model				
2	15:10	15:27	00:17	Looking at Drawing				
2	15:27	15:58	00:31	Assembling Assembly	pt 5			
2	15:58	16:20	00:22	Adjusting Clips				
2	16:20	16:40	00:20	Manipulating Stands				
2	16:40	17:05	00:25	Looking at 3D Model				
2	17:05	17:15	00:10	Model Segmentation				
2	17:15	17:31	00:16	Manipulating Stands				
2	17:31	18:20	00:49	Chatting with Administrator				
2	18:20	18:40	00:20	Scan Processing				
3	18:40	20:15	01:35	Scan Acquisition	Rescan			
3	20:15	21:59	01:44	Scan Processing				
3	21:59	22:10	00:11	Output Analysis				
3	22:10	22:25	00:15	Chatting with Administrator				
3	22:25	22:33	00:08	Looking at 3D Model				
3	22:33	22:42	00:09	Adjusting Clips				
3	22:42	22:52	00:10	Completing Rework	rw2			
3	22:52	23:15	00:23	Adjusting Clips				
3	23:15	23:20	00:05	Completing Rework	rw2			
3	23:20	23:37	00:17	Adjusting Clips				
3	23:37	24:10	00:33	Chatting with Administrator				
4	24:10	24:58	00:48	Scan Acquisition				
4	24:58	26:25	01:27	Scan Processing				
4	26:25	26:30	00:05	Output Analysis				
4	26:30	26:52	00:22	Adjusting Clips				
4	26:52	26:58	00:06	Completing Rework	rw1			
4	26:58	27:17	00:19	Adjusting Clips				
5	27:17	28:14	00:57	Scan Acquisition				
5	28:14	28:30	00:16	Chatting with Administrator				
5	28:30	29:45	01:15	Scan Processing				
5	29:45	29:55	00:10	Output Analysis				
5	29:55	30:16	00:21	Adjusting Clips				
5	30:16	0:30:22	00:06	Completing Rework	rw1			
5	30:22	30:44	00:22	Adjusting Clips				
5	30:44	30:55	00:11	Manipulating Stands				
6	30:55	32:10	01:15	Scan Acquisition				
6	32:10	33:20	01:10	Scan Processing				
6	33:20	33:40	00:20	Output Analysis				
6	33:40	33:50	00:10	Chatting with Administrator				
6	33:50	34:00	00:10	Manipulating Stands				
7	34:00	34:38	00:38	Scan Acquisition				
7	34:38	35:40	01:02	Scan Processing				
7	35:40	35:50	00:10	Output Analysis				
7	35:50	36:21	00:31	Chatting with Administrator				
7	36:21	36:35	00:14	Output Analysis				
7	36:35	36:50	00:15	Adjusting Clips				
7	36:50	37:00	00:10	Completing Rework	rw1			
7	37:00	0:37:16	00:16	Adjusting Clips				
7	37:16	37:22	00:06	Manipulating Stands				
8	37:22	38:20	00:58	Scan Acquisition				
8	38:20	39:05	00:45	Chatting with Administrator				
8	39:05	40:29	01:24	Scan Processing				
8	40:29	40:36	00:07	Output Analysis				
8	40:36	40:58	00:22	Chatting with Administrator				

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:52	02:52	Chatting with Administrator	
1	02:52	03:22	00:30	Model Segmentation	
1	03:22	03:32	00:10	Chatting with Administrator	
1	03:32	03:42	00:10	Assembling Assembly	pt 2 *
1	03:42	03:55	00:13	Looking at 3D Model	
1	03:55	04:10	00:15	Adjusting Assembly	
1	04:10	04:20	00:10	Looking at 3D Model	
1	04:20	04:26	00:06	Model Segmentation	
1	04:26	05:15	00:49	Looking at Drawing	.
1	05:15	05:33	00:18	Chatting with Administrator	
1	05:33	05:55	00:22	Looking at Drawing	
1	05:55	06:12	00:17	Chatting with Administrator	
1	06:12	07:42	01:30	Looking at Drawing	
1	07:42	08:02	00:20	Looking at 3D Model	
1	08:02	08:15	00:13	Looking at Drawing	
1	08:15	08:40	00:25	Chatting with Administrator	
1	08:40	09:15	00:35	Looking at 3D Model	
1	09:15	11:25	02:10	Chatting with Administrator	
1	11:25	11:40	00:15	Looking at Drawing	
1	11:40	12:22	00:42	Manipulating Stands	
1	12:22	12:50	00:28	Measuring Assembly	
1	12:50	13:15	00:25	Adjusting Clips	
1	13:15	13:45	00:30	Manipulating Stands	
1	13:45	13:59	00:14	Chatting with Administrator	
1	13:59	14:13	00:14	Measuring Assembly	
1	14:13	14:22	00:09	Manipulating Stands	
1	14:22	14:33	00:11	Measuring Assembly	
1	14:33	15:10	00:37	Chatting with Administrator	
2	15:10	16:04	00:54	Scan Acquisition	
2	16:04	17:00	00:56	Scan Processing	
2	17:00	17:15	00:15	Output Analysis	
2	17:15	17:40	00:25	Chatting with Administrator	
2	17:40	18:13	00:33	Model Segmentation	
2	18:13	18:40	00:27	Looking at 3D Model	
2	18:40	19:10	00:30	Assembling Assembly	pt 3
2	19:10	19:27	00:17	Looking at 3D Model	
2	19:27	19:45	00:18	Adjusting Assembly	
2	19:45	20:45	01:00	Looking at Drawing	
2	20:45	24:17	03:32	Measuring Assembly	
2	24:17	24:27	00:10	Adjusting Clips	
2	24:27	24:32	00:05	Adjusting Assembly	
2	24:32	24:40	00:08	Measuring Assembly	
2	24:40	24:45	00:05	Adjusting Clips	
2	24:45	25:00	00:15	Looking at Drawing	
2	25:00	25:40	00:40	Measuring Assembly	
2	25:40	26:40	01:00	Looking at 3D Model	
2	26:40	27:45	01:05	Manipulating Stands	
2	27:45	27:53	00:08	Looking at 3D Model	
2	27:53	28:30	00:37	Looking at Drawing	
2	28:30	29:00	00:30	Measuring Assembly	
2	29:00	29:20	00:20	Chatting with Administrator	
2	29:20	29:40	00:20	Adjusting Clips	
2	29:40	29:49	00:09	Adjusting Assembly	
2	29:49	30:20	00:31	Adjusting Clips	
2	30:20	31:00	00:40	Looking at Drawing	
2	31:00	31:25	00:25	Measuring Assembly	
2	31:25	31:42	00:17	Adjusting Clips	
2	31:42	31:48	00:06	Measuring Assembly	
2	31:48	31:54	00:06	Adjusting Assembly	
2	31:54	32:00	00:06	Measuring Assembly	
2	32:00	32:10	00:10	Adjusting Assembly	
2	32:10	32:28	00:18	Measuring Assembly	
2	32:28	32:45	00:17	Adjusting Assembly	
2	32:45	33:00	00:15	Looking at 3D Model	
2	33:00	33:05	00:05	Adjusting Assembly	
2	33:05	33:20	00:15	Measuring Assembly	
2	33:20	33:42	00:22	Adjusting Assembly	

Totals	
Chatting with Administrator	09:11
Assembling Assembly	02:07
Adjusting Clips	01:56
Measuring Assembly	14:02
Checking Assembly	00:00
Manipulating Stands	02:26
Adjusting Assembly	02:51
Assembly Layout	00:00
Looking at Drawing	10:44
Completing Rework	01:14
Model Segmentation	01:19
Looking at 3D Model	08:01
Scan Acquisition	05:13
Scan Processing	09:35
Output Analysis	01:24
Total	1:10:03

2	33:42	33:46	00:04	Measuring Assembly	
2	33:46	33:55	00:09	Adjusting Assembly	
2	33:55	34:08	00:13	Looking at Drawing	
2	34:08	34:22	00:14	Measuring Assembly	
2	34:22	34:35	00:13	Looking at Drawing	
2	34:35	35:04	00:29	Measuring Assembly	
2	35:04	35:30	00:26	Looking at Drawing	
2	35:30	36:02	00:32	Measuring Assembly	
2	36:02	36:15	00:13	Looking at 3D Model	
2	36:15	36:25	00:10	Adjusting Assembly	
2	36:25	36:55	00:30	Looking at 3D Model	
2	36:55	37:05	00:10	Looking at Drawing	
2	37:05	37:45	00:40	Measuring Assembly	
2	37:45	38:40	00:55	Looking at Drawing	annotation
2	38:40	38:56	00:16	Measuring Assembly	
3	38:56	39:45	00:49	Scan Acquisition	
3	39:45	41:44	01:59	Scan Processing	
3	41:44	42:03	00:19	Output Analysis	
3	42:03	42:38	00:35	Looking at 3D Model	
3	42:38	42:55	00:17	Completing Rework	rw4
3	42:55	43:10	00:15	Looking at 3D Model	
3	43:10	43:13	00:03	Completing Rework	rw1
4	43:13	43:55	00:42	Scan Acquisition	
4	43:55	44:50	00:55	Scan Processing	
4	44:50	45:05	00:15	Output Analysis	
4	45:05	45:10	00:05	Looking at 3D Model	
4	45:10	45:20	00:10	Scan Processing	
4	45:20	45:24	00:04	Output Analysis	
4	45:24	45:35	00:11	Adjusting Assembly	
4	45:35	45:50	00:15	Looking at 3D Model	
4	45:50	45:59	00:09	Adjusting Assembly	
4	45:59	46:26	00:27	Looking at 3D Model	
5	46:26	47:05	00:39	Scan Acquisition	
5	47:05	48:40	01:35	Scan Processing	
5	48:40	48:50	00:10	Output Analysis	
5	48:50	49:00	00:10	Completing Rework	rw1
5	49:00	49:10	00:10	Chatting with Administrator	
5	49:10	50:10	01:00	Measuring Assembly	
5	50:10	50:40	00:30	Looking at Drawing	annotation
5	50:40	50:55	00:15	Chatting with Administrator	
5	50:55	51:35	00:40	Looking at Drawing	
5	51:35	52:05	00:30	Measuring Assembly	
6	52:05	52:35	00:30	Scan Acquisition	
6	52:35	53:04	00:29	Chatting with Administrator	crash
6	53:04	54:04	01:00	Scan Processing	
6	54:04	54:12	00:08	Output Analysis	
6	54:12	54:48	00:36	Looking at 3D Model	
6	54:48	54:55	00:07	Completing Rework	rw4
6	54:55	55:25	00:30	Looking at Drawing	
6	55:25	56:20	00:55	Measuring Assembly	
6	56:20	56:35	00:15	Completing Rework	rw3
6	56:35	56:50	00:15	Measuring Assembly	
6	56:50	57:00	00:10	Completing Rework	rw3
6	57:00	57:33	00:33	Measuring Assembly	
6	57:33	57:50	00:17	Looking at 3D Model	
7	57:50	58:22	00:32	Scan Acquisition	
7	58:22	59:26	01:04	Scan Processing	
7	59:26	59:30	00:04	Output Analysis	
7	59:30	59:50	00:20	Chatting with Administrator	
7	59:50	1:00:00	00:10	Model Segmentation	
7	1:00:00	1:00:10	00:10	Looking at 3D Model	
7	1:00:10	1:00:18	00:08	Adjusting Clips	
7	1:00:18	1:01:45	01:27	Assembling Assembly	pt 5
7	1:01:45	1:02:10	00:25	Looking at Drawing	
7	1:02:10	1:03:10	01:00	Measuring Assembly	
7	1:03:10	1:03:20	00:10	Adjusting Assembly	
7	1:03:20	1:03:27	00:07	Measuring Assembly	
7	1:03:27	1:03:30	00:03	Adjusting Assembly	
7	1:03:30	1:03:50	00:20	Looking at Drawing	
7	1:03:50	1:03:58	00:08	Measuring Assembly	
7	1:03:58	1:04:39	00:41	Looking at Drawing	

7	1:04:39	1:05:05	00:26	Measuring Assembly	
7	1:05:05	1:05:17	00:12	Adjusting Assembly	
7	1:05:17	1:05:40	00:23	Looking at 3D Model	
8	1:05:40	1:06:20	00:40	Scan Acquisition	
8	1:06:20	1:07:20	01:00	Scan Processing	
8	1:07:20	1:07:25	00:05	Output Analysis	
8	1:07:25	1:08:08	00:43	Looking at 3D Model	
8	1:08:08	1:08:20	00:12	Completing Rework	rw5
8	1:08:20	1:08:27	00:07	Looking at 3D Model	
9	1:08:27	1:08:54	00:27	Scan Acquisition	
9	1:08:54	1:09:50	00:56	Scan Processing	
9	1:09:50	1:09:54	00:04	Output Analysis	
9	1:09:54	1:10:03	00:09	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	03:30	03:30	Chatting with Administrator	
1	03:30	03:38	00:08	Looking at Drawing	
1	03:38	03:58	00:20	Chatting with Administrator	
1	03:58	04:09	00:11	Model Segmentation	
1	04:09	04:20	00:11	Chatting with Administrator	
1	04:20	04:29	00:09	Model Segmentation	
1	04:29	04:42	00:13	Looking at 3D Model	
1	04:42	04:46	00:04	Assembling Assembly	pt 2**
1	04:46	04:51	00:05	Looking at 3D Model	.
1	04:51	05:00	00:09	Assembling Assembly	
1	05:00	05:05	00:05	Looking at Drawing	
1	05:05	05:10	00:05	Looking at 3D Model	
1	05:10	05:15	00:05	Looking at Drawing	
1	05:15	05:32	00:17	Looking at 3D Model	
1	05:32	05:40	00:08	Looking at Drawing	
1	05:40	05:54	00:14	Looking at 3D Model	
1	05:54	06:01	00:07	Looking at Drawing	
1	06:01	06:20	00:19	Looking at 3D Model	
1	06:20	07:25	01:05	Chatting with Administrator	
2	07:25	08:09	00:44	Scan Acquisition	
2	08:09	09:45	01:36	Scan Processing	wrong
2	09:45	10:30	00:45	Scan Processing	
2	10:30	10:35	00:05	Output Analysis	
2	10:35	11:00	00:25	Chatting with Administrator	
2	11:00	11:25	00:25	Looking at Drawing	
2	11:25	11:43	00:18	Assembling Assembly	pt 3 pt 5**
2	11:43	11:58	00:15	Model Segmentation	
2	11:58	12:40	00:42	Chatting with Administrator	
2	12:40	13:15	00:35	Looking at 3D Model	
2	13:15	13:23	00:08	Adjusting Assembly	
2	13:23	13:35	00:12	Looking at 3D Model	
2	13:35	13:48	00:13	Looking at Drawing	
2	13:48	18:08	04:20	Chatting with Administrator	
2	18:08	18:50	00:42	Measuring Assembly	
2	18:50	19:33	00:43	Looking at Drawing	
2	19:33	20:15	00:42	Looking at 3D Model	
2	20:15	20:23	00:08	Model Segmentation	
2	20:23	20:35	00:12	Looking at 3D Model	
2	20:35	20:42	00:07	Assembling Assembly	5
2	20:42	21:15	00:33	Looking at 3D Model	
2	21:15	21:25	00:10	Adjusting Assembly	UNDOC RW 5
2	21:25	21:59	00:34	Model Segmentation	
2	21:59	22:38	00:39	Looking at 3D Model	
2	22:38	22:50	00:12	Adjusting Assembly	UNDOC RW 5
2	22:50	23:55	01:05	Looking at 3D Model	
2	23:55	24:04	00:09	Adjusting Assembly	
3	24:04	25:36	01:32	Scan Acquisition	
3	25:36	27:44	02:08	Scan Processing	
3	27:44	28:06	00:22	Output Analysis	
3	28:06	28:32	00:26	Looking at 3D Model	
3	28:32	28:40	00:08	Completing Rework	RW 1
3	28:40	28:50	00:10	Completing Rework	RW 5
3	28:50	29:45	00:55	Chatting with Administrator	

Totals	
Chatting with Administrator	18:55
Assembling Assembly	00:38
Adjusting Clips	01:39
Measuring Assembly	00:42
Checking Assembly	00:00
Manipulating Stands	00:00
Adjusting Assembly	00:39
Assembly Layout	00:00
Looking at Drawing	02:22
Completing Rework	03:35
Model Segmentation	01:17
Looking at 3D Model	16:15
Scan Acquisition	14:44
Scan Processing	12:56
Output Analysis	01:50
Total	1:15:32

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3	29:45	31:08	01:23	Chatting with Administrator	
3	31:08	33:30	02:22	Chatting with Administrator	
4	33:30	34:20	00:50	Scan Acquisition	
4	34:20	35:15	00:55	Scan Processing	
4	35:15	35:45	00:30	Chatting with Administrator	
4	35:45	35:55	00:10	Output Analysis	
4	35:55	36:40	00:45	Looking at 3D Model	
4	36:40	36:56	00:16	Completing Rework	RW 2
4	36:56	37:12	00:16	Looking at 3D Model	
4	37:12	37:40	00:28	Looking at Drawing	
4	37:40	38:02	00:22	Chatting with Administrator	
5	38:02	41:01	02:59	Scan Acquisition	
5	41:01	42:10	01:09	Scan Processing	
5	42:10	42:20	00:10	Output Analysis	
5	42:20	42:32	00:12	Looking at 3D Model	
5	42:32	42:40	00:08	Completing Rework	
5	42:40	42:57	00:17	Looking at 3D Model	
5	42:57	43:04	00:07	Completing Rework	RW 5
5	43:04	43:15	00:11	Looking at 3D Model	
5	43:15	43:17	00:02	Completing Rework	RW 5
5	43:17	43:48	00:31	Looking at 3D Model	
5	43:48	44:10	00:22	Completing Rework	RW 2
6	44:10	45:08	00:58	Scan Acquisition	
6	45:08	45:52	00:44	Scan Processing	
6	45:52	46:02	00:10	Output Analysis	
6	46:02	47:10	01:08	Looking at 3D Model	
6	47:10	47:14	00:04	Completing Rework	RW 1
6	47:14	47:22	00:08	Looking at 3D Model	
6	47:22	47:39	00:17	Completing Rework	RW 5
7	47:39	48:23	00:44	Scan Acquisition	
7	48:23	49:30	01:07	Chatting with Administrator	CRASH
7	49:30	49:48	00:18	Scan Processing	
7	49:48	50:01	00:13	Output Analysis	
7	50:01	50:11	00:10	Looking at 3D Model	
7	50:11	50:18	00:07	Completing Rework	RW 5
7	50:18	50:28	00:10	Chatting with Administrator	
7	50:28	50:33	00:05	Completing Rework	RW 1
7	50:33	50:50	00:17	Looking at 3D Model	
7	50:50	50:53	00:03	Completing Rework	RW 1
7	50:53	51:00	00:07	Chatting with Administrator	
8	51:00	52:46	01:46	Scan Acquisition	
8	52:46	53:32	00:46	Scan Processing	
8	53:32	53:40	00:08	Output Analysis	
8	53:40	54:15	00:35	Looking at 3D Model	
8	54:15	54:42	00:27	Completing Rework	RW 5
8	54:42	55:00	00:18	Looking at 3D Model	
8	55:00	55:10	00:10	Completing Rework	RW 1
8	55:10	55:20	00:10	Looking at 3D Model	
8	55:20	55:35	00:15	Completing Rework	RW 1
8	55:35	56:25	00:50	Looking at 3D Model	
8	56:25	56:35	00:10	Chatting with Administrator	
9	56:35	58:00	01:25	Scan Acquisition	
9	58:00	58:59	00:59	Scan Processing	
9	58:59	59:16	00:17	Output Analysis	
9	59:16	59:52	00:36	Looking at 3D Model	
9	59:52	59:58	00:06	Completing Rework	RW 5
9	59:58	1:00:03	00:05	Looking at 3D Model	
9	1:00:03	1:00:08	00:05	Completing Rework	RW 5
9	1:00:08	1:00:31	00:23	Looking at 3D Model	
9	1:00:31	1:01:53	01:22	Adjusting Clips	
9	1:01:53	1:02:50	00:57	Looking at 3D Model	
9	1:02:50	1:02:54	00:04	Completing Rework	RW 1
9	1:02:54	1:03:34	00:40	Looking at 3D Model	
10	1:03:34	1:04:49	01:15	Scan Acquisition	
10	1:04:49	1:05:29	00:40	Scan Processing	
10	1:05:29	1:05:34	00:05	Output Analysis	
10	1:05:34	1:05:51	00:17	Adjusting Clips	
10	1:05:51	1:06:04	00:13	Chatting with Administrator	
10	1:06:04	1:06:41	00:37	Looking at 3D Model	
10	1:06:41	1:07:10	00:29	Completing Rework	RW 5
10	1:07:10	1:07:29	00:19	Looking at 3D Model	

10	1:07:29	1:07:34	00:05	Completing Rework	RW 5
10	1:07:34	1:07:56	00:22	Chatting with Administrator	
11	1:07:56	1:08:48	00:52	Scan Acquisition	
11	1:08:48	1:09:26	00:38	Scan Processing	
11	1:09:26	1:09:30	00:04	Output Analysis	
11	1:09:30	1:09:44	00:14	Chatting with Administrator	
11	1:09:44	1:10:07	00:23	Looking at 3D Model	
11	1:10:07	1:10:10	00:03	Completing Rework	RW 5
12	1:10:10	1:11:08	00:58	Scan Acquisition	
12	1:11:08	1:11:45	00:37	Scan Processing	
12	1:11:45	1:11:47	00:02	Output Analysis	
12	1:11:47	1:12:37	00:50	Looking at 3D Model	
12	1:12:37	1:12:39	00:02	Completing Rework	RW 5
13	1:12:39	1:13:20	00:41	Scan Acquisition	
13	1:13:20	1:15:01	01:41	Scan Processing	
13	1:15:01	1:15:05	00:04	Output Analysis	
13	1:15:05	1:15:32	00:27	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	03:40	03:40	Chatting with Administrator	
1	03:40	03:48	00:08	Assembly Layout	
1	03:48	03:55	00:07	Looking at Drawing	
1	03:55	04:05	00:10	Looking at 3D Model	
1	04:05	04:10	00:05	Chatting with Administrator	
1	04:10	04:42	00:32	Looking at 3D Model	
1	04:42	04:52	00:10	Looking at Drawing	
1	04:52	05:08	00:16	Assembling Assembly	
1	05:08	05:52	00:44	Chatting with Administrator	.
1	05:52	06:16	00:24	Assembling Assembly	pt 2
1	06:16	06:46	00:30	Looking at Drawing	
1	06:46	06:52	00:06	Assembling Assembly	
1	06:52	07:00	00:08	Looking at Drawing	
1	07:00	07:53	00:53	Assembling Assembly	
1	07:53	07:57	00:04	Looking at Drawing	
1	07:57	08:05	00:08	Assembling Assembly	pt 4
1	08:05	08:56	00:51	Measuring Assembly	
1	08:56	09:04	00:08	Assembling Assembly	
1	09:04	09:10	00:06	Manipulating Stands	
1	09:10	09:16	00:06	Adjusting Clips	
1	09:16	09:36	00:20	Manipulating Stands	
1	09:36	09:40	00:04	Adjusting Clips	
1	09:40	10:05	00:25	Measuring Assembly	
1	10:05	10:16	00:11	Adjusting Clips	
1	10:16	10:23	00:07	Measuring Assembly	
1	10:23	10:32	00:09	Looking at Drawing	
1	10:32	11:01	00:29	Measuring Assembly	
1	11:01	11:09	00:08	Assembling Assembly	pt 5
1	11:09	11:11	00:02	Measuring Assembly	
1	11:11	11:20	00:09	Assembling Assembly	
1	11:20	11:35	00:15	Looking at Drawing	
1	11:35	11:40	00:05	Measuring Assembly	
1	11:40	11:51	00:11	Assembling Assembly	
1	11:51	11:59	00:08	Measuring Assembly	
1	11:59	12:32	00:33	Assembling Assembly	
1	12:32	12:41	00:09	Checking Assembly	
1	12:41	12:46	00:05	Assembly Layout	
1	12:46	12:50	00:04	Looking at Drawing	
1	12:50	12:59	00:09	Assembling Assembly	
1	12:59	13:10	00:11	Looking at Drawing	
1	13:10	13:26	00:16	Chatting with Administrator	
1	13:26	13:52	00:26	Looking at Drawing	
1	13:52	14:01	00:09	Assembling Assembly	
1	14:01	14:38	00:37	Looking at Drawing	
1	14:38	14:54	00:16	Chatting with Administrator	
1	14:54	15:00	00:06	Looking at Drawing	
1	15:00	15:15	00:15	Manipulating Stands	
1	15:15	15:28	00:13	Measuring Assembly	

Totals	
Chatting with Administrator	12:38
Assembling Assembly	05:17
Adjusting Clips	04:12
Measuring Assembly	10:46
Checking Assembly	00:22
Manipulating Stands	07:48
Adjusting Assembly	00:00
Assembly Layout	00:24
Looking at Drawing	09:46
Completing Rework	02:39
Model Segmentation	00:00
Looking at 3D Model	04:09
Scan Acquisition	19:34
Scan Processing	22:54
Output Analysis	04:12
Total	1:44:41

1	15:28	15:32	00:04	Chatting with Administrator	
1	15:32	16:46	01:14	Looking at Drawing	
1	16:46	17:17	00:31	Measuring Assembly	
1	17:17	17:26	00:09	Adjusting Clips	
1	17:26	18:05	00:39	Measuring Assembly	
1	18:05	19:18	01:13	Looking at Drawing	
1	19:18	20:00	00:42	Chatting with Administrator	
1	20:00	21:12	01:12	Looking at Drawing	
1	21:12	22:04	00:52	Chatting with Administrator	
1	22:04	22:20	00:16	Looking at Drawing	
1	22:20	22:50	00:30	Chatting with Administrator	
1	22:50	23:01	00:11	Assembly Layout	
1	23:01	23:38	00:37	Measuring Assembly	
1	23:38	24:04	00:26	Assembling Assembly	
1	24:04	24:12	00:08	Adjusting Clips	
1	24:12	24:16	00:04	Manipulating Stands	
1	24:16	24:30	00:14	Adjusting Clips	
1	24:30	24:59	00:29	Assembling Assembly	
1	24:59	25:19	00:20	Measuring Assembly	
1	25:19	25:37	00:18	Looking at Drawing	
1	25:37	25:42	00:05	Manipulating Stands	
1	25:42	25:53	00:11	Assembling Assembly	
1	25:53	26:04	00:11	Manipulating Stands	
1	26:04	26:16	00:12	Adjusting Clips	
1	26:16	26:25	00:09	Manipulating Stands	
1	26:25	26:33	00:08	Measuring Assembly	
1	26:33	26:38	00:05	Looking at Drawing	
1	26:38	26:50	00:12	Measuring Assembly	
1	26:50	26:57	00:07	Assembling Assembly	
1	26:57	27:07	00:10	Adjusting Clips	
1	27:07	27:20	00:13	Measuring Assembly	
1	27:20	27:32	00:12	Adjusting Clips	
1	27:32	27:43	00:11	Measuring Assembly	
1	27:43	27:57	00:14	Looking at Drawing	
1	27:57	28:08	00:11	Manipulating Stands	
1	28:08	28:20	00:12	Assembling Assembly	
1	28:20	28:43	00:23	Adjusting Clips	
1	28:43	29:08	00:25	Measuring Assembly	
1	29:08	30:18	01:10	Looking at Drawing	
1	30:18	30:27	00:09	Manipulating Stands	
1	30:27	30:31	00:04	Assembling Assembly	
1	30:31	31:12	00:41	Looking at Drawing	
1	31:12	31:31	00:19	Measuring Assembly	
1	31:31	31:50	00:19	Looking at Drawing	
1	31:50	32:10	00:20	Assembling Assembly	
1	32:10	32:16	00:06	Measuring Assembly	
1	32:16	32:24	00:08	Assembling Assembly	
1	32:24	32:34	00:10	Looking at Drawing	
1	32:34	32:40	00:06	Measuring Assembly	
1	32:40	32:46	00:06	Assembling Assembly	
1	32:46	32:51	00:05	Measuring Assembly	
1	32:51	32:58	00:07	Looking at Drawing	
1	32:58	33:03	00:05	Checking Assembly	
1	33:03	34:40	01:37	Chatting with Administrator	
1	34:40	34:55	00:15	Chatting with Administrator	
2	34:55	36:20	01:25	Scan Acquisition	
2	36:20	37:56	01:36	Chatting with Administrator	
2	37:56	39:00	01:04	Scan Processing	
2	39:00	39:14	00:14	Chatting with Administrator	
2	39:14	39:37	00:23	Output Analysis	
2	39:37	39:54	00:17	Completing Rework	
2	39:54	39:56	00:02	Completing Rework	RW 1
2	39:56	40:03	00:07	Adjusting Clips	
2	40:03	40:30	00:27	Measuring Assembly	
2	40:30	40:37	00:07	Manipulating Stands	
2	40:37	40:45	00:08	Checking Assembly	
3	40:45	43:03	02:18	Scan Acquisition	
3	43:03	44:27	01:24	Scan Processing	
3	44:27	44:44	00:17	Output Analysis	
3	44:44	45:00	00:16	Chatting with Administrator	
3	45:00	45:10	00:10	Looking at 3D Model	

3	45:10	45:25	00:15	Output Analysis	
3	45:25	45:30	00:05	Completing Rework	RW 1
3	45:30	45:59	00:29	Chatting with Administrator	
3	45:59	46:10	00:11	Looking at 3D Model	
3	46:10	46:12	00:02	Chatting with Administrator	
3	46:12	46:41	00:29	Measuring Assembly	
3	46:41	46:55	00:14	Looking at 3D Model	
3	46:55	47:06	00:11	Completing Rework	RW 5
4	47:06	48:10	01:04	Scan Acquisition	
4	48:10	51:50	03:40	Scan Processing	
4	51:50	51:59	00:09	Output Analysis	
4	51:59	52:09	00:10	Completing Rework	RW 5
4	52:09	52:16	00:07	Looking at 3D Model	
4	52:16	52:25	00:09	Manipulating Stands	
4	52:25	52:29	00:04	Manipulating Stands	
5	52:29	54:38	02:09	Scan Acquisition	
5	54:38	56:21	01:43	Scan Processing	
5	56:21	56:38	00:17	Output Analysis	
5	56:38	58:01	01:23	Manipulating Stands	
5	58:01	58:14	00:13	Completing Rework	RW 5
5	58:14	58:22	00:08	Looking at 3D Model	
5	58:22	58:35	00:13	Measuring Assembly	
5	58:35	58:41	00:06	Manipulating Stands	
5	58:41	59:09	00:28	Measuring Assembly	
6	59:09	1:00:26	01:17	Scan Acquisition	
6	1:00:26	1:01:57	01:31	Scan Processing	
6	1:01:57	1:02:19	00:22	Output Analysis	
6	1:02:19	1:02:31	00:12	Looking at 3D Model	
6	1:02:31	1:02:38	00:07	Output Analysis	
6	1:02:38	1:03:05	00:27	Scan Processing	
6	1:03:05	1:03:36	00:31	Output Analysis	
6	1:03:36	1:04:13	00:37	Adjusting Clips	
6	1:04:13	1:04:15	00:02	Completing Rework	RW 2
6	1:04:15	1:04:31	00:16	Manipulating Stands	
7	1:04:31	1:05:52	01:21	Scan Acquisition	
7	1:05:52	1:07:50	01:58	Scan Processing	
7	1:07:50	1:08:00	00:10	Output Analysis	
7	1:08:00	1:08:16	00:16	Looking at 3D Model	
7	1:08:16	1:08:22	00:06	Completing Rework	RW 5
7	1:08:22	1:08:39	00:17	Output Analysis	
7	1:08:39	1:08:52	00:13	Completing Rework	
7	1:08:52	1:08:56	00:04	Manipulating Stands	
7	1:08:56	1:09:19	00:23	Looking at 3D Model	
7	1:09:19	1:09:36	00:17	Chatting with Administrator	
7	1:09:36	1:09:57	00:21	Adjusting Clips	
7	1:09:57	1:10:05	00:08	Manipulating Stands	
7	1:10:05	1:10:18	00:13	Adjusting Clips	
7	1:10:18	1:10:29	00:11	Manipulating Stands	
7	1:10:29	1:12:02	01:33	Measuring Assembly	
7	1:12:02	1:12:23	00:21	Manipulating Stands	
7	1:12:23	1:12:38	00:15	Measuring Assembly	
8	1:12:38	1:14:10	01:32	Scan Acquisition	
8	1:14:10	1:16:47	02:37	Scan Processing	technical difficulty
8	1:16:47	1:17:08	00:21	Chatting with Administrator	
8	1:17:08	1:17:26	00:18	Output Analysis	
8	1:17:26	1:18:22	00:56	Manipulating Stands	
8	1:18:22	1:18:50	00:28	Measuring Assembly	
8	1:18:50	1:19:13	00:23	Manipulating Stands	
8	1:19:13	1:19:16	00:03	Completing Rework	RW 2
8	1:19:16	1:19:30	00:14	Measuring Assembly	
8	1:19:30	1:19:46	00:16	Manipulating Stands	
9	1:19:46	1:21:14	01:28	Scan Acquisition	
9	1:21:14	1:22:16	01:02	Scan Processing	
9	1:22:16	1:22:30	00:14	Output Analysis	
9	1:22:30	1:22:37	00:07	Completing Rework	RW 5
9	1:22:37	1:22:45	00:08	Looking at 3D Model	
9	1:22:45	1:23:20	00:35	Manipulating Stands	
10	1:23:20	1:24:25	01:05	Scan Acquisition	
10	1:24:25	1:25:24	00:59	Scan Processing	
10	1:25:24	1:25:35	00:11	Output Analysis	
10	1:25:35	1:26:07	00:32	Manipulating Stands	

10	1:26:07	1:26:34	00:27	Measuring Assembly	
11	1:26:34	1:27:46	01:12	Scan Acquisition	
11	1:27:46	1:28:48	01:02	Scan Processing	
11	1:28:48	1:28:58	00:10	Output Analysis	
11	1:28:58	1:29:11	00:13	Looking at 3D Model	
11	1:29:11	1:29:19	00:08	Completing Rework	RW 5
11	1:29:19	1:29:28	00:09	Chatting with Administrator	
11	1:29:28	1:29:36	00:08	Looking at 3D Model	
11	1:29:36	1:30:03	00:27	Manipulating Stands	
12	1:30:03	1:31:12	01:09	Scan Acquisition	
12	1:31:12	1:32:16	01:04	Scan Processing	
12	1:32:16	1:32:26	00:10	Output Analysis	
12	1:32:26	1:32:52	00:26	Looking at 3D Model	
12	1:32:52	1:33:17	00:25	Adjusting Clips	
12	1:33:17	1:33:39	00:22	Completing Rework	RW 2
12	1:33:39	1:33:53	00:14	Manipulating Stands	
12	1:33:53	1:34:12	00:19	Completing Rework	RW 1
12	1:34:12	1:34:25	00:13	Adjusting Clips	
13	1:34:25	1:35:22	00:57	Scan Acquisition	
13	1:35:22	1:36:16	00:54	Scan Processing	
13	1:36:16	1:36:26	00:10	Output Analysis	
13	1:36:26	1:36:45	00:19	Looking at 3D Model	
13	1:36:45	1:36:58	00:13	Completing Rework	RW 2
13	1:36:58	1:37:15	00:17	Looking at 3D Model	
14	1:37:15	1:38:13	00:58	Scan Acquisition	
14	1:38:13	1:38:53	00:40	Scan Processing	
14	1:38:53	1:39:01	00:08	Chatting with Administrator	
14	1:39:01	1:39:12	00:11	Output Analysis	
14	1:39:12	1:39:27	00:15	Looking at 3D Model	
14	1:39:27	1:39:33	00:06	Manipulating Stands	
14	1:39:33	1:40:00	00:27	Adjusting Clips	
14	1:40:00	1:40:08	00:08	Completing Rework	RW 1
14	1:40:08	1:40:13	00:05	Chatting with Administrator	
15	1:40:13	1:41:52	01:39	Scan Acquisition	
15	1:41:52	1:42:38	00:46	Scan Processing	
15	1:42:38	1:44:41	02:03	Scan Processing	

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:43	00:43	Chatting with Administrator	
1	00:43	01:05	00:22	Model Segmentation	
1	01:05	01:11	00:06	Looking at 3D Model	
1	01:11	01:13	00:02	Looking at Drawing	
1	01:13	01:19	00:06	Assembling Assembly	pt 2
1	01:19	01:22	00:03	Looking at Drawing	
1	01:22	01:41	00:19	Looking at 3D Model	
1	01:41	01:47	00:06	Adjusting Assembly	
1	01:47	02:06	00:19	Looking at Drawing	.
1	02:06	02:15	00:09	Looking at 3D Model	
1	02:15	02:48	00:33	Chatting with Administrator	
1	02:48	02:55	00:07	Manipulating Stands	
1	02:55	03:30	00:35	Chatting with Administrator	
1	03:30	03:38	00:08	Looking at 3D Model	
1	03:38	03:45	00:07	Looking at Drawing	
1	03:45	04:10	00:25	Measuring Assembly	
1	04:10	04:14	00:04	Adjusting Assembly	
1	04:14	04:50	00:36	Measuring Assembly	
1	04:50	05:20	00:30	Adjusting Clips	
1	05:20	06:00	00:40	Chatting with Administrator	
2	06:00	07:03	01:03	Scan Acquisition	
2	07:03	08:26	01:23	Chatting with Administrator	
2	08:26	09:07	00:41	Scan Processing	
2	09:07	09:13	00:06	Output Analysis	
2	09:13	09:30	00:17	Chatting with Administrator	
2	09:30	10:00	00:30	Model Segmentation	
2	10:00	10:10	00:10	Chatting with Administrator	
2	10:10	10:18	00:08	Assembling Assembly	pt 4
2	10:18	10:25	00:07	Looking at 3D Model	
2	10:25	10:33	00:08	Assembling Assembly	

Totals	
Chatting with Administrator	07:45
Assembling Assembly	00:54
Adjusting Clips	03:28
Measuring Assembly	01:01
Checking Assembly	00:00
Manipulating Stands	00:30
Adjusting Assembly	00:53
Assembly Layout	00:00
Looking at Drawing	01:25
Completing Rework	00:20
Model Segmentation	01:36
Looking at 3D Model	05:20
Scan Acquisition	03:43
Scan Processing	05:48
Output Analysis	00:40
Total	33:23

Cycle	Start	End	Duration	Category	Note
2	10:33	10:47	00:14	Model Segmentation	
2	10:47	11:03	00:16	Looking at 3D Model	
2	11:03	11:18	00:15	Model Segmentation	
2	11:18	11:24	00:06	Looking at 3D Model	
2	11:24	11:36	00:12	Assembling Assembly	
2	11:36	11:50	00:14	Looking at 3D Model	
2	11:50	12:00	00:10	Adjusting Assembly	
2	12:00	12:05	00:05	Chatting with Administrator	
2	12:05	12:20	00:15	Looking at 3D Model	
2	12:20	12:35	00:15	Model Segmentation	
2	12:35	12:42	00:07	Looking at 3D Model	
2	12:42	12:50	00:08	Adjusting Assembly	
2	12:50	13:13	00:23	Manipulating Stands	
2	13:13	13:23	00:10	Looking at Drawing	
2	13:23	13:48	00:25	Looking at 3D Model	
2	13:48	14:00	00:12	Adjusting Assembly	
2	14:00	14:10	00:10	Looking at 3D Model	
2	14:10	14:18	00:08	Adjusting Assembly	
2	14:18	14:40	00:22	Looking at Drawing	
2	14:40	14:45	00:05	Adjusting Assembly	
2	14:45	15:15	00:30	Looking at 3D Model	
2	15:15	16:05	00:50	Adjusting Clips	
2	16:05	16:50	00:45	Chatting with Administrator	
3	16:50	17:45	00:55	Scan Acquisition	
3	17:45	19:30	01:45	Scan Processing	
3	19:30	19:50	00:20	Output Analysis	
3	19:50	19:55	00:05	Adjusting Clips	
3	19:55	21:50	01:55	Chatting with Administrator	
3	21:50	21:55	00:05	Looking at 3D Model	
3	21:55	23:16	01:21	Adjusting Clips	
3	23:16	23:36	00:20	Completing Rework	rw4
4	23:36	24:35	00:59	Scan Acquisition	
4	24:35	26:25	01:50	Scan Processing	
4	26:25	26:29	00:04	Output Analysis	
4	26:29	26:43	00:14	Scan Processing	
4	26:43	26:54	00:11	Chatting with Administrator	
4	26:54	27:22	00:28	Adjusting Clips	
4	27:22	27:30	00:08	Looking at Drawing	
4	27:30	27:50	00:20	Looking at 3D Model	
4	27:50	28:07	00:17	Assembling Assembly	
4	28:07	0:28:19	00:12	Looking at 3D Model	
4	28:19	28:22	00:03	Assembling Assembly	pt 5
4	28:22	28:40	00:18	Looking at 3D Model	
4	28:40	28:46	00:06	Looking at Drawing	
4	28:46	28:57	00:11	Looking at 3D Model	
4	28:57	29:11	00:14	Adjusting Clips	
4	29:11	29:19	00:08	Looking at Drawing	
4	29:19	29:35	00:16	Looking at 3D Model	
4	29:35	30:41	01:06	Looking at 3D Model	
5	30:41	31:27	00:46	Scan Acquisition	
5	31:27	31:59	00:32	Scan Processing	
5	31:59	32:13	00:14	Chatting with Administrator	
5	32:13	32:59	00:46	Scan Processing	
5	32:59	33:09	00:10	Output Analysis	
5	33:09	33:23	00:14	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:08	00:08	Looking at Drawing	
1	00:08	00:22	00:14	Chatting with Administrator	
1	00:22	00:34	00:12	Looking at Drawing	
1	00:34	00:42	00:08	Assembly Layout	
1	00:42	00:53	00:11	Looking at Drawing	
1	00:53	01:19	00:26	Chatting with Administrator	
1	01:19	01:27	00:08	Looking at 3D Model	
1	01:27	01:35	00:08	Assembly Layout	
1	01:35	01:53	00:18	Chatting with Administrator	.
1	01:53	02:07	00:14	Looking at 3D Model	
1	02:07	02:17	00:10	Assembly Layout	

Totals	
Chatting with Administrator	10:51
Assembling Assembly	00:55
Adjusting Clips	00:40
Measuring Assembly	17:42
Checking Assembly	00:00
Manipulating Stands	07:00
Adjusting Assembly	03:06
Assembly Layout	01:24
Looking at Drawing	08:11
Completing Rework	03:06

1	02:17	02:29	00:12	Chatting with Administrator			Model Segmentation	00:18
1	02:29	03:02	00:33	Looking at 3D Model			Looking at 3D Model	06:14
1	03:02	03:11	00:09	Assembly Layout			Scan Acquisition	05:13
1	03:11	03:24	00:13	Chatting with Administrator			Scan Processing	06:48
1	03:24	03:32	00:08	Looking at 3D Model			Output Analysis	02:09
1	03:32	03:36	00:04	Assembly Layout			Total	1:13:37
1	03:36	04:06	00:30	Chatting with Administrator				
1	04:06	04:38	00:32	Looking at 3D Model				
1	04:38	05:54	01:16	Chatting with Administrator				
1	05:54	06:16	00:22	Looking at Drawing				
1	06:16	06:21	00:05	Adjusting Assembly	DIS 3			
1	06:21	06:41	00:20	Looking at Drawing				
1	06:41	07:19	00:38	Adjusting Assembly	UNCOD RW 2			
1	07:19	08:13	00:54	Measuring Assembly				
1	08:13	08:40	00:27	Chatting with Administrator				
1	08:40	08:54	00:14	Manipulating Stands				
1	08:54	09:39	00:45	Chatting with Administrator				
1	09:39	10:01	00:22	Measuring Assembly				
1	10:01	10:11	00:10	Manipulating Stands				
1	10:11	11:01	00:50	Chatting with Administrator				
1	11:01	11:15	00:14	Measuring Assembly				
1	11:15	11:40	00:25	Manipulating Stands				
1	11:40	12:04	00:24	Measuring Assembly				
1	12:04	12:19	00:15	Manipulating Stands				
1	12:19	12:44	00:25	Measuring Assembly				
1	12:44	13:30	00:46	Manipulating Stands				
1	13:30	14:16	00:46	Measuring Assembly				
1	14:16	14:31	00:15	Looking at Drawing				
1	14:31	14:42	00:11	Manipulating Stands				
1	14:42	14:58	00:16	Looking at 3D Model				
1	14:58	15:28	00:30	Looking at Drawing				
1	15:28	15:52	00:24	Manipulating Stands				
1	15:52	16:22	00:30	Looking at Drawing				
1	16:22	16:50	00:28	Looking at 3D Model				
1	16:50	17:35	00:45	Looking at Drawing				
1	17:35	18:33	00:58	Measuring Assembly				
1	18:33	18:41	00:08	Manipulating Stands				
1	18:41	19:34	00:53	Chatting with Administrator				
1	19:34	20:07	00:33	Measuring Assembly				
1	20:07	20:25	00:18	Assembly Layout				
1	20:25	20:39	00:14	Manipulating Stands				
1	20:39	20:52	00:13	Assembly Layout				
1	20:52	21:42	00:50	Measuring Assembly				
1	21:42	21:59	00:17	Manipulating Stands				
1	21:59	22:13	00:14	Measuring Assembly				
1	22:13	22:53	00:40	Adjusting Clips				
1	22:53	23:00	00:07	Adjusting Assembly	UNCOD RW 2			
1	23:00	23:18	00:18	Assembling Assembly				
1	23:18	23:59	00:41	Looking at 3D Model				
1	23:59	24:17	00:18	Chatting with Administrator				
1	24:17	24:55	00:38	Looking at Drawing				
1	24:55	25:12	00:17	Chatting with Administrator				
1	25:12	26:14	01:02	Looking at 3D Model				
1	26:14	26:27	00:13	Adjusting Assembly	UNDOC RW 3 was four			
1	26:27	26:48	00:21	Chatting with Administrator				
1	26:48	27:43	00:55	Measuring Assembly				
1	27:43	28:00	00:17	Manipulating Stands				
1	28:00	28:09	00:09	Measuring Assembly				
1	28:09	28:23	00:14	Looking at Drawing				
1	28:23	29:00	00:37	Measuring Assembly				
1	29:00	29:13	00:13	Manipulating Stands				
1	29:13	29:53	00:40	Looking at Drawing	chk			
1	29:53	30:03	00:10	Adjusting Assembly	UNDOC RW dis 3			
1	30:03	30:13	00:10	Chatting with Administrator				
1	30:13	30:18	00:05	Manipulating Stands				
1	30:18	31:25	01:07	Measuring Assembly				
1	31:25	31:57	00:32	Looking at Drawing				
1	31:57	32:26	00:29	Measuring Assembly				
1	32:26	32:40	00:14	Assembly Layout				
1	32:40	32:55	00:15	Manipulating Stands				
1	32:55	33:00	00:05	Assembling Assembly				

1	33:00	33:12	00:12	Measuring Assembly	
1	33:12	33:27	00:15	Adjusting Assembly	UNDOC RW 2
1	33:27	33:52	00:25	Assembling Assembly	RE ASS 3
1	33:52	34:47	00:55	Measuring Assembly	
1	34:47	35:06	00:19	Chatting with Administrator	
1	35:06	35:38	00:32	Looking at 3D Model	
1	35:38	35:58	00:20	Looking at Drawing	
1	35:58	36:22	00:24	Manipulating Stands	
1	36:22	36:59	00:37	Looking at 3D Model	
1	36:59	37:17	00:18	Model Segmentation	
1	37:17	37:28	00:11	Chatting with Administrator	
1	37:28	37:46	00:18	Looking at 3D Model	
1	37:46	37:52	00:06	Chatting with Administrator	
1	37:52	38:17	00:25	Looking at Drawing	
1	38:17	39:06	00:49	Measuring Assembly	
1	39:06	39:07	00:01	Adjusting Assembly	UNDOC RW four
1	39:07	39:35	00:28	Measuring Assembly	
1	39:35	39:46	00:11	Adjusting Assembly	UNDOC RW four
1	39:46	40:05	00:19	Looking at Drawing	
1	40:05	40:20	00:15	Measuring Assembly	
1	40:20	41:30	01:10	Chatting with Administrator	
1	41:30	42:34	01:04	Adjusting Assembly	DIS 3
1	42:34	42:48	00:14	Looking at Drawing	
1	42:48	43:08	00:20	Manipulating Stands	
1	43:08	43:23	00:15	Chatting with Administrator	
2	43:23	44:43	01:20	Scan Acquisition	
2	44:43	45:35	00:52	Scan Processing	
2	45:35	46:34	00:59	Chatting with Administrator	
2	46:34	47:00	00:26	Scan Processing	
2	47:00	47:56	00:56	Output Analysis	
2	47:56	49:00	01:04	Measuring Assembly	
2	49:00	49:20	00:20	Manipulating Stands	
2	49:20	49:30	00:10	Completing Rework	RW 1
2	49:30	50:17	00:47	Measuring Assembly	
2	50:17	51:02	00:45	Looking at Drawing	
2	51:02	51:22	00:20	Measuring Assembly	
2	51:22	51:34	00:12	Completing Rework	RW 4
2	51:34	51:48	00:14	Looking at Drawing	
2	51:48	51:56	00:08	Completing Rework	RW 4
2	51:56	52:18	00:22	Measuring Assembly	
2	52:18	52:29	00:11	Completing Rework	RW 4
2	52:29	52:45	00:16	Manipulating Stands	
2	52:45	53:30	00:45	Measuring Assembly	
2	53:30	53:44	00:14	Completing Rework	
2	53:44	53:51	00:07	Assembling Assembly	pt 5
2	53:51	54:19	00:28	Measuring Assembly	
2	54:19	54:22	00:03	Adjusting Assembly	UNDOC RW 5
2	54:22	56:15	01:53	Measuring Assembly	
2	56:15	56:29	00:14	Completing Rework	RW 4
2	56:29	56:53	00:24	Looking at Drawing	
2	56:53	57:20	00:27	Measuring Assembly	
2	57:20	57:31	00:11	Completing Rework	RW 4
2	57:31	57:44	00:13	Adjusting Assembly	UNDOC RW 5
2	57:44	58:22	00:38	Manipulating Stands	
2	58:22	58:37	00:15	Completing Rework	RW 4
2	58:37	58:50	00:13	Looking at Drawing	
2	58:50	58:56	00:06	Adjusting Assembly	UNDOC RW 5
2	58:56	59:09	00:13	Manipulating Stands	
2	59:09	59:15	00:06	Chatting with Administrator	
3	59:15	1:00:08	00:53	Scan Acquisition	
3	1:00:08	1:01:39	01:31	Scan Processing	
3	1:01:39	1:02:00	00:21	Output Analysis	
3	1:02:00	1:02:12	00:12	Completing Rework	RW 5
3	1:02:12	1:02:23	00:11	Output Analysis	
3	1:02:23	1:02:41	00:18	Completing Rework	RW 1
3	1:02:41	1:02:50	00:09	Chatting with Administrator	
4	1:02:50	1:03:30	00:40	Scan Acquisition	
4	1:03:30	1:03:56	00:26	Chatting with Administrator	CRASH
4	1:03:56	1:04:20	00:24	Scan Processing	
4	1:04:20	1:04:38	00:18	Output Analysis	
4	1:04:38	1:05:00	00:22	Completing Rework	RW 1

Cycle	Start	End	Duration	Category	Note
4	1:05:00	1:05:15	00:15	Manipulating Stands	
5	1:05:15	1:06:05	00:50	Scan Acquisition	
5	1:06:05	1:06:58	00:53	Scan Processing	
5	1:06:58	1:07:50	00:52	Scan Processing	more proc
5	1:07:50	1:08:02	00:12	Output Analysis	
5	1:08:02	1:08:47	00:45	Looking at 3D Model	
5	1:08:47	1:08:55	00:08	Completing Rework	RW 2
5	1:08:55	1:09:10	00:15	Manipulating Stands	
5	1:09:10	1:09:13	00:03	Completing Rework	RW 1
5	1:09:13	1:09:38	00:25	Manipulating Stands	
5	1:09:38	1:09:45	00:07	Completing Rework	RW 1
6	1:09:45	1:10:30	00:45	Scan Acquisition	
6	1:10:30	1:11:08	00:38	Scan Processing	
6	1:11:08	1:11:19	00:11	Output Analysis	
6	1:11:19	1:11:40	00:21	Completing Rework	RW 1
7	1:11:40	1:12:25	00:45	Scan Acquisition	
7	1:12:25	1:13:37	01:12	Scan Processing	

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:34	00:34	Chatting with Administrator	
1	00:34	01:14	00:40	Looking at Drawing	
1	01:14	01:32	00:18	Assembling Assembly	pt 2 3 5 *
1	01:32	01:36	00:04	Looking at 3D Model	
1	01:36	01:41	00:05	Adjusting Assembly	
1	01:41	01:49	00:08	Looking at 3D Model	
1	01:49	01:51	00:02	Adjusting Assembly	
1	01:51	01:58	00:07	Looking at 3D Model	
1	01:58	02:00	00:02	Adjusting Assembly	.
1	02:00	02:13	00:13	Looking at Drawing	
1	02:13	02:35	00:22	Assembling Assembly	
1	02:35	02:52	00:17	Looking at Drawing	
1	02:52	03:28	00:36	Measuring Assembly	
1	03:28	04:01	00:33	Looking at Drawing	
1	04:01	04:34	00:33	Manipulating Stands	
1	04:34	04:47	00:13	Looking at Drawing	
1	04:47	04:58	00:11	Chatting with Administrator	
1	04:58	05:34	00:36	Measuring Assembly	
1	05:34	05:50	00:16	Looking at Drawing	
1	05:50	06:12	00:22	Adjusting Assembly	
1	06:12	06:40	00:28	Measuring Assembly	
1	06:40	06:50	00:10	Adjusting Assembly	
1	06:50	07:59	01:09	Looking at 3D Model	
1	07:59	08:40	00:41	Chatting with Administrator	
1	08:40	08:54	00:14	Manipulating Stands	
1	08:54	08:59	00:05	Model Segmentation	
2	08:59	10:35	01:36	Scan Acquisition	
2	10:35	11:16	00:41	Scan Processing	
2	11:16	11:17	00:01	Output Analysis	
2	11:17	11:22	00:05	Completing Rework	rw5
2	11:22	11:24	00:02	Output Analysis	
2	11:24	11:39	00:15	Completing Rework	rw1
2	11:39	11:48	00:09	Manipulating Stands	
2	11:48	12:21	00:33	Looking at Drawing	
2	12:21	13:44	01:23	Looking at 3D Model	
2	13:44	14:09	00:25	Measuring Assembly	
2	14:09	14:50	00:41	Chatting with Administrator	
2	14:50	15:12	00:22	Measuring Assembly	
2	15:12	15:16	00:04	Completing Rework	rw4
2	15:16	15:20	00:04	Measuring Assembly	
2	15:20	16:16	00:56	Looking at Drawing	
2	16:16	16:55	00:39	Measuring Assembly	
2	16:55	16:58	00:03	Completing Rework	rw4
2	16:58	17:38	00:40	Looking at Drawing	
2	17:38	18:04	00:26	Measuring Assembly	
2	18:04	18:10	00:06	Looking at Drawing	
2	18:10	18:14	00:04	Completing Rework	rw5
2	18:14	18:31	00:17	Measuring Assembly	
2	18:31	18:41	00:10	Looking at Drawing	

Totals	
Chatting with Administrator	02:07
Assembling Assembly	00:40
Adjusting Clips	00:00
Measuring Assembly	11:10
Checking Assembly	00:00
Manipulating Stands	02:23
Adjusting Assembly	00:41
Assembly Layout	00:00
Looking at Drawing	04:59
Completing Rework	01:47
Model Segmentation	00:13
Looking at 3D Model	06:24
Scan Acquisition	03:51
Scan Processing	03:32
Output Analysis	00:38
Total	38:25

Cycle	Start	End	Duration	Category	Note
2	18:41	19:35	00:54	Looking at 3D Model	
2	19:35	20:14	00:39	Completing Rework	rw2
2	20:14	20:43	00:29	Manipulating Stands	
2	20:43	21:21	00:38	Measuring Assembly	
3	21:21	21:52	00:31	Scan Acquisition	
3	21:52	22:00	00:08	Model Segmentation	
3	22:00	22:51	00:51	Scan Processing	
3	22:51	23:17	00:26	Output Analysis	
3	23:17	23:35	00:18	Looking at 3D Model	
3	23:35	23:38	00:03	Completing Rework	rw5
3	23:38	23:52	00:14	Looking at 3D Model	
3	23:52	24:02	00:10	Completing Rework	rw3
3	24:02	25:11	01:09	Looking at 3D Model	
3	25:11	25:21	00:10	Looking at Drawing	
3	25:21	27:08	01:47	Measuring Assembly	
3	27:08	27:10	00:02	Looking at Drawing	
3	27:10	27:33	00:23	Looking at 3D Model	
3	27:33	28:15	00:42	Measuring Assembly	
3	28:15	28:21	00:06	Completing Rework	rw3
3	28:21	29:01	00:40	Measuring Assembly	
3	29:01	29:09	00:08	Completing Rework	rw4
3	29:09	0:29:15	00:06	Measuring Assembly	
3	29:15	29:23	00:08	Completing Rework	rw4
3	29:23	30:08	00:45	Measuring Assembly	
3	30:08	30:23	00:15	Manipulating Stands	
3	30:23	30:58	00:35	Looking at 3D Model	
4	30:58	31:57	00:59	Scan Acquisition	
4	31:57	33:20	01:23	Scan Processing	
4	33:20	33:26	00:06	Output Analysis	
4	33:26	33:28	00:02	Completing Rework	rw5
4	33:28	33:52	00:24	Manipulating Stands	
4	33:52	34:28	00:36	Measuring Assembly	
4	34:28	34:40	00:12	Manipulating Stands	
4	34:40	36:00	01:20	Measuring Assembly	
4	36:00	36:10	00:10	Looking at Drawing	
4	36:10	36:42	00:32	Measuring Assembly	
4	36:42	36:49	00:07	Manipulating Stands	
4	36:49	37:00	00:11	Measuring Assembly	
5	37:00	37:45	00:45	Scan Acquisition	
5	37:45	38:22	00:37	Scan Processing	
5	38:22	38:25	00:03	Output Analysis	

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Cycle	Start	End	Duration	Category	Note
1	00:00	03:09	03:09	Chatting with Administrator	
1	03:09	03:32	00:23	Assembling Assembly	
1	03:32	03:49	00:17	Looking at 3D Model	
1	03:49	04:00	00:11	Looking at 3D Model	
1	04:00	04:40	00:40	Assembling Assembly	pt 1 3 5 *
1	04:40	05:27	00:47	Manipulating Stands	
1	05:27	06:08	00:41	Chatting with Administrator	
1	06:08	06:22	00:14	Looking at Drawing	
1	06:22	07:15	00:53	Chatting with Administrator	.
1	07:15	07:30	00:15	Looking at Drawing	
1	07:30	10:16	02:46	Chatting with Administrator	
1	10:16	10:56	00:40	Looking at 3D Model	
1	10:56	11:20	00:24	Looking at Drawing	
1	11:20	14:55	03:35	Chatting with Administrator	
1	14:55	15:20	00:25	Measuring Assembly	
1	15:20	15:51	00:31	Looking at Drawing	
1	15:51	16:36	00:45	Measuring Assembly	
1	16:36	16:42	00:06	Adjusting Assembly	UNDOC RW 1
1	16:42	16:56	00:14	Measuring Assembly	
1	16:56	17:01	00:05	Adjusting Assembly	UNDOC RW 1
1	17:01	17:34	00:33	Looking at Drawing	
1	17:34	17:42	00:08	Adjusting Assembly	UNDOC RW 1
1	17:42	18:13	00:31	Chatting with Administrator	
2	18:13	19:15	01:02	Scan Acquisition	
2	19:15	20:26	01:11	Scan Processing	

Totals	
Chatting with Administrator	18:00
Assembling Assembly	01:03
Adjusting Clips	00:00
Measuring Assembly	01:24
Checking Assembly	00:00
Manipulating Stands	00:47
Adjusting Assembly	00:19
Assembly Layout	00:00
Looking at Drawing	01:57
Completing Rework	01:58
Model Segmentation	00:00
Looking at 3D Model	03:01
Scan Acquisition	09:38
Scan Processing	20:12
Output Analysis	02:51
Total	1:01:10

2	20:26	20:38	00:12	Output Analysis	
2	20:38	20:43	00:05	Completing Rework	RW 1
2	20:43	20:49	00:06	Output Analysis	
2	20:49	20:56	00:07	Completing Rework	RW 1
2	20:56	21:05	00:09	Chatting with Administrator	
3	21:05	22:01	00:56	Scan Acquisition	
3	22:01	23:06	01:05	Scan Processing	
3	23:06	23:41	00:35	Output Analysis	
3	23:41	23:55	00:14	Looking at 3D Model	
3	23:55	24:06	00:11	Completing Rework	RW 1
4	24:06	25:02	00:56	Scan Acquisition	
4	25:02	25:52	00:50	Scan Processing	
4	25:52	26:01	00:09	Output Analysis	
4	26:01	26:05	00:04	Completing Rework	RW 1
5	26:05	26:48	00:43	Scan Acquisition	
5	26:48	27:27	00:39	Scan Processing	
5	27:27	27:44	00:17	Output Analysis	
5	27:44	27:53	00:09	Completing Rework	RW 1
6	27:53	28:35	00:42	Scan Acquisition	
6	28:35	29:33	00:58	Scan Processing	
6	29:33	29:52	00:19	Output Analysis	
6	29:52	30:02	00:10	Completing Rework	RW 4
6	30:02	30:29	00:27	Looking at 3D Model	
6	30:29	30:35	00:06	Completing Rework	RW 4
6	30:35	30:42	00:07	Looking at 3D Model	
6	30:42	30:55	00:13	Completing Rework	RW 4
7	30:55	31:42	00:47	Scan Acquisition	
7	31:42	34:30	02:48	Scan Processing	
7	34:30	34:49	00:19	Output Analysis	
7	34:49	35:29	00:40	Looking at 3D Model	
7	35:29	35:36	00:07	Completing Rework	RW 4
7	35:36	35:47	00:11	Looking at 3D Model	
7	35:47	36:03	00:16	Completing Rework	RW 4
7	36:03	37:03	01:00	Chatting with Administrator	BAD SCAN
7	37:03	38:41	01:38	Chatting with Administrator	
7	38:41	38:58	00:17	Chatting with Administrator	
7	38:58	40:06	01:08	Chatting with Administrator	
8	40:06	41:08	01:02	Scan Acquisition	
8	41:08	43:05	01:57	Scan Processing	
8	43:05	44:00	00:55	Chatting with Administrator	CRASH
8	44:00	47:02	03:02	Scan Processing	
8	47:02	47:06	00:04	Chatting with Administrator	
8	47:06	47:26	00:20	Scan Processing	
8	47:26	47:38	00:12	Output Analysis	
8	47:38	47:52	00:14	Looking at 3D Model	
8	47:52	47:56	00:04	Completing Rework	RW 5
9	47:56	49:43	01:47	Scan Acquisition	
9	49:43	53:29	03:46	Scan Processing	
9	53:29	53:42	00:13	Output Analysis	
9	53:42	53:50	00:08	Completing Rework	RW 5
10	53:50	54:54	01:04	Scan Acquisition	
10	54:54	57:35	02:41	Scan Processing	
10	57:35	57:52	00:17	Output Analysis	
10	57:52	57:59	00:07	Completing Rework	RW 5
10	57:59	58:11	00:12	Output Analysis	
10	58:11	58:30	00:19	Chatting with Administrator	
10	58:30	58:41	00:11	Completing Rework	RW 1
10	58:41	59:00	00:19	Chatting with Administrator	
11	59:00	59:39	00:39	Scan Acquisition	
11	59:39	1:00:34	00:55	Scan Processing	
11	1:00:34	1:01:10	00:36	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note		Totals	
1	00:00	01:39	01:39	Chatting with Administrator				
1	01:39	01:54	00:15	Looking at Drawing		Chatting with Administrator	10:23
1	01:54	02:06	00:12	Looking at 3D Model		Assembling Assembly	01:32
1	02:06	03:26	01:20	Chatting with Administrator		Adjusting Clips	01:41
1	03:26	04:08	00:42	Looking at 3D Model		Measuring Assembly	00:00

1	04:08	04:28	00:20	Assembling Assembly		Checking Assembly	00:00
1	04:28	04:51	00:23	Chatting with Administrator		Manipulating Stands	01:42
1	04:51	04:58	00:07	Looking at Drawing		Adjusting Assembly	00:18
1	04:58	05:16	00:18	Assembling Assembly	.	Assembly Layout	00:00
1	05:16	05:30	00:14	Model Segmentation		Looking at Drawing	01:10
1	05:30	05:40	00:10	Looking at 3D Model		Completing Rework	00:59
1	05:40	05:51	00:11	Adjusting Assembly	UNDOC RW 2	Model Segmentation	00:57
1	05:51	06:00	00:09	Looking at 3D Model		Looking at 3D Model	02:37
2	06:00	06:55	00:55	Scan Acquisition		Scan Acquisition	08:41
2	06:55	08:17	01:22	Scan Processing		Scan Processing	07:31
2	08:17	08:35	00:18	Output Analysis		Output Analysis	02:53
2	08:35	08:40	00:05	Chatting with Administrator		Total	40:24
2	08:40	08:48	00:08	Output Analysis			
2	08:48	09:08	00:20	Chatting with Administrator			
2	09:08	09:22	00:14	Completing Rework	RW 2		
2	09:22	09:44	00:22	Adjusting Clips			
3	09:44	10:32	00:48	Scan Acquisition			
3	10:32	11:20	00:48	Scan Processing			
3	11:20	11:42	00:22	Output Analysis			
3	11:42	11:50	00:08	Chatting with Administrator			
3	11:50	11:58	00:08	Adjusting Clips			
3	11:58	12:05	00:07	Completing Rework	RW 2		
3	12:05	12:12	00:07	Adjusting Clips			
4	12:12	12:48	00:36	Scan Acquisition			
4	12:48	13:50	01:02	Scan Processing			
4	13:50	14:06	00:16	Output Analysis			
4	14:06	15:25	01:19	Chatting with Administrator			
4	15:25	15:50	00:25	Adjusting Clips			
4	15:50	16:27	00:37	Model Segmentation			
4	16:27	16:43	00:16	Looking at 3D Model			
4	16:43	17:30	00:47	Assembling Assembly	pt 3 *		
4	17:30	17:59	00:29	Manipulating Stands			
4	17:59	19:30	01:31	Chatting with Administrator	bad scan		
4	19:30	19:40	00:10	Manipulating Stands			
5	19:40	22:52	03:12	Scan Acquisition			
5	22:52	23:51	00:59	Scan Processing			
5	23:51	24:05	00:14	Output Analysis			
5	24:05	24:59	00:54	Chatting with Administrator			
5	24:59	25:40	00:41	Scan Processing			
5	25:40	25:49	00:09	Output Analysis			
5	25:49	26:08	00:19	Chatting with Administrator			
5	26:08	26:29	00:21	Output Analysis			
5	26:29	26:39	00:10	Chatting with Administrator			
5	26:39	27:00	00:21	Output Analysis			
5	27:00	27:19	00:19	Completing Rework	RW 3		
5	27:19	27:28	00:09	Chatting with Administrator			
5	27:28	27:53	00:25	Adjusting Clips			
5	27:53	28:08	00:15	Completing Rework	RW 3		
5	28:08	28:22	00:14	Adjusting Clips			
6	28:22	29:17	00:55	Scan Acquisition			
6	29:17	30:20	01:03	Scan Processing			
6	30:20	30:40	00:20	Output Analysis			
6	30:40	30:46	00:06	Chatting with Administrator			
6	30:46	30:50	00:04	Output Analysis			
6	30:50	30:59	00:09	Chatting with Administrator			
6	30:59	31:33	00:34	Looking at 3D Model			
6	31:33	31:40	00:07	Manipulating Stands			
6	31:40	31:48	00:08	Looking at 3D Model			
6	31:48	31:55	00:07	Assembling Assembly			
6	31:55	32:15	00:20	Looking at Drawing			
6	32:15	32:42	00:27	Chatting with Administrator			
6	32:42	33:10	00:28	Looking at Drawing			
6	33:10	33:17	00:07	Adjusting Assembly	UNDOC RW 5		
6	33:17	33:43	00:26	Looking at 3D Model			
6	33:43	33:49	00:06	Model Segmentation			
7	33:49	34:59	01:10	Scan Acquisition			
7	34:59	35:53	00:54	Scan Processing			
7	35:53	36:39	00:46	Manipulating Stands			
7	36:39	36:50	00:11	Scan Processing			
7	36:50	36:59	00:09	Output Analysis			
7	36:59	37:03	00:04	Completing Rework	RW 5		

Cycle	Start	End	Duration	Category	Note
8	37:03	38:08	01:05	Scan Acquisition	
8	38:08	38:39	00:31	Scan Processing	
8	38:39	38:50	00:11	Output Analysis	
8	38:50	39:00	00:10	Manipulating Stands	
8	39:00	40:24	01:24	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:15	00:15	Chatting with Administrator	
1	00:15	00:29	00:14	Looking at Drawing	
1	00:29	00:52	00:23	Assembling Assembly	
1	00:52	01:02	00:10	Looking at Drawing	
1	01:02	01:20	00:18	Looking at 3D Model	
1	01:20	01:25	00:05	Assembling Assembly	
1	01:25	02:06	00:41	Looking at 3D Model	
1	02:06	02:45	00:39	Assembling Assembly	
1	02:45	03:15	00:30	Measuring Assembly	
1	03:15	03:55	00:40	Chatting with Administrator	
1	03:55	04:10	00:15	Assembling Assembly	
1	04:10	04:42	00:32	Manipulating Stands	
1	04:42	04:59	00:17	Chatting with Administrator	
1	04:59	05:20	00:21	Manipulating Stands	
1	05:20	05:40	00:20	Chatting with Administrator	
1	05:40	05:49	00:09	Assembling Assembly	
1	05:49	05:58	00:09	Manipulating Stands	
1	05:58	06:06	00:08	Looking at Drawing	
1	06:06	06:20	00:14	Looking at 3D Model	
1	06:20	06:30	00:10	Adjusting Assembly	undoc rw 3
1	06:30	06:52	00:22	Adjusting Assembly	undoc rw two
1	06:52	07:08	00:16	Looking at Drawing	
1	07:08	07:40	00:32	Measuring Assembly	
1	07:40	08:12	00:32	Looking at Drawing	
1	08:12	08:35	00:23	Looking at 3D Model	
1	08:35	08:47	00:12	Adjusting Assembly	undoc rw 3
1	08:47	09:07	00:20	Measuring Assembly	
1	09:07	09:14	00:07	Adjusting Assembly	undoc rw 3
1	09:14	09:25	00:11	Measuring Assembly	
1	09:25	09:40	00:15	Looking at Drawing	
1	09:40	09:47	00:07	Measuring Assembly	
1	09:47	10:30	00:43	Looking at Drawing	
1	10:30	10:40	00:10	Manipulating Stands	
1	10:40	10:53	00:13	Looking at Drawing	
1	10:53	11:03	00:10	Adjusting Assembly	undoc rw 3
1	11:03	11:28	00:25	Measuring Assembly	
1	11:28	12:08	00:40	Manipulating Stands	
1	12:08	12:19	00:11	Measuring Assembly	
1	12:19	12:26	00:07	Looking at Drawing	
1	12:26	13:03	00:37	Manipulating Stands	
1	13:03	14:05	01:02	Looking at 3D Model	
1	14:05	14:18	00:13	Adjusting Assembly	undoc rw 3
1	14:18	14:42	00:24	Measuring Assembly	
1	14:42	15:02	00:20	Adjusting Assembly	undoc rw 3
1	15:02	15:18	00:16	Measuring Assembly	
1	15:18	15:26	00:08	Adjusting Assembly	undoc rw 3
1	15:26	15:40	00:14	Measuring Assembly	
1	15:40	15:46	00:06	Manipulating Stands	
1	15:46	15:50	00:04	Adjusting Assembly	undoc rw 3
1	15:50	16:03	00:13	Measuring Assembly	
1	16:03	16:20	00:17	Manipulating Stands	
1	16:20	16:33	00:13	Adjusting Assembly	undoc rw 3
1	16:33	16:56	00:23	Looking at 3D Model	
1	16:56	17:03	00:07	Looking at Drawing	
1	17:03	17:10	00:07	Adjusting Assembly	undoc rw 3
1	17:10	17:45	00:35	Measuring Assembly	
1	17:45	19:20	01:35	Looking at Drawing	
1	19:20	19:37	00:17	Adjusting Assembly	undoc rw five
1	19:37	20:14	00:37	Looking at 3D Model	
1	20:14	20:22	00:08	Adjusting Assembly	undoc rw five
1	20:22	20:39	00:17	Looking at Drawing	

Totals

Chatting with Administrator	16:01
Assembling Assembly	02:06
Adjusting Clips	00:32
Measuring Assembly	08:49
Checking Assembly	00:57
Manipulating Stands	04:32
Adjusting Assembly	05:42
Assembly Layout	00:00
Looking at Drawing	08:56
Completing Rework	01:38
Model Segmentation	00:58
Looking at 3D Model	05:22
Scan Acquisition	09:03
Scan Processing	12:36
Output Analysis	01:28
Total	1:18:40

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1	20:39	20:46	00:07	Adjusting Assembly	undoc rw two
1	20:46	21:22	00:36	Looking at Drawing	
1	21:22	21:28	00:06	Adjusting Assembly	undoc rw one
1	21:28	21:43	00:15	Measuring Assembly	
1	21:43	21:54	00:11	Adjusting Assembly	undoc rw one
1	21:54	22:02	00:08	Measuring Assembly	
1	22:02	22:23	00:21	Adjusting Assembly	undoc rw one
1	22:23	22:35	00:12	Measuring Assembly	
1	22:35	23:46	01:11	Chatting with Administrator	
1	23:46	23:53	00:07	Adjusting Assembly	undoc rw one
1	23:53	24:16	00:23	Measuring Assembly	
1	24:16	24:24	00:08	Adjusting Assembly	undoc rw one
1	24:24	24:39	00:15	Measuring Assembly	
1	24:39	24:45	00:06	Adjusting Assembly	undoc rw one
1	24:45	24:55	00:10	Manipulating Stands	
1	24:55	25:00	00:05	Adjusting Assembly	undoc rw one
1	25:00	25:06	00:06	Looking at Drawing	
1	25:06	25:43	00:37	Measuring Assembly	
1	25:43	25:54	00:11	Adjusting Assembly	undoc rw one
1	25:54	26:08	00:14	Measuring Assembly	
1	26:08	26:27	00:19	Adjusting Assembly	undoc rw one
1	26:27	26:58	00:31	Measuring Assembly	
1	26:58	27:15	00:17	Checking Assembly	
1	27:15	27:19	00:04	Looking at Drawing	
1	27:19	27:27	00:08	Looking at 3D Model	
1	27:27	27:49	00:22	Checking Assembly	
1	27:49	28:45	00:56	Chatting with Administrator	
2	28:45	30:10	01:25	Scan Acquisition	
2	30:10	30:50	00:40	Scan Processing	
2	30:50	31:10	00:20	Output Analysis	
2	31:10	32:45	01:35	Chatting with Administrator	
2	32:45	32:52	00:07	Completing Rework	disasseble
2	32:52	33:01	00:09	Model Segmentation	
2	33:01	33:15	00:14	Chatting with Administrator	
2	33:15	33:20	00:05	Adjusting Assembly	und 5
2	33:20	33:47	00:27	Manipulating Stands	
2	33:47	34:55	01:08	Looking at Drawing	
2	34:55	35:15	00:20	Manipulating Stands	
2	35:15	35:27	00:12	Looking at 3D Model	
2	35:27	35:56	00:29	Adjusting Assembly	und 5
2	35:56	36:27	00:31	Measuring Assembly	
2	36:27	36:45	00:18	Chatting with Administrator	
3	36:45	37:10	00:25	Scan Acquisition	
3	37:10	37:46	00:36	Scan Processing	
3	37:46	37:56	00:10	Chatting with Administrator	
3	37:56	38:04	00:08	Output Analysis	
3	38:04	38:08	00:04	Completing Rework	rw 5
3	38:08	38:36	00:28	Chatting with Administrator	
3	38:36	38:50	00:14	Measuring Assembly	
3	38:50	39:10	00:20	Looking at Drawing	
3	39:10	39:24	00:14	Completing Rework	rw5
3	39:24	39:47	00:23	Chatting with Administrator	
4	39:47	40:10	00:23	Scan Acquisition	
4	40:10	40:35	00:25	Scan Processing	
4	40:35	40:37	00:02	Output Analysis	
4	40:37	41:06	00:29	Model Segmentation	
4	41:06	41:16	00:10	Chatting with Administrator	
4	41:16	41:21	00:05	Model Segmentation	
4	41:21	41:29	00:08	Looking at 3D Model	
4	41:29	41:48	00:19	Assembling Assembly	
4	41:48	42:05	00:17	Looking at Drawing	
4	42:05	42:15	00:10	Chatting with Administrator	
4	42:15	42:29	00:14	Looking at Drawing	
4	42:29	42:34	00:05	Measuring Assembly	
4	42:34	42:49	00:15	Looking at 3D Model	
4	42:49	42:58	00:09	Adjusting Assembly	pt 2
4	42:58	43:11	00:13	Measuring Assembly	
4	43:11	43:40	00:29	Chatting with Administrator	
5	43:40	44:30	00:50	Scan Acquisition	
5	44:30	45:10	00:40	Scan Processing	
5	45:10	45:35	00:25	Chatting with Administrator	

5	45:35	46:35	01:00	Scan Processing	
5	46:35	47:08	00:33	Chatting with Administrator	
5	47:08	47:28	00:20	Scan Processing	
5	47:28	47:32	00:04	Output Analysis	
5	47:32	47:43	00:11	Scan Processing	
5	47:43	47:52	00:09	Output Analysis	
5	47:52	48:10	00:18	Completing Rework	rw 2
5	48:10	48:28	00:18	Looking at Drawing	
5	48:28	51:10	02:42	Chatting with Administrator	
5	51:10	52:05	00:55	Looking at Drawing	
5	52:05	52:10	00:05	Completing Rework	rw 2
5	52:10	52:29	00:19	Chatting with Administrator	
5	52:29	52:39	00:10	Measuring Assembly	
5	52:39	52:44	00:05	Completing Rework	rw 2
5	52:44	53:06	00:22	Measuring Assembly	
5	53:06	53:25	00:19	Completing Rework	rw 2
5	53:25	53:41	00:16	Adjusting Clips	
5	53:41	53:55	00:14	Chatting with Administrator	
6	53:55	55:02	01:07	Scan Acquisition	
6	55:02	55:52	00:50	Chatting with Administrator	
6	55:52	56:57	01:05	Scan Processing	
6	56:57	57:04	00:07	Output Analysis	
6	57:04	57:15	00:11	Chatting with Administrator	
6	57:15	57:36	00:21	Scan Processing	
6	57:36	57:38	00:02	Output Analysis	
6	57:38	57:57	00:19	Chatting with Administrator	
6	57:57	58:02	00:05	Output Analysis	
6	58:02	58:18	00:16	Adjusting Clips	
6	58:18	58:28	00:10	Adjusting Assembly	
7	58:28	1:00:14	01:46	Scan Acquisition	
7	1:00:14	1:01:18	01:04	Scan Processing	
7	1:01:18	1:01:25	00:07	Output Analysis	
7	1:01:25	1:01:31	00:06	Completing Rework	rw 2
7	1:01:31	1:03:06	01:35	Chatting with Administrator	
8	1:03:06	1:03:55	00:49	Scan Acquisition	
8	1:03:55	1:05:40	01:45	Scan Processing	
8	1:05:40	1:05:51	00:11	Chatting with Administrator	
8	1:05:51	1:06:06	00:15	Model Segmentation	
8	1:06:06	1:06:16	00:10	Looking at Drawing	
8	1:06:16	1:06:24	00:08	Assembling Assembly	
8	1:06:24	1:06:40	00:16	Manipulating Stands	
8	1:06:40	1:06:53	00:13	Looking at 3D Model	
8	1:06:53	1:07:01	00:08	Assembling Assembly	
8	1:07:01	1:07:22	00:21	Manipulating Stands	
8	1:07:22	1:07:36	00:14	Looking at 3D Model	
8	1:07:36	1:07:42	00:06	Manipulating Stands	
8	1:07:42	1:07:54	00:12	Adjusting Assembly	und 1
8	1:07:54	1:08:21	00:27	Looking at 3D Model	
8	1:08:21	1:08:32	00:11	Adjusting Assembly	und 1
8	1:08:32	1:08:43	00:11	Looking at Drawing	
8	1:08:43	1:09:24	00:41	Measuring Assembly	
8	1:09:24	1:09:28	00:04	Adjusting Assembly	und 1
8	1:09:28	1:09:46	00:18	Checking Assembly	
8	1:09:46	1:09:53	00:07	Looking at 3D Model	
8	1:09:53	1:10:03	00:10	Adjusting Assembly	und 1
9	1:10:03	1:11:06	01:03	Scan Acquisition	
9	1:11:06	1:12:30	01:24	Scan Processing	
9	1:12:30	1:12:38	00:08	Output Analysis	
9	1:12:38	1:12:51	00:13	Completing Rework	rw 1
10	1:12:51	1:13:21	00:30	Scan Acquisition	
10	1:13:21	1:14:58	01:37	Scan Processing	
10	1:14:58	1:15:58	01:00	Chatting with Administrator	crash
10	1:15:58	1:16:22	00:24	Scan Processing	
10	1:16:22	1:16:38	00:16	Output Analysis	
10	1:16:38	1:16:45	00:07	Completing Rework	rw 1
11	1:16:45	1:17:30	00:45	Scan Acquisition	
11	1:17:30	1:18:34	01:04	Scan Processing	
11	1:18:34	1:18:40	00:06	Chatting with Administrator	

Cycle Count	Start	End	Duration	Category	Note
1	00:00	01:58	01:58	Chatting with Administrator	
1	01:58	02:30	00:32	Looking at 3D Model	
1	02:30	02:55	00:25	Assembling Assembly	
1	02:55	03:21	00:26	Looking at 3D Model	
1	03:21	03:31	00:10	Assembling Assembly	
1	03:31	03:40	00:09	Looking at 3D Model	
1	03:40	04:10	00:30	Looking at 3D Model	
1	04:10	05:00	00:50	Measuring Assembly	
1	05:00	05:15	00:15	Assembling Assembly	
1	05:15	05:56	00:41	Measuring Assembly	
1	05:56	06:01	00:05	Adjusting Assembly	undoc rw 1
1	06:01	06:08	00:07	Measuring Assembly	
1	06:08	06:34	00:26	Chatting with Administrator	
1	06:34	06:40	00:06	Model Segmentation	
1	06:40	09:53	03:13	Chatting with Administrator	
2	09:53	10:27	00:34	Scan Acquisition	
2	10:27	11:20	00:53	Scan Processing	
2	11:20	12:10	00:50	Chatting with Administrator	
2	12:10	12:22	00:12	Output Analysis	
2	12:22	12:33	00:11	Completing Rework	rw 2
3	12:33	13:05	00:32	Scan Acquisition	
3	13:05	13:20	00:15	Scan Processing	rw 2
3	13:20	13:23	00:03	Output Analysis	
3	13:23	13:30	00:07	Completing Rework	rw 2
3	13:30	13:40	00:10	Chatting with Administrator	
4	13:40	14:00	00:20	Scan Acquisition	
4	14:00	14:34	00:34	Scan Processing	
4	14:34	14:36	00:02	Output Analysis	
4	14:36	15:20	00:44	Model Segmentation	
4	15:20	15:45	00:25	Chatting with Administrator	
4	15:45	16:05	00:20	Looking at Drawing	
4	16:05	16:15	00:10	Manipulating Stands	
4	16:15	16:45	00:30	Looking at Drawing	
4	16:45	16:59	00:14	Assembling Assembly	
4	16:59	18:10	01:11	Looking at 3D Model	
4	18:10	18:22	00:12	Adjusting Assembly	undoc rw 5
4	18:22	18:40	00:18	Looking at 3D Model	
4	18:40	18:49	00:09	Adjusting Assembly	undoc rw 5
4	18:49	19:05	00:16	Looking at 3D Model	
5	19:05	19:58	00:53	Scan Acquisition	
5	19:58	20:58	01:00	Scan Processing	
5	20:58	21:03	00:05	Output Analysis	
5	21:03	21:34	00:31	Chatting with Administrator	
5	21:34	21:52	00:18	Looking at 3D Model	
5	21:52	22:20	00:28	Assembling Assembly	weld 3 putting the two halfs together
5	22:20	23:10	00:50	Manipulating Stands	
5	23:10	23:25	00:15	Chatting with Administrator	
6	23:25	23:55	00:30	Scan Acquisition	
6	23:55	24:35	00:40	Scan Processing	
6	24:35	24:39	00:04	Output Analysis	
6	24:39	24:47	00:08	Chatting with Administrator	

Totals	
Chatting with Administrator	07:56
Assembling Assembly	01:32
Adjusting Clips	00:00
Measuring Assembly	01:38
Checking Assembly	00:00
Manipulating Stands	01:00
Adjusting Assembly	00:26
Assembly Layout	00:00
Looking at Drawing	00:50
Completing Rework	00:18
Model Segmentation	00:50
Looking at 3D Model	03:40
Scan Acquisition	02:49
Scan Processing	03:22
Output Analysis	00:26
Total	24:47

Cycle	Start	End	Duration	Category	Note
1	00:00	01:57	01:57	Chatting with Administrator	
1	01:57	04:39	02:42	Looking at 3D Model	
1	04:39	04:47	00:08	Chatting with Administrator	
1	04:47	05:57	01:10	Looking at 3D Model	
1	05:57	08:15	02:18	Chatting with Administrator	
1	08:15	08:53	00:38	Assembling Assembly	whole
1	08:53	09:15	00:22	Model Segmentation	
1	09:15	09:27	00:12	Looking at 3D Model	
1	09:27	10:10	00:43	Assembling Assembly	

Totals	
Chatting with Administrator	09:00
Assembling Assembly	04:45
Adjusting Clips	02:36
Measuring Assembly	10:03
Checking Assembly	00:00
Manipulating Stands	10:59
Adjusting Assembly	02:02
Assembly Layout	00:00

1	10:10	10:20	00:10	Manipulating Stands		Looking at Drawing	07:33
1	10:20	10:57	00:37	Assembling Assembly		Completing Rework	00:29
1	10:57	11:07	00:10	Looking at 3D Model		Model Segmentation	00:38
1	11:07	11:55	00:48	Measuring Assembly		Looking at 3D Model	06:21
1	11:55	13:02	01:07	Chatting with Administrator		Scan Acquisition	05:20
1	13:02	13:15	00:13	Looking at Drawing		Scan Processing	04:14
1	13:15	13:20	00:05	Assembling Assembly		Output Analysis	00:16
1	13:20	13:43	00:23	Looking at 3D Model		Total	1:04:16
1	13:43	14:02	00:19	Assembling Assembly			
1	14:02	14:45	00:43	Manipulating Stands			
1	14:45	15:10	00:25	Assembling Assembly			
1	15:10	16:06	00:56	Manipulating Stands			
1	16:06	17:00	00:54	Looking at Drawing			
1	17:00	17:05	00:05	Manipulating Stands			
1	17:05	17:28	00:23	Assembling Assembly			
1	17:28	17:57	00:29	Measuring Assembly			
1	17:57	18:08	00:11	Looking at Drawing			
1	18:08	18:21	00:13	Assembling Assembly			
1	18:21	18:46	00:25	Looking at Drawing			
1	18:46	18:53	00:07	Manipulating Stands			
1	18:53	20:05	01:12	Adjusting Clips			
1	20:05	20:53	00:48	Manipulating Stands			
1	20:53	21:12	00:19	Looking at Drawing			
1	21:12	21:29	00:17	Manipulating Stands			
1	21:29	22:01	00:32	Looking at Drawing			
1	22:01	22:09	00:08	Adjusting Assembly	adj1		
1	22:09	24:15	02:06	Looking at Drawing			
1	24:15	24:40	00:25	Measuring Assembly			
1	24:40	24:50	00:10	Manipulating Stands			
1	24:50	24:56	00:06	Adjusting Assembly	adjfive		
1	24:56	25:01	00:05	Looking at Drawing			
1	25:01	25:11	00:10	Adjusting Assembly	adj1		
1	25:11	25:15	00:04	Looking at Drawing			
1	25:15	25:32	00:17	Adjusting Assembly	adjthree		
1	25:32	25:49	00:17	Looking at Drawing			
1	25:49	25:58	00:09	Adjusting Assembly	adjthree		
1	25:58	26:25	00:27	Looking at Drawing			
1	26:25	26:46	00:21	Looking at 3D Model			
1	26:46	26:52	00:06	Adjusting Assembly	adjthree		
1	26:52	27:40	00:48	Looking at 3D Model			
1	27:40	27:48	00:08	Adjusting Assembly	dis five		
1	27:48	28:04	00:16	Adjusting Assembly	dis three		
1	28:04	28:15	00:11	Manipulating Stands			
1	28:15	28:31	00:16	Adjusting Assembly	adj1		
1	28:31	28:45	00:14	Chatting with Administrator			
2	28:45	29:20	00:35	Scan Acquisition			
2	29:20	29:27	00:07	Model Segmentation			
2	29:27	30:20	00:53	Scan Processing			
2	30:20	30:21	00:01	Output Analysis			
2	30:21	31:24	01:03	Adjusting Clips			
2	31:24	31:36	00:12	Assembling Assembly			
2	31:36	32:02	00:26	Looking at 3D Model			
2	32:02	32:15	00:13	Assembling Assembly	pt 3		
2	32:15	32:57	00:42	Looking at Drawing			
2	32:57	34:09	01:12	Measuring Assembly			
2	34:09	34:17	00:08	Completing Rework			
2	34:17	34:32	00:15	Chatting with Administrator			
2	34:32	34:39	00:07	Measuring Assembly			
2	34:39	35:54	01:15	Manipulating Stands			
2	35:54	36:10	00:16	Measuring Assembly			
2	36:10	36:20	00:10	Manipulating Stands			
2	36:20	36:39	00:19	Measuring Assembly			
2	36:39	36:44	00:05	Manipulating Stands			
2	36:44	36:54	00:10	Measuring Assembly			
2	36:54	37:15	00:21	Assembling Assembly			
2	37:15	38:24	01:09	Manipulating Stands			
2	38:24	38:35	00:11	Adjusting Assembly	pt 3		
2	38:35	38:55	00:20	Manipulating Stands			
2	38:55	39:04	00:09	Measuring Assembly	pt 3		
2	39:04	39:06	00:02	Adjusting Assembly	pt 3		
2	39:06	39:33	00:27	Measuring Assembly			

Cycle	Start	End	Duration	Category	Note
2	39:33	40:02	00:29	Manipulating Stands	
2	40:02	40:13	00:11	Measuring Assembly	
2	40:13	41:44	01:31	Manipulating Stands	
2	41:44	42:20	00:36	Chatting with Administrator	
2	42:20	43:15	00:55	Manipulating Stands	
2	43:15	43:40	00:25	Chatting with Administrator	
2	43:40	43:56	00:16	Measuring Assembly	
2	43:56	44:30	00:34	Chatting with Administrator	
2	44:30	45:08	00:38	Measuring Assembly	
2	45:08	45:20	00:12	Looking at Drawing	
2	45:20	45:27	00:07	Adjusting Assembly	pt 2
2	45:27	45:58	00:31	Looking at Drawing	
2	45:58	46:10	00:12	Measuring Assembly	
2	46:10	46:24	00:14	Manipulating Stands	
2	46:24	47:08	00:44	Measuring Assembly	
2	47:08	47:12	00:04	Looking at Drawing	
2	47:12	47:20	00:08	Measuring Assembly	
2	47:20	47:26	00:06	Adjusting Assembly	pt 2
2	47:26	47:36	00:10	Measuring Assembly	
2	47:36	48:04	00:28	Looking at Drawing	
3	48:04	51:16	03:12	Scan Acquisition	
3	51:16	51:25	00:09	Model Segmentation	
3	51:25	52:28	01:03	Scan Processing	
3	52:28	52:46	00:18	Chatting with Administrator	
3	52:46	52:57	00:11	Output Analysis	
3	52:57	53:09	00:12	Scan Processing	
3	53:09	53:11	00:02	Output Analysis	
3	53:11	53:20	00:09	Looking at 3D Model	
3	53:20	53:27	00:07	Completing Rework	rw4
3	53:27	53:48	00:21	Adjusting Clips	
3	53:48	54:43	00:55	Manipulating Stands	
3	54:43	54:55	00:12	Measuring Assembly	
3	54:55	55:06	00:11	Manipulating Stands	
3	55:06	55:22	00:16	Measuring Assembly	
3	55:22	55:40	00:18	Manipulating Stands	
3	55:40	57:30	01:50	Measuring Assembly	
3	57:30	57:39	00:09	Completing Rework	rw4
3	57:39	57:51	00:12	Measuring Assembly	
3	57:51	57:56	00:05	Completing Rework	rw4
3	57:56	58:07	00:11	Measuring Assembly	
4	58:07	58:50	00:43	Scan Acquisition	
4	58:50	1:00:06	01:16	Scan Processing	
4	1:00:06	1:00:07	00:01	Output Analysis	
4	1:00:07	1:01:15	01:08	Chatting with Administrator	
4	1:01:15	1:01:33	00:18	Assembling Assembly	
4	1:01:33	1:01:36	00:03	Looking at Drawing	
4	1:01:36	1:01:50	00:14	Assembling Assembly	pt 5
4	1:01:50	1:02:18	00:28	Measuring Assembly	
4	1:02:18	1:02:22	00:04	Assembling Assembly	
4	1:02:22	1:02:35	00:13	Measuring Assembly	
5	1:02:35	1:03:25	00:50	Scan Acquisition	
5	1:03:25	1:04:15	00:50	Scan Processing	
5	1:04:15	1:04:16	00:01	Output Analysis	

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Cycle	Start	End	Duration	Category	Note			
1	00:00	01:51	01:51	Chatting with Administrator			**Totals**	
1	01:51	02:16	00:25	Looking at 3D Model			Chatting with Administrator	19:05
1	02:16	02:22	00:06	Chatting with Administrator			Assembling Assembly	00:40
1	02:22	02:39	00:17	Model Segmentation			Adjusting Clips	05:13
1	02:39	02:41	00:02	Looking at 3D Model			Measuring Assembly	03:49
1	02:41	03:00	00:19	Assembly Layout			Checking Assembly	01:27
1	03:00	03:05	00:05	Looking at 3D Model			Manipulating Stands	03:43
1	03:05	03:08	00:03	Assembly Layout			Adjusting Assembly	02:25
1	03:08	03:15	00:07	Looking at 3D Model			Assembly Layout	00:22
1	03:15	03:20	00:05	Assembling Assembly	pt 2		Looking at Drawing	11:26
1	03:20	03:30	00:10	Looking at Drawing			Completing Rework	00:57
1	03:30	03:34	00:04	Adjusting Assembly	adj 2		Model Segmentation	00:52
1	03:34	03:55	00:21	Looking at Drawing			Looking at 3D Model	07:10

1	03:55	04:18	00:23	Looking at 3D Model		Scan Acquisition	02:45
1	04:18	04:47	00:29	Looking at Drawing		Scan Processing	05:41
1	04:47	06:00	01:13	Chatting with Administrator		Output Analysis	00:25
1	06:00	06:06	00:06	Adjusting Assembly	adj 2	Total	1:06:00
1	06:06	06:15	00:09	Looking at Drawing			
1	06:15	06:35	00:20	Adjusting Assembly	adj 2		
1	06:35	06:54	00:19	Model Segmentation			
1	06:54	07:10	00:16	Looking at 3D Model			
1	07:10	07:20	00:10	Assembling Assembly	pt 5		
1	07:20	07:32	00:12	Looking at 3D Model			
1	07:32	07:38	00:06	Adjusting Assembly	adj 5		
1	07:38	07:55	00:17	Looking at Drawing			
1	07:55	07:59	00:04	Adjusting Assembly	adj 5		
1	07:59	08:06	00:07	Adjusting Clips			
1	08:06	08:16	00:10	Looking at Drawing			
1	08:16	08:27	00:11	Looking at 3D Model			
1	08:27	08:40	00:13	Adjusting Clips			
1	08:40	08:57	00:17	Looking at 3D Model			
1	08:57	09:03	00:06	Adjusting Clips			
1	09:03	09:10	00:07	Looking at 3D Model			
1	09:10	09:15	00:05	Model Segmentation			
1	09:15	09:40	00:25	Looking at 3D Model			
1	09:40	09:50	00:10	Adjusting Assembly	adj 2		
1	09:50	09:55	00:05	Looking at 3D Model			
1	09:55	10:15	00:20	Looking at Drawing			
1	10:15	10:19	00:04	Adjusting Assembly	adj 2		
1	10:19	11:03	00:44	Measuring Assembly			
1	11:03	11:09	00:06	Adjusting Assembly	adj one		
1	11:09	11:15	00:06	Manipulating Stands			
1	11:15	11:35	00:20	Looking at Drawing			
1	11:35	11:46	00:11	Model Segmentation			
1	11:46	12:43	00:57	Looking at 3D Model			
1	12:43	12:59	00:16	Looking at Drawing			
1	12:59	13:14	00:15	Chatting with Administrator			
1	13:14	13:22	00:08	Looking at 3D Model			
1	13:22	13:36	00:14	Looking at Drawing			
1	13:36	13:48	00:12	Looking at 3D Model			
1	13:48	14:10	00:22	Looking at Drawing			
1	14:10	14:25	00:15	Measuring Assembly			
1	14:25	14:50	00:25	Manipulating Stands			
1	14:50	15:05	00:15	Looking at Drawing			
1	15:05	15:15	00:10	Measuring Assembly			
1	15:15	15:50	00:35	Looking at Drawing			
1	15:50	16:15	00:25	Assembling Assembly	pt 3 to two		
1	16:15	16:30	00:15	Manipulating Stands			
1	16:30	16:55	00:25	Looking at Drawing			
1	16:55	17:10	00:15	Measuring Assembly			
1	17:10	17:50	00:40	Looking at 3D Model			
1	17:50	18:10	00:20	Looking at Drawing			
1	18:10	18:27	00:17	Measuring Assembly			
1	18:27	19:14	00:47	Looking at Drawing			
1	19:14	19:39	00:25	Chatting with Administrator			
1	19:39	19:47	00:08	Looking at Drawing			
1	19:47	20:02	00:15	Looking at 3D Model			
1	20:02	20:12	00:10	Looking at Drawing			
1	20:12	20:18	00:06	Looking at 3D Model			
1	20:18	20:55	00:37	Looking at Drawing			
1	20:55	21:23	00:28	Adjusting Clips			
1	21:23	21:32	00:09	Looking at Drawing			
1	21:32	21:40	00:08	Adjusting Clips			
1	21:40	21:46	00:06	Adjusting Assembly	adj 5		
1	21:46	21:50	00:04	Looking at Drawing			
1	21:50	21:56	00:06	Adjusting Assembly	adj 5		
1	21:56	22:00	00:04	Adjusting Clips			
1	22:00	22:10	00:10	Adjusting Clips			
1	22:10	22:32	00:22	Manipulating Stands			
1	22:32	22:41	00:09	Checking Assembly			
1	22:41	23:26	00:45	Measuring Assembly			
1	23:26	23:36	00:10	Manipulating Stands			
1	23:36	23:45	00:09	Measuring Assembly			
1	23:45	23:55	00:10	Manipulating Stands			

1	23:55	24:17	00:22	Measuring Assembly	
1	24:17	24:23	00:06	Manipulating Stands	
1	24:23	24:30	00:07	Measuring Assembly	
1	24:30	24:33	00:03	Manipulating Stands	
1	24:33	24:40	00:07	Measuring Assembly	
1	24:40	25:06	00:26	Looking at Drawing	
1	25:06	25:12	00:06	Adjusting Assembly	undrw 3
1	25:12	25:21	00:09	Adjusting Assembly	undrw 2
1	25:21	25:25	00:04	Manipulating Stands	
1	25:25	25:35	00:10	Adjusting Assembly	undrw 3
1	25:35	25:55	00:20	Manipulating Stands	
1	25:55	26:02	00:07	Measuring Assembly	
1	26:02	26:10	00:08	Adjusting Assembly	undrw 3
1	26:10	26:18	00:08	Manipulating Stands	
1	26:18	26:44	00:26	Measuring Assembly	
1	26:44	26:50	00:06	Adjusting Assembly	undrw 3
1	26:50	26:56	00:06	Manipulating Stands	
1	26:56	27:01	00:05	Measuring Assembly	
1	27:01	27:34	00:33	Looking at Drawing	
1	27:34	27:38	00:04	Manipulating Stands	
1	27:38	28:13	00:35	Looking at 3D Model	
1	28:13	28:40	00:27	Looking at Drawing	
1	28:40	28:50	00:10	Looking at 3D Model	
1	28:50	29:04	00:14	Looking at Drawing	
1	29:04	29:22	00:18	Adjusting Assembly	undrw 1
1	29:22	30:02	00:40	Looking at Drawing	
1	30:02	30:32	00:30	Looking at 3D Model	
1	30:32	30:41	00:09	Adjusting Assembly	undrw 1
1	30:41	30:52	00:11	Looking at 3D Model	
1	30:52	30:59	00:07	Adjusting Assembly	undrw 3
1	30:59	31:35	00:36	Looking at Drawing	
1	31:35	31:58	00:23	Chatting with Administrator	
1	31:58	32:35	00:37	Adjusting Clips	
1	32:35	33:20	00:45	Chatting with Administrator	
2	33:20	33:58	00:38	Scan Acquisition	
2	33:58	44:00	10:02	Chatting with Administrator	
2	44:00	45:01	01:01	Chatting with Administrator	
2	45:01	45:36	00:35	Scan Processing	
2	45:36	46:10	00:34	Chatting with Administrator	
2	46:10	46:15	00:05	Output Analysis	
2	46:15	46:25	00:10	Manipulating Stands	
2	46:25	46:35	00:10	Adjusting Clips	
2	46:35	46:45	00:10	Completing Rework	rw 5
2	46:45	47:02	00:17	Adjusting Clips	
2	47:02	47:35	00:33	Looking at 3D Model	
2	47:35	47:57	00:22	Adjusting Clips	
2	47:57	48:11	00:14	Completing Rework	rw 3
2	48:11	48:27	00:16	Adjusting Clips	
2	48:27	48:49	00:22	Checking Assembly	
2	48:49	48:58	00:09	Looking at 3D Model	
2	48:58	49:10	00:12	Adjusting Clips	
2	49:10	49:15	00:05	Completing Rework	rw 5
2	49:15	49:23	00:08	Adjusting Clips	
2	49:23	49:35	00:12	Manipulating Stands	
2	49:35	49:55	00:20	Chatting with Administrator	
2	49:55	50:05	00:10	Looking at Drawing	
2	50:05	50:11	00:06	Checking Assembly	
2	50:11	50:42	00:31	Looking at Drawing	
2	50:42	50:52	00:10	Manipulating Stands	
2	50:52	51:11	00:19	Adjusting Clips	
2	51:11	51:25	00:14	Completing Rework	rw 3
2	51:25	51:30	00:05	Manipulating Stands	
2	51:30	51:50	00:20	Checking Assembly	
2	51:50	51:58	00:08	Manipulating Stands	
2	51:58	52:20	00:22	Looking at Drawing	
2	52:20	52:24	00:04	Manipulating Stands	
2	52:24	52:40	00:16	Checking Assembly	
2	52:40	52:44	00:04	Looking at Drawing	
2	52:44	52:58	00:14	Checking Assembly	
2	52:58	53:01	00:03	Completing Rework	rw 5
2	53:01	53:30	00:29	Manipulating Stands	

2	53:30	53:56	00:26	Looking at Drawing	
2	53:56	54:27	00:31	Chatting with Administrator	
2	54:27	54:45	00:18	Adjusting Clips	
2	54:45	55:55	01:10	Chatting with Administrator	
2	55:55	56:01	00:06	Scan Processing	
2	56:01	56:15	00:14	Chatting with Administrator	
3	56:15	56:47	00:32	Scan Acquisition	
3	56:47	59:08	02:21	Scan Processing	
3	59:08	59:20	00:12	Output Analysis	
3	59:20	59:35	00:15	Chatting with Administrator	
3	59:35	59:43	00:08	Adjusting Clips	
3	59:43	59:50	00:07	Completing Rework	rw 3
3	59:50	59:56	00:06	Manipulating Stands	
3	59:56	1:00:00	00:04	Completing Rework	rw 3
3	1:00:00	1:00:08	00:08	Adjusting Clips	
3	1:00:08	1:00:17	00:09	Looking at 3D Model	
3	1:00:17	1:00:36	00:19	Looking at Drawing	
4	1:00:36	1:01:25	00:49	Scan Acquisition	
4	1:01:25	1:02:39	01:14	Scan Processing	
4	1:02:39	1:02:45	00:06	Output Analysis	
4	1:02:45	1:03:02	00:17	Scan Processing	
4	1:03:02	1:03:04	00:02	Output Analysis	
4	1:03:04	1:04:06	01:02	Adjusting Clips	
4	1:04:06	1:04:52	00:46	Scan Acquisition	
4	04:52	1:06:00	01:08	Scan Processing	

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Cycle	Start	End	Duration	Category	Note
1	00:00	01:00	01:00	Chatting with Administrator	
1	01:00	01:08	00:08	Looking at 3D Model	
1	01:08	01:30	00:22	Looking at Drawing	
1	01:30	01:40	00:10	Chatting with Administrator	
1	01:40	01:45	00:05	Looking at 3D Model	
1	01:45	02:05	00:20	Chatting with Administrator	
1	02:05	02:20	00:15	Model Segmentation	
1	02:20	02:44	00:24	Assembling Assembly	pt 2
2	02:44	03:20	00:36	Scan Acquisition	
2	03:20	04:00	00:40	Scan Processing	
2	04:00	05:34	01:34	Chatting with Administrator	
2	05:34	05:50	00:16	Output Analysis	
2	05:50	05:59	00:09	Looking at 3D Model	
2	05:59	06:15	00:16	Completing Rework	rw 2
2	06:15	06:48	00:33	Chatting with Administrator	
2	06:48	07:10	00:22	Assembly Layout	
2	07:10	07:25	00:15	Manipulating Stands	
2	07:25	07:38	00:13	Chatting with Administrator	
2	07:38	08:04	00:26	Manipulating Stands	
2	08:04	08:10	00:06	Assembly Layout	
2	08:10	08:35	00:25	Manipulating Stands	
2	08:35	08:53	00:18	Looking at Drawing	
2	08:53	09:00	00:07	Manipulating Stands	
2	09:00	09:35	00:35	Assembly Layout	
2	09:35	10:00	00:25	Measuring Assembly	
2	10:00	10:30	00:30	Chatting with Administrator	
3	10:30	10:45	00:15	Scan Acquisition	
3	10:45	12:06	01:21	Scan Processing	
3	12:06	12:18	00:12	Chatting with Administrator	
3	12:18	12:22	00:04	Output Analysis	
3	12:22	12:37	00:15	Chatting with Administrator	
3	12:37	13:09	00:32	Model Segmentation	
3	13:09	13:32	00:23	Assembling Assembly	pt 3
3	13:32	13:50	00:18	Looking at Drawing	
3	13:50	13:56	00:06	Adjusting Assembly	pt four
3	13:56	14:22	00:26	Looking at Drawing	
3	14:22	14:37	00:15	Chatting with Administrator	
3	14:37	14:55	00:18	Looking at 3D Model	
3	14:55	15:08	00:13	Looking at Drawing	
3	15:08	15:26	00:18	Chatting with Administrator	
4	15:26	16:10	00:44	Scan Acquisition	

Totals	
Chatting with Administrator	07:27
Assembling Assembly	01:07
Adjusting Clips	00:00
Measuring Assembly	00:25
Checking Assembly	00:00
Manipulating Stands	01:13
Adjusting Assembly	00:06
Assembly Layout	01:03
Looking at Drawing	01:37
Completing Rework	00:52
Model Segmentation	01:01
Looking at 3D Model	02:18
Scan Acquisition	05:21
Scan Processing	08:07
Output Analysis	00:40
Total	31:17

4	16:10	17:40	01:30	Scan Processing	
4	17:40	17:44	00:04	Output Analysis	
4	17:44	17:55	00:11	Looking at 3D Model	
4	17:55	18:04	00:09	Completing Rework	rw 4
5	18:04	18:47	00:43	Scan Acquisition	
5	18:47	19:36	00:49	Scan Processing	
5	19:36	19:40	00:04	Output Analysis	
5	19:40	19:55	00:15	Looking at 3D Model	
5	19:55	20:00	00:05	Completing Rework	rw 4
6	20:00	20:50	00:50	Scan Acquisition	
6	20:50	21:38	00:48	Scan Processing	
6	21:38	21:44	00:06	Output Analysis	
6	21:44	22:00	00:16	Looking at 3D Model	
6	22:00	22:15	00:15	Completing Rework	rw 4
7	22:15	22:41	00:26	Scan Acquisition	
7	22:41	23:08	00:27	Scan Processing	
7	23:08	23:10	00:02	Output Analysis	
7	23:10	23:24	00:14	Model Segmentation	
7	23:24	23:37	00:13	Looking at 3D Model	
7	23:37	23:50	00:13	Looking at 3D Model	
7	23:50	23:55	00:05	Assembling Assembly	pt 5
7	23:55	24:25	00:30	Looking at 3D Model	
7	24:25	24:40	00:15	Assembling Assembly	pt 5
7	24:40	24:55	00:15	Chatting with Administrator	
8	24:55	25:30	00:35	Scan Acquisition	
8	25:30	25:58	00:28	Scan Processing	
8	25:58	26:00	00:02	Output Analysis	
8	26:00	26:03	00:03	Completing Rework	rw 5
9	26:03	26:29	00:26	Scan Acquisition	
9	26:29	27:13	00:44	Scan Processing	
9	27:13	27:45	00:32	Chatting with Administrator	crash
9	27:45	28:00	00:15	Scan Processing	
9	28:00	28:35	00:35	Chatting with Administrator	
9	28:35	28:40	00:05	Scan Acquisition	
9	28:40	28:44	00:04	Completing Rework	rw 5
10	28:44	29:25	00:41	Scan Acquisition	
10	29:25	30:30	01:05	Scan Processing	
10	30:30	30:32	00:02	Output Analysis	
10	30:32	31:17	00:45	Chatting with Administrator	

Appendix E

Engineers with Isometric Raw Data

				E-P-01			

Cycle	Start	End	Duration	Category	Note		
1	00:00	00:13	00:13	Looking at Drawing		**Totals**	
1	00:13	01:20	01:07	Chatting with Administrator		Chatting with Administrator	17:53
1	01:20	04:25	03:05	Looking at Drawing		Assembling Assembly	01:02
1	04:25	06:10	01:45	Chatting with Administrator		Adjusting Clips	00:00
1	06:10	06:30	00:20	Assembly Layout		Measuring Assembly	13:28
1	06:30	07:10	00:40	Looking at Drawing		Checking Assembly	00:00
1	07:10	07:30	00:20	Assembly Layout		Manipulating Stands	04:10
1	07:30	08:22	00:52	Looking at Drawing		Adjusting Assembly	03:18
1	08:22	08:43	00:21	Chatting with Administrator		Assembly Layout	01:11
1	08:43	08:56	00:13	Manipulating Stands		Looking at Drawing	12:17
1	08:56	09:10	00:14	Assembling Assembly	pt 2	Completing Rework	00:45
1	09:10	09:23	00:13	Manipulating Stands		Quality Control	09:02
1	09:23	10:16	00:53	Measuring Assembly		Conveying Corrections	01:02
1	10:16	10:23	00:07	Adjusting Assembly	pt 2	Total	1:04:08
1	10:23	10:37	00:14	Looking at Drawing			
1	10:37	11:00	00:23	Adjusting Assembly	pt 2		
1	11:00	11:22	00:22	Looking at Drawing			
1	11:22	11:33	00:11	Assembly Layout			
1	11:33	11:44	00:11	Manipulating Stands			
1	11:44	11:52	00:08	Looking at Drawing			
1	11:52	12:08	00:16	Manipulating Stands			
1	12:08	12:35	00:27	Looking at Drawing			
1	12:35	12:43	00:08	Assembling Assembly	pt 5		
1	12:43	12:53	00:10	Looking at Drawing			
1	12:53	12:55	00:02	Adjusting Assembly	pt 5		
1	12:55	13:23	00:28	Looking at Drawing			
1	13:23	13:29	00:06	Adjusting Assembly	pt 5		
1	13:29	13:40	00:11	Manipulating Stands			
1	13:40	14:10	00:30	Looking at Drawing			
1	14:10	14:45	00:35	Measuring Assembly			
1	14:45	15:30	00:45	Adjusting Assembly	pt 2		
1	15:30	15:55	00:25	Measuring Assembly			
1	15:55	16:10	00:15	Manipulating Stands			
1	16:10	16:20	00:10	Looking at Drawing			
1	16:20	16:28	00:08	Measuring Assembly			
1	16:28	17:40	01:12	Measuring Assembly			
1	17:40	18:00	00:20	Looking at Drawing			
1	18:00	18:20	00:20	Assembly Layout			
1	18:20	18:48	00:28	Looking at Drawing			
1	18:48	19:14	00:26	Assembling Assembly	pt 3		
1	19:14	19:21	00:07	Looking at Drawing			
1	19:21	19:35	00:14	Assembling Assembly	pt 5		
1	19:35	20:28	00:53	Manipulating Stands			
1	20:28	20:36	00:08	Adjusting Assembly	pt 3		
1	20:36	20:45	00:09	Manipulating Stands			
1	20:45	21:34	00:49	Chatting with Administrator			
1	21:34	21:54	00:20	Adjusting Assembly	pt 2		
1	21:54	22:00	00:06	Manipulating Stands			
1	22:00	22:22	00:22	Looking at Drawing			
1	22:22	22:53	00:31	Measuring Assembly			
1	22:53	23:30	00:37	Looking at Drawing			
1	23:30	23:40	00:10	Measuring Assembly			
1	23:40	23:50	00:10	Looking at Drawing			
1	23:50	24:00	00:10	Measuring Assembly			
1	24:00	24:12	00:12	Looking at Drawing			
1	24:12	24:22	00:10	Adjusting Assembly	pt 3		
1	24:22	24:30	00:08	Manipulating Stands			
1	24:30	24:43	00:13	Looking at Drawing			
1	24:43	24:55	00:12	Measuring Assembly			
1	24:55	25:38	00:43	Looking at Drawing			

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1	25:38	27:06	01:28	Measuring Assembly	
1	27:06	27:36	00:30	Looking at Drawing	
1	27:36	28:27	00:51	Measuring Assembly	
1	28:27	28:33	00:06	Looking at Drawing	
1	28:33	28:52	00:19	Chatting with Administrator	
1	28:52	29:20	00:28	Looking at Drawing	
1	29:20	29:33	00:13	Chatting with Administrator	
1	29:33	29:40	00:07	Adjusting Assembly	pt 5
1	29:40	30:05	00:25	Measuring Assembly	
1	30:05	30:22	00:17	Looking at Drawing	
1	30:22	30:28	00:06	Adjusting Assembly	pt 5
1	30:28	30:45	00:17	Manipulating Stands	
1	30:45	31:39	00:54	Measuring Assembly	
1	31:39	31:42	00:03	Adjusting Assembly	pt 5
1	31:42	31:47	00:05	Measuring Assembly	
1	31:47	31:50	00:03	Adjusting Assembly	pt 5
1	31:50	32:00	00:10	Measuring Assembly	
1	32:00	32:07	00:07	Adjusting Assembly	pt 5
1	32:07	32:18	00:11	Measuring Assembly	
1	32:18	32:44	00:26	Adjusting Clips	
1	32:44	33:00	00:16	Looking at Drawing	
1	33:00	33:30	00:30	Measuring Assembly	
1	33:30	34:06	00:36	Adjusting Assembly	pt one
1	34:06	34:24	00:18	Measuring Assembly	
1	34:24	34:39	00:15	Adjusting Assembly	pt one
1	34:39	34:58	00:19	Manipulating Stands	
1	34:58	35:15	00:17	Measuring Assembly	
1	35:15	35:24	00:09	Looking at Drawing	
1	35:24	36:30	01:06	Chatting with Administrator	
2	36:30	38:30	02:00	Quality Control	
2	38:30	38:37	00:07	Conveying Corrections	
2	38:37	38:45	00:08	Chatting with Administrator	
2	38:45	38:55	00:10	Adjusting Clips	
2	38:55	39:02	00:07	Completing Rework	rw 5
2	39:02	39:08	00:06	Manipulating Stands	
2	39:08	39:30	00:22	Conveying Corrections	
2	39:30	39:38	00:08	Chatting with Administrator	
2	39:38	39:49	00:11	Manipulating Stands	
2	39:49	40:02	00:13	Chatting with Administrator	
2	40:02	40:09	00:07	Conveying Corrections	
2	40:09	40:22	00:13	Manipulating Stands	
2	40:22	40:40	00:18	Conveying Corrections	
2	40:40	40:55	00:15	Chatting with Administrator	
2	40:55	41:00	00:05	Completing Rework	rw 3
2	41:00	41:05	00:05	Chatting with Administrator	
2	41:05	41:09	00:04	Completing Rework	rw 3
2	41:09	41:10	00:01	Completing Rework	rw 5
2	41:10	41:44	00:34	Chatting with Administrator	
3	41:44	44:00	02:16	Quality Control	
3	44:00	44:08	00:08	Conveying Corrections	
3	44:08	44:13	00:05	Chatting with Administrator	
3	44:13	44:18	00:05	Completing Rework	rw 5
3	44:18	44:28	00:10	Measuring Assembly	
3	44:28	44:40	00:12	Completing Rework	rw 5
3	44:40	45:14	00:34	Chatting with Administrator	
4	45:14	47:15	02:01	Quality Control	
4	47:15	47:23	00:08	Manipulating Stands	
4	47:23	47:37	00:14	Chatting with Administrator	
4	47:37	47:58	00:21	Manipulating Stands	
4	47:58	48:03	00:05	Completing Rework	rw 5
4	48:03	48:14	00:11	Chatting with Administrator	
4	48:14	48:22	00:08	Measuring Assembly	
4	48:22	48:28	00:06	Completing Rework	rw 5
5	48:28	51:13	02:45	Quality Control	
5	51:13	54:38	03:25	Chatting with Administrator	
5	54:38	58:23	03:45	Measuring Assembly	
5	58:23	1:04:44	06:21	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:15	00:15	Looking at Drawing	
1	00:15	00:22	00:07	Chatting with Administrator	
1	00:22	00:40	00:18	Looking at Drawing	
1	00:40	00:51	00:11	Assembling Assembly	
1	00:51	00:54	00:03	Looking at Drawing	
1	00:54	01:00	00:06	Assembling Assembly	
1	01:00	01:05	00:05	Looking at Drawing	
1	01:05	01:18	00:13	Assembling Assembly	
1	01:18	01:38	00:20	Assembling Assembly	.
1	01:38	02:00	00:22	Looking at Drawing	
1	02:00	02:11	00:11	Assembling Assembly	pt2
1	02:11	02:40	00:29	Looking at Drawing	
1	02:40	03:23	00:43	Manipulating Stands	
1	03:23	03:33	00:10	Assembling Assembly	pt4
1	03:33	03:54	00:21	Measuring Assembly	
1	03:54	04:08	00:14	Manipulating Stands	
1	04:08	09:45	05:37	Measuring Assembly	(some thinking about tools)
1	09:45	11:11	01:26	Looking at Drawing	
1	11:11	11:30	00:19	Manipulating Stands	
1	11:30	11:45	00:15	Adjusting Assembly	pt5
1	11:45	11:58	00:13	Looking at Drawing	
1	11:58	12:15	00:17	Adjusting Assembly	
1	12:15	12:20	00:05	Looking at Drawing	
1	12:20	12:53	00:33	Adjusting Assembly	
1	12:53	12:55	00:02	Manipulating Stands	
1	12:55	13:03	00:08	Looking at Drawing	
1	13:03	13:53	00:50	Measuring Assembly	
1	13:53	14:15	00:22	Manipulating Stands	fell off
1	14:15	14:25	00:10	Adjusting Assembly	
1	14:25	15:10	00:45	Measuring Assembly	
1	15:10	15:30	00:20	Manipulating Stands	
1	15:30	16:05	00:35	Measuring Assembly	
1	16:05	16:35	00:30	Adjusting Assembly	
1	16:35	16:48	00:13	Chatting with Administrator	
1	16:48	0:17:12	00:24	Looking at Drawing	(measure?)
1	17:12	17:27	00:15	Adjusting Assembly	
1	17:27	18:06	00:39	Adjusting Clips	
1	18:06	18:16	00:10	Adjusting Assembly	
1	18:16	21:00	02:44	Measuring Assembly	
1	21:00	21:05	00:05	Adjusting Assembly	
1	21:05	21:27	00:22	Looking at Drawing	
1	21:27	21:45	00:18	Adjusting Clips	
1	21:45	21:50	00:05	Adjusting Assembly	
1	21:50	22:20	00:30	Looking at Drawing	
1	22:20	23:05	00:45	Measuring Assembly	
1	23:05	0:23:30	00:25	Manipulating Stands	
1	23:30	24:14	00:44	Adjusting Assembly	
1	24:14	25:00	00:46	Adjusting Clips	
2	25:00	29:23	04:23	Quality Control	

Totals	
Chatting with Administrator	00:20
Assembling Assembly	01:11
Adjusting Clips	01:43
Measuring Assembly	11:37
Checking Assembly	00:00
Manipulating Stands	02:25
Adjusting Assembly	03:04
Assembly Layout	00:00
Looking at Drawing	04:40
Completing Rework	00:00
Quality Control	04:23
Conveying Corrections	00:00
Total	29:23

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:38	00:38	Chatting with Administrator	
1	00:38	01:23	00:45	Assembly Layout	
1	01:23	02:16	00:53	Looking at Drawing	
1	02:16	02:25	00:09	Measuring Assembly	
1	02:25	03:10	00:45	Looking at Drawing	
1	03:10	03:33	00:23	Measuring Assembly	
1	03:33	03:45	00:12	Assembling Assembly	
1	03:45	04:02	00:17	Measuring Assembly	
1	04:02	04:29	00:27	Adjusting Clips	
1	04:29	04:33	00:04	Assembling Assembly	
1	04:33	04:50	00:17	Measuring Assembly	
1	04:50	05:08	00:18	Assembling Assembly	
1	05:08	05:20	00:12	Adjusting Clips	

Totals	
Chatting with Administrator	15:20
Assembling Assembly	01:35
Adjusting Clips	01:30
Measuring Assembly	31:10
Checking Assembly	00:00
Manipulating Stands	05:50
Adjusting Assembly	03:01
Assembly Layout	00:45
Looking at Drawing	11:31
Completing Rework	05:11
Quality Control	33:03
Conveying Corrections	04:26

							Total	1:53:22
1	05:20	06:25	01:05	Looking at Drawing				
1	06:25	06:55	00:30	Assembling Assembly				
1	06:55	07:07	00:12	Assembling Assembly				
1	07:07	07:21	00:14	Adjusting Clips				
1	07:21	08:08	00:47	Chatting with Administrator				
1	08:08	08:36	00:28	Looking at Drawing				
1	08:36	08:50	00:14	Assembling Assembly				
1	08:50	09:06	00:16	Manipulating Stands				
1	09:06	09:20	00:14	Looking at Drawing				
1	09:20	11:10	01:50	Measuring Assembly				
1	11:10	11:58	00:48	Looking at Drawing				
1	11:58	12:35	00:37	Measuring Assembly				
1	12:35	12:52	00:17	Manipulating Stands				
1	12:52	13:04	00:12	Looking at Drawing				
1	13:04	13:20	00:16	Measuring Assembly				
1	13:20	17:10	03:50	Looking at Drawing				
1	17:10	17:37	00:27	Measuring Assembly				
1	17:37	17:43	00:06	Adjusting Assembly	UNDOC RW 1			
1	17:43	18:05	00:22	Measuring Assembly				
1	18:05	18:16	00:11	Adjusting Assembly	UNDOC RW 4			
1	18:16	18:20	00:04	Looking at Drawing				
1	18:20	18:27	00:07	Adjusting Assembly	UNDOC RW 4			
1	18:27	18:45	00:18	Looking at Drawing				
1	18:45	19:15	00:30	Measuring Assembly				
1	19:15	19:21	00:06	Adjusting Assembly	UNDOC RW 4			
1	19:21	19:50	00:29	Looking at Drawing				
1	19:50	19:52	00:02	Adjusting Assembly	UNDOC RW 4			
1	19:52	20:00	00:08	Looking at Drawing				
1	20:00	20:12	00:12	Adjusting Assembly	UNDOC RW 1			
1	20:12	20:22	00:10	Adjusting Assembly	UNDOC RW 5			
1	20:22	20:44	00:22	Looking at Drawing				
1	20:44	21:00	00:16	Measuring Assembly				
1	21:00	21:10	00:10	Adjusting Assembly	UNDOC RW 4			
1	21:10	21:26	00:16	Looking at Drawing				
1	21:26	22:08	00:42	Measuring Assembly				
1	22:08	22:19	00:11	Adjusting Assembly	UNDOC RW 4			
1	22:19	22:33	00:14	Measuring Assembly				
1	22:33	22:55	00:22	Adjusting Assembly	UNDOC RW 4			
1	22:55	23:27	00:32	Looking at Drawing				
1	23:27	23:32	00:05	Adjusting Assembly	UNDOC RW 4			
1	23:32	23:42	00:10	Measuring Assembly				
1	23:42	23:48	00:06	Adjusting Assembly	UNDOC RW 4			
1	23:48	23:52	00:04	Measuring Assembly				
1	23:52	24:00	00:08	Adjusting Assembly	UNDOC RW 4			
1	24:00	24:11	00:11	Measuring Assembly				
1	24:11	24:14	00:03	Adjusting Assembly	UNDOC RW 4			
1	24:14	24:50	00:36	Measuring Assembly				
1	24:50	24:55	00:05	Assembling Assembly				
1	24:55	25:30	00:35	Measuring Assembly				
1	25:30	26:26	00:56	Manipulating Stands				
1	26:26	26:35	00:09	Chatting with Administrator				
1	26:35	27:37	01:02	Measuring Assembly				
1	27:37	27:53	00:16	Adjusting Clips				
1	27:53	28:06	00:13	Adjusting Assembly	UNDOC RW 3			
1	28:06	28:14	00:08	Measuring Assembly				
1	28:14	28:23	00:09	Adjusting Assembly	UNDOC RW 3			
1	28:23	29:10	00:47	Measuring Assembly				
1	29:10	29:15	00:05	Adjusting Assembly	UNDOC RW 2			
1	29:15	29:52	00:37	Measuring Assembly				
1	29:52	29:59	00:07	Adjusting Assembly	UNDOC RW 3			
1	29:59	31:00	01:01	Measuring Assembly				
1	31:00	31:10	00:10	Adjusting Assembly	UNDOC RW 4			
1	31:10	31:24	00:14	Manipulating Stands				
1	31:24	31:30	00:06	Measuring Assembly				
1	31:30	31:32	00:02	Adjusting Assembly	UNDOC RW 4			
1	31:32	31:42	00:10	Measuring Assembly				
1	31:42	31:48	00:06	Adjusting Assembly	UNDOC RW 4			
1	31:48	31:53	00:05	Measuring Assembly				
1	31:53	32:00	00:07	Adjusting Assembly	UNDOC RW 4			
1	32:00	32:11	00:11	Measuring Assembly				
1	32:11	32:14	00:03	Adjusting Assembly	UNDOC RW 4			

1	32:14	32:54	00:40	Measuring Assembly	
1	32:54	33:08	00:14	Looking at Drawing	
1	33:08	35:35	02:27	Chatting with Administrator	
2	35:35	37:16	01:41	Quality Control	
2	37:16	37:28	00:12	Chatting with Administrator	
2	37:28	37:35	00:07	Quality Control	
2	37:35	37:44	00:09	Conveying Corrections	
2	37:44	38:10	00:26	Quality Control	
2	38:10	38:13	00:03	Conveying Corrections	
2	38:13	38:30	00:17	Chatting with Administrator	
2	38:30	38:39	00:09	Conveying Corrections	
2	38:39	38:50	00:11	Looking at Drawing	
2	38:50	39:29	00:39	Measuring Assembly	
2	39:29	39:33	00:04	Completing Rework	RW 1
2	39:33	39:45	00:12	Measuring Assembly	
2	39:45	39:49	00:04	Looking at Drawing	
2	39:49	40:10	00:21	Measuring Assembly	
2	40:10	40:38	00:28	Looking at Drawing	
2	40:38	40:56	00:18	Measuring Assembly	
2	40:56	41:06	00:10	Completing Rework	RW 4
2	41:06	41:22	00:16	Measuring Assembly	
2	41:22	41:36	00:14	Manipulating Stands	
2	41:36	41:48	00:12	Measuring Assembly	
2	41:48	41:50	00:02	Manipulating Stands	
2	41:50	41:59	00:09	Measuring Assembly	
2	41:59	42:18	00:19	Completing Rework	RW 2
2	42:18	42:23	00:05	Completing Rework	RW 1
2	42:23	42:37	00:14	Manipulating Stands	
2	42:37	43:06	00:29	Measuring Assembly	
2	43:06	43:10	00:04	Completing Rework	RW 4
2	43:10	43:28	00:18	Completing Rework	RW 2
2	43:28	43:41	00:13	Manipulating Stands	
2	43:41	44:01	00:20	Measuring Assembly	
2	44:01	44:29	00:28	Manipulating Stands	
2	44:29	45:42	01:13	Measuring Assembly	
2	45:42	45:50	00:08	Completing Rework	RW 4
2	45:50	47:53	02:03	Measuring Assembly	
2	47:53	47:55	00:02	Chatting with Administrator	
3	47:55	50:53	02:58	Quality Control	
3	50:53	51:02	00:09	Conveying Corrections	
3	51:02	51:08	00:06	Manipulating Stands	
3	51:08	51:55	00:47	Quality Control	
3	51:55	52:05	00:10	Conveying Corrections	
3	52:05	52:10	00:05	Chatting with Administrator	
3	52:10	52:25	00:15	Adjusting Clips	
3	52:25	52:34	00:09	Completing Rework	RW 1
3	52:34	52:53	00:19	Chatting with Administrator	
3	52:53	53:44	00:51	Measuring Assembly	
3	53:44	53:58	00:14	Completing Rework	RW 5
3	53:58	54:02	00:04	Measuring Assembly	
3	54:02	55:10	01:08	Chatting with Administrator	
3	55:10	55:18	00:08	Measuring Assembly	
3	55:18	58:03	02:45	Chatting with Administrator	
4	58:03	1:00:00	01:57	Quality Control	
4	1:00:00	1:00:14	00:14	Conveying Corrections	
4	1:00:14	1:00:30	00:16	Quality Control	
4	1:00:30	1:00:50	00:20	Conveying Corrections	
4	1:00:50	1:01:02	00:12	Completing Rework	
4	1:01:02	1:03:18	02:16	Measuring Assembly	
5	1:03:18	1:06:15	02:57	Quality Control	
5	1:06:15	1:06:22	00:07	Conveying Corrections	
5	1:06:22	1:06:33	00:11	Completing Rework	RW 3
5	1:06:33	1:07:02	00:29	Chatting with Administrator	
5	1:07:02	1:07:19	00:17	Measuring Assembly	
5	1:07:19	1:07:26	00:07	Completing Rework	RW 3
5	1:07:26	1:07:38	00:12	Measuring Assembly	
5	1:07:38	1:07:50	00:12	Completing Rework	RW 3
5	1:07:50	1:07:54	00:04	Measuring Assembly	
5	1:07:54	1:08:00	00:06	Completing Rework	RW 1
5	1:08:00	1:08:12	00:12	Manipulating Stands	
5	1:08:12	1:08:32	00:20	Measuring Assembly	

5	1:08:32	1:09:10	00:38	Chatting with Administrator	
6	1:09:10	1:10:49	01:39	Quality Control	
6	1:10:49	1:11:14	00:25	Conveying Corrections	
6	1:11:14	1:11:23	00:09	Manipulating Stands	
6	1:11:23	1:12:01	00:38	Measuring Assembly	
6	1:12:01	1:12:07	00:06	Completing Rework	RW 2
6	1:12:07	1:12:15	00:08	Measuring Assembly	
6	1:12:15	1:12:20	00:05	Completing Rework	RW 2
6	1:12:20	1:12:55	00:35	Measuring Assembly	
6	1:12:55	1:13:19	00:24	Chatting with Administrator	
6	1:13:19	1:13:35	00:16	Measuring Assembly	
6	1:13:35	1:14:00	00:25	Chatting with Administrator	
7	1:14:00	1:15:30	01:30	Quality Control	
7	1:15:30	1:15:36	00:06	Conveying Corrections	
7	1:15:36	1:15:48	00:12	Manipulating Stands	
7	1:15:48	1:15:59	00:11	Completing Rework	RW 3
7	1:15:59	1:16:25	00:26	Measuring Assembly	
7	1:16:25	1:16:30	00:05	Manipulating Stands	
7	1:16:30	1:18:10	01:40	Measuring Assembly	
7	1:18:10	1:19:30	01:20	Chatting with Administrator	
8	1:19:30	1:20:15	00:45	Quality Control	
8	1:20:15	1:20:27	00:12	Conveying Corrections	
8	1:20:27	1:20:58	00:31	Measuring Assembly	
8	1:20:58	1:21:08	00:10	Completing Rework	RW 3
8	1:21:08	1:21:30	00:22	Manipulating Stands	
8	1:21:30	1:22:22	00:52	Measuring Assembly	
8	1:22:22	1:22:26	00:04	Completing Rework	RW 3
8	1:22:26	1:23:15	00:49	Chatting with Administrator	
9	1:23:15	1:23:58	00:43	Quality Control	
9	1:23:58	1:24:15	00:17	Conveying Corrections	
9	1:24:15	1:24:34	00:19	Manipulating Stands	
9	1:24:34	1:24:50	00:16	Measuring Assembly	
9	1:24:50	1:24:58	00:08	Completing Rework	RW 1
9	1:24:58	1:25:09	00:11	Manipulating Stands	
9	1:25:09	1:25:22	00:13	Measuring Assembly	
9	1:25:22	1:25:32	00:10	Completing Rework	RW 1
10	1:25:32	1:27:05	01:33	Quality Control	
10	1:27:05	1:27:13	00:08	Conveying Corrections	
10	1:27:13	1:27:52	00:39	Measuring Assembly	
10	1:27:52	1:28:07	00:15	Quality Control	
10	1:28:07	1:28:19	00:12	Manipulating Stands	
10	1:28:19	1:28:26	00:07	Completing Rework	RW 1
10	1:28:26	1:28:55	00:29	Chatting with Administrator	
10	1:28:55	1:29:07	00:12	Measuring Assembly	
10	1:29:07	1:29:18	00:11	Manipulating Stands	
10	1:29:18	1:30:10	00:52	Measuring Assembly	
10	1:30:10	1:30:20	00:10	Looking at Drawing	
10	1:30:20	1:31:05	00:45	Measuring Assembly	
11	1:31:05	1:32:56	01:51	Quality Control	
11	1:32:56	1:33:15	00:19	Chatting with Administrator	crash
11	1:33:15	1:33:46	00:31	Quality Control	crash
11	1:33:46	1:33:59	00:13	Conveying Corrections	
11	1:33:59	1:34:08	00:09	Manipulating Stands	
11	1:34:08	1:34:14	00:06	Completing Rework	RW 1
11	1:34:14	1:34:38	00:24	Manipulating Stands	
11	1:34:38	1:34:44	00:06	Adjusting Clips	
11	1:34:44	1:34:55	00:11	Completing Rework	RW 1
11	1:34:55	1:35:18	00:23	Chatting with Administrator	
12	1:35:18	1:36:39	01:21	Quality Control	
12	1:36:39	1:36:50	00:11	Conveying Corrections	
12	1:36:50	1:37:04	00:14	Completing Rework	RW 3
12	1:37:04	1:37:14	00:10	Manipulating Stands	
12	1:37:14	1:37:26	00:12	Completing Rework	RW 3
12	1:37:26	1:38:17	00:51	Chatting with Administrator	
13	1:38:17	1:39:27	01:10	Quality Control	
13	1:39:27	1:39:36	00:09	Conveying Corrections	
13	1:39:36	1:40:00	00:24	Chatting with Administrator	
13	1:40:00	1:40:08	00:08	Conveying Corrections	
13	1:40:08	1:40:22	00:14	Manipulating Stands	
14	1:40:22	1:41:58	01:36	Quality Control	
14	1:41:58	1:42:02	00:04	Conveying Corrections	

Cycle	Start	End	Duration	Category	Note
14	1:42:02	1:42:10	00:08	Completing Rework	RW 2
15	1:42:10	1:43:35	01:25	Quality Control	
15	1:43:35	1:43:45	00:10	Conveying Corrections	
15	1:43:45	1:43:59	00:14	Completing Rework	RW 1
16	1:43:59	1:45:35	01:36	Quality Control	
16	1:45:35	1:46:03	00:28	Conveying Corrections	
16	1:46:03	1:46:10	00:07	Completing Rework	RW 1
17	1:46:10	1:48:12	02:02	Quality Control	
17	1:48:12	1:48:37	00:25	Conveying Corrections	
17	1:48:37	1:50:46	02:09	Quality Control	
17	1:50:46	1:50:55	00:09	Conveying Corrections	
17	1:50:55	1:51:34	00:39	Completing Rework	RW 1
18	1:51:34	1:53:22	01:48	Quality Control	

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:57	02:57	Chatting with Administrator	
1	02:57	04:15	01:18	Looking at Drawing	
1	04:15	05:24	01:09	Chatting with Administrator	
1	05:24	05:34	00:10	Looking at Drawing	
1	05:34	05:40	00:06	Assembling Assembly	
1	05:40	05:50	00:10	Adjusting Clips	
1	05:50	06:11	00:21	Looking at Drawing	
1	06:11	06:24	00:13	Adjusting Clips	
1	06:24	06:30	00:06	Adjusting Assembly	Undoc RW 1
1	06:30	06:43	00:13	Looking at Drawing	
1	06:43	06:47	00:04	Manipulating Stands	
1	06:47	07:02	00:15	Assembling Assembly	
1	07:02	07:12	00:10	Adjusting Clips	
1	07:12	08:49	01:37	Looking at Drawing	
1	08:49	08:55	00:06	Manipulating Stands	
1	08:55	10:03	01:08	Looking at Drawing	
1	10:03	10:39	00:36	Measuring Assembly	
1	10:39	10:50	00:11	Adjusting Assembly	Undoc RW 3
1	10:50	11:04	00:14	Adjusting Clips	
1	11:04	11:20	00:16	Measuring Assembly	
1	11:20	11:53	00:33	Adjusting Clips	
1	11:53	12:05	00:12	Looking at Drawing	
1	12:05	12:34	00:29	Chatting with Administrator	
1	12:34	12:51	00:17	Adjusting Clips	
1	12:51	13:48	00:57	Looking at Drawing	
1	13:48	13:54	00:06	Assembling Assembly	
1	13:54	14:47	00:53	Looking at Drawing	
1	14:47	15:10	00:23	Manipulating Stands	
1	15:10	15:48	00:38	Measuring Assembly	
1	15:48	15:58	00:10	Assembling Assembly	pt 5
1	15:58	16:25	00:27	Adjusting Clips	
1	16:25	17:14	00:49	Looking at Drawing	
1	17:14	18:04	00:50	Measuring Assembly	
1	18:04	18:34	00:30	Adjusting Clips	
1	18:34	0:18:52	00:18	Checking Assembly	
1	18:52	18:55	00:03	Adjusting Clips	
1	18:55	19:35	00:40	Measuring Assembly	
1	19:35	19:45	00:10	Chatting with Administrator	
1	19:45	20:08	00:23	Manipulating Stands	
1	20:08	20:48	00:40	Chatting with Administrator	
2	20:48	22:36	01:48	Quality Control	
2	22:36	0:22:57	00:21	Chatting with Administrator	
2	22:57	0:23:15	00:18	Conveying Corrections	
2	23:15	0:23:23	00:08	Chatting with Administrator	
2	23:23	23:52	00:29	Conveying Corrections	
2	23:52	24:06	00:14	Chatting with Administrator	
2	24:06	24:43	00:37	Looking at Drawing	
2	24:43	25:22	00:39	Measuring Assembly	
2	25:22	25:35	00:13	Looking at Drawing	
2	25:35	25:46	00:11	Measuring Assembly	
2	25:46	25:56	00:10	Looking at Drawing	
2	25:56	26:03	00:07	Manipulating Stands	

Totals	
Chatting with Administrator	09:47
Assembling Assembly	00:37
Adjusting Clips	06:38
Measuring Assembly	09:37
Checking Assembly	02:14
Manipulating Stands	01:57
Adjusting Assembly	00:17
Assembly Layout	00:00
Looking at Drawing	23:44
Completing Rework	07:16
Quality Control	14:22
Conveying Corrections	01:53
Total	1:18:22

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2	26:03	28:40	02:37	Looking at Drawing	
2	28:40	28:45	00:05	Manipulating Stands	
2	28:45	29:30	00:45	Looking at Drawing	
2	29:30	29:41	00:11	Adjusting Clips	
2	29:41	29:58	00:17	Looking at Drawing	
2	29:58	30:07	00:09	Adjusting Clips	
2	30:07	31:04	00:57	Completing Rework	RW 5
2	31:04	31:25	00:21	Measuring Assembly	
2	31:25	31:34	00:09	Completing Rework	RW 5
2	31:34	31:42	00:08	Measuring Assembly	
2	31:42	31:46	00:04	Completing Rework	RW 5
2	31:46	32:06	00:20	Measuring Assembly	
2	32:06	32:16	00:10	Completing Rework	RW 5
2	32:16	32:22	00:06	Measuring Assembly	
2	32:22	32:43	00:21	Adjusting Clips	
2	32:43	32:58	00:15	Checking Assembly	
2	32:58	33:14	00:16	Adjusting Clips	
2	33:14	33:20	00:06	Completing Rework	RW 5
2	33:20	33:31	00:11	Measuring Assembly	
2	33:31	33:41	00:10	Adjusting Clips	
2	33:41	34:24	00:43	Checking Assembly	
2	34:24	34:35	00:11	Manipulating Stands	
2	34:35	38:20	03:45	Looking at Drawing	
2	38:20	38:52	00:32	Checking Assembly	
2	38:52	39:01	00:09	Adjusting Clips	
2	39:01	39:14	00:13	Completing Rework	RW 5
2	39:14	39:36	00:22	Measuring Assembly	
2	39:36	39:44	00:08	Completing Rework	RW 5
2	39:44	39:54	00:10	Measuring Assembly	
2	39:54	40:01	00:07	Completing Rework	RW 5
2	40:01	40:21	00:20	Measuring Assembly	
2	40:21	40:26	00:05	Completing Rework	RW 5
2	40:26	40:37	00:11	Measuring Assembly	
2	40:37	40:53	00:16	Adjusting Clips	
2	40:53	42:35	01:42	Looking at Drawing	
2	42:35	43:15	00:40	Measuring Assembly	
2	43:15	43:44	00:29	Chatting with Administrator	
2	43:44	46:11	02:27	Looking at Drawing	
2	46:11	46:30	00:19	Chatting with Administrator	
3	46:30	48:26	01:56	Quality Control	
3	48:26	48:54	00:28	Conveying Corrections	
3	48:54	49:04	00:10	Chatting with Administrator	
3	49:04	49:13	00:09	Conveying Corrections	
3	49:13	52:21	03:08	Looking at Drawing	
3	52:21	52:51	00:30	Measuring Assembly	
3	52:51	53:02	00:11	Adjusting Clips	
3	53:02	53:08	00:06	Completing Rework	RW 2
3	53:08	53:16	00:08	Checking Assembly	
3	53:16	53:33	00:17	Completing Rework	RW 2
3	53:33	53:51	00:18	Checking Assembly	
3	53:51	53:57	00:06	Adjusting Clips	
3	53:57	54:05	00:08	Completing Rework	RW 2
3	54:05	54:30	00:25	Measuring Assembly	
3	54:30	54:39	00:09	Adjusting Clips	
3	54:39	54:45	00:06	Completing Rework	RW 2
3	54:45	54:51	00:06	Adjusting Clips	
3	54:51	54:57	00:06	Looking at Drawing	
3	54:57	55:16	00:19	Looking at Drawing	
3	55:16	55:19	00:03	Adjusting Clips	
3	55:19	56:54	01:35	Completing Rework	RW 3
3	56:54	57:12	00:18	Adjusting Clips	
3	57:12	58:33	01:21	Measuring Assembly	
3	58:33	58:43	00:10	Adjusting Clips	
3	58:43	59:16	00:33	Completing Rework	RW 5
3	59:16	59:20	00:04	Measuring Assembly	
3	59:20	59:44	00:24	Completing Rework	RW 5
3	59:44	1:00:12	00:28	Measuring Assembly	
3	1:00:12	1:00:31	00:19	Adjusting Clips	
4	1:00:31	1:03:39	03:08	Quality Control	
4	1:03:39	1:03:48	00:09	Conveying Corrections	
4	1:03:48	1:04:05	00:17	Adjusting Clips	

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4	1:04:05	1:05:12	01:07	Completing Rework	RW 1
4	1:05:12	1:05:23	00:11	Adjusting Clips	
5	1:05:23	1:07:17	01:54	Quality Control	
5	1:07:17	1:07:27	00:10	Conveying Corrections	
5	1:07:27	1:07:59	00:32	Chatting with Administrator	
5	1:07:59	1:08:11	00:12	Adjusting Clips	
5	1:08:11	1:08:40	00:29	Chatting with Administrator	
5	1:08:40	1:08:50	00:10	Measuring Assembly	
5	1:08:50	1:09:20	00:30	Chatting with Administrator	
5	1:09:20	1:09:37	00:17	Adjusting Clips	
5	1:09:37	1:10:08	00:31	Completing Rework	RW 1
6	1:10:08	1:11:45	01:37	Quality Control	
6	1:11:45	1:11:55	00:10	Conveying Corrections	
6	1:11:55	1:12:25	00:30	Chatting with Administrator	
6	1:12:25	1:12:35	00:10	Adjusting Clips	
6	1:12:35	1:12:50	00:15	Chatting with Administrator	
6	1:12:50	1:13:20	00:30	Completing Rework	RW 1
6	1:13:20	1:13:28	00:08	Manipulating Stands	
6	1:13:28	1:13:47	00:19	Chatting with Administrator	
7	1:13:47	1:16:20	02:33	Quality Control	
7	1:16:20	1:16:50	00:30	Manipulating Stands	RW MOVE STANDS
7	1:16:50	1:18:16	01:26	Quality Control	
7	1:18:16	1:18:22	00:06	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:40	02:40	Chatting with Administrator	
1	02:40	02:46	00:06	Looking at Drawing	
1	02:46	03:15	00:29	Assembly Layout	
1	03:15	03:40	00:25	Looking at Drawing	
1	03:40	03:43	00:03	Assembling Assembly	
1	03:43	03:55	00:12	Looking at Drawing	
1	03:55	04:02	00:07	Adjusting Assembly	
1	04:02	05:07	01:05	Measuring Assembly	
1	05:07	05:17	00:10	Adjusting Assembly	UNDOC RW 2
1	05:17	05:55	00:38	Adjusting Clips	
1	05:55	06:05	00:10	Adjusting Assembly	UNDOC RW 2
1	06:05	06:10	00:05	Measuring Assembly	
1	06:10	06:23	00:13	Adjusting Assembly	UNDOC RW 2
1	06:23	06:45	00:22	Adjusting Clips	
1	06:45	06:56	00:11	Looking at Drawing	
1	06:56	07:02	00:06	Adjusting Clips	
1	07:02	07:16	00:14	Adjusting Assembly	UNDOC RW 2
1	07:16	07:26	00:10	Looking at Drawing	
1	07:26	07:32	00:06	Assembling Assembly	
1	07:32	08:00	00:28	Chatting with Administrator	
1	08:00	09:22	01:22	Manipulating Stands	
1	09:22	09:30	00:08	Looking at Drawing	
1	09:30	10:07	00:37	Measuring Assembly	
1	10:07	10:10	00:03	Adjusting Assembly	UNDOC RW 1
1	10:10	11:12	01:02	Measuring Assembly	
1	11:12	11:20	00:08	Adjusting Assembly	UNDOC RW 3
1	11:20	11:40	00:20	Manipulating Stands	
1	11:40	12:20	00:40	Measuring Assembly	
1	12:20	12:26	00:06	Adjusting Assembly	UNDOC RW 1
1	12:26	12:36	00:10	Adjusting Assembly	UNDOC RW 2
1	12:36	12:48	00:12	Measuring Assembly	
1	12:48	13:05	00:17	Manipulating Stands	
1	13:05	13:08	00:03	Adjusting Assembly	UNDOC RW 1
1	13:08	13:48	00:40	Measuring Assembly	
1	13:48	14:06	00:18	Manipulating Stands	
1	14:06	14:53	00:47	Measuring Assembly	
1	14:53	15:04	00:11	Manipulating Stands	
1	15:04	15:40	00:36	Measuring Assembly	
1	15:40	16:23	00:43	Looking at Drawing	
1	16:23	17:06	00:43	Manipulating Stands	
1	17:06	17:30	00:24	Measuring Assembly	
1	17:30	17:56	00:26	Looking at Drawing	

Totals	
Chatting with Administrator	18:02
Assembling Assembly	00:09
Adjusting Clips	01:16
Measuring Assembly	25:33
Checking Assembly	00:08
Manipulating Stands	10:22
Adjusting Assembly	01:36
Assembly Layout	00:29
Looking at Drawing	07:49
Completing Rework	04:33
Quality Control	22:42
Conveying Corrections	05:03
Total	1:37:42

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1	17:56	18:26	00:30	Measuring Assembly	
1	18:26	18:38	00:12	Adjusting Assembly	UNDOC RW 5
1	18:38	19:31	00:53	Chatting with Administrator	
2	19:31	24:35	05:04	Quality Control	
2	24:35	24:46	00:11	Conveying Corrections	
2	24:46	25:06	00:20	Chatting with Administrator	
2	25:06	25:12	00:06	Chatting with Administrator	
2	25:12	25:23	00:11	Quality Control	
2	25:23	25:41	00:18	Conveying Corrections	
2	25:41	25:58	00:17	Chatting with Administrator	
2	25:58	26:24	00:26	Quality Control	
2	26:24	26:40	00:16	Conveying Corrections	
3	26:40	26:53	00:13	Quality Control	
3	26:53	27:16	00:23	Conveying Corrections	
3	27:16	27:35	00:19	Chatting with Administrator	
3	27:35	27:56	00:21	Conveying Corrections	
3	27:56	28:17	00:21	Chatting with Administrator	
3	28:17	29:07	00:50	Measuring Assembly	
3	29:07	29:12	00:05	Completing Rework	RW 3
3	29:12	29:30	00:18	Manipulating Stands	
3	29:30	29:56	00:26	Measuring Assembly	
3	29:56	30:03	00:07	Completing Rework	RW 2
3	30:03	30:43	00:40	Manipulating Stands	
3	30:43	30:51	00:08	Measuring Assembly	
3	30:51	31:03	00:12	Completing Rework	RW 3
3	31:03	31:15	00:12	Manipulating Stands	
3	31:15	31:22	00:07	Completing Rework	RW 5
3	31:22	31:40	00:18	Manipulating Stands	
3	31:40	31:46	00:06	Measuring Assembly	
3	31:46	33:23	01:37	Manipulating Stands	
3	33:23	33:49	00:26	Measuring Assembly	
3	33:49	34:34	00:45	Chatting with Administrator	
3	34:34	34:45	00:11	Completing Rework	RW 3
3	34:45	35:11	00:26	Measuring Assembly	
3	35:11	35:24	00:13	Completing Rework	RW 3
3	35:24	36:19	00:55	Measuring Assembly	
3	36:19	36:24	00:05	Looking at Drawing	
3	36:24	36:29	00:05	Measuring Assembly	
3	36:29	36:51	00:22	Looking at Drawing	
3	36:51	36:57	00:06	Completing Rework	RW 5
3	36:57	38:16	01:19	Measuring Assembly	
3	38:16	38:37	00:21	Looking at Drawing	
3	38:37	38:48	00:11	Completing Rework	RW 1
3	38:48	39:34	00:46	Measuring Assembly	
3	39:34	40:28	00:54	Looking at Drawing	
3	40:28	40:36	00:08	Measuring Assembly	
3	40:36	40:56	00:20	Chatting with Administrator	
3	40:56	43:26	02:30	Quality Control	
3	43:26	43:41	00:15	Conveying Corrections	
4	43:41	44:15	00:34	Quality Control	
4	44:15	45:03	00:48	Conveying Corrections	
4	45:03	45:10	00:07	Chatting with Administrator	
4	45:10	45:34	00:24	Conveying Corrections	
4	45:34	45:51	00:17	Chatting with Administrator	
4	45:51	46:16	00:25	Quality Control	
4	46:16	48:24	02:08	Chatting with Administrator	
4	48:24	48:36	00:12	Manipulating Stands	
4	48:36	48:41	00:05	Completing Rework	RW 2
4	48:41	48:51	00:10	Completing Rework	RW 4
4	48:51	49:06	00:15	Measuring Assembly	
4	49:06	49:20	00:14	Completing Rework	RW 4
4	49:20	49:34	00:14	Looking at Drawing	
4	49:34	50:04	00:30	Manipulating Stands	
4	50:04	51:19	01:15	Measuring Assembly	
4	51:19	51:22	00:03	Completing Rework	RW 4
4	51:22	51:38	00:16	Measuring Assembly	
4	51:38	51:45	00:07	Completing Rework	RW 3
4	51:45	52:16	00:31	Measuring Assembly	
4	52:16	52:36	00:20	Completing Rework	RW 4
4	52:36	52:41	00:05	Manipulating Stands	
4	52:41	54:01	01:20	Measuring Assembly	

4	54:01	54:28	00:27	Looking at Drawing	
4	54:28	54:46	00:18	Measuring Assembly	
4	54:46	54:52	00:06	Completing Rework	RW 4
4	54:52	55:16	00:24	Measuring Assembly	
4	55:16	55:26	00:10	Chatting with Administrator	
5	55:26	59:46	04:20	Quality Control	
5	59:46	59:52	00:06	Conveying Corrections	
5	59:52	1:00:36	00:44	Chatting with Administrator	
5	1:00:36	1:00:56	00:20	Conveying Corrections	
5	1:00:56	1:01:34	00:38	Chatting with Administrator	
5	1:01:34	1:01:46	00:12	Completing Rework	RW 4
5	1:01:46	1:01:56	00:10	Adjusting Clips	
5	1:01:56	1:02:14	00:18	Completing Rework	RW 4
5	1:02:14	1:02:25	00:11	Manipulating Stands	
5	1:02:25	1:03:06	00:41	Measuring Assembly	
5	1:03:06	1:03:52	00:46	Manipulating Stands	
5	1:03:52	1:04:16	00:24	Measuring Assembly	
5	1:04:16	1:04:57	00:41	Manipulating Stands	
5	1:04:57	1:06:06	01:09	Measuring Assembly	
5	1:06:06	1:06:15	00:09	Manipulating Stands	
5	1:06:15	1:06:58	00:43	Measuring Assembly	
5	1:06:58	1:07:13	00:15	Chatting with Administrator	
5	1:07:13	1:07:46	00:33	Looking at Drawing	
5	1:07:46	1:07:56	00:10	Measuring Assembly	
5	1:07:56	1:08:51	00:55	Chatting with Administrator	
5	1:08:51	1:09:16	00:25	Looking at Drawing	
5	1:09:16	1:09:37	00:21	Measuring Assembly	
5	1:09:37	1:09:43	00:06	Completing Rework	RW 1
5	1:09:43	1:09:56	00:13	Manipulating Stands	
5	1:09:56	1:10:26	00:30	Measuring Assembly	
5	1:10:26	1:10:32	00:06	Completing Rework	RW 4
5	1:10:32	1:11:30	00:58	Measuring Assembly	
5	1:11:30	1:11:43	00:13	Completing Rework	RW 4
5	1:11:43	1:12:23	00:40	Measuring Assembly	
5	1:12:23	1:12:30	00:07	Completing Rework	RW 5
5	1:12:30	1:12:51	00:21	Measuring Assembly	
5	1:12:51	1:13:04	00:13	Chatting with Administrator	
5	1:13:04	1:13:15	00:11	Looking at Drawing	
5	1:13:15	1:13:22	00:07	Completing Rework	RW 5
5	1:13:22	1:13:42	00:20	Measuring Assembly	
5	1:13:42	1:13:49	00:07	Completing Rework	RW 5
5	1:13:49	1:14:12	00:23	Measuring Assembly	
6	1:14:12	1:16:26	02:14	Quality Control	
6	1:16:26	1:16:44	00:18	Conveying Corrections	
6	1:16:44	1:17:11	00:27	Manipulating Stands	
6	1:17:11	1:17:29	00:18	Chatting with Administrator	
7	1:17:29	1:19:56	02:27	Quality Control	
7	1:19:56	1:20:53	00:57	Chatting with Administrator	
7	1:20:53	1:20:59	00:06	Manipulating Stands	
7	1:20:59	1:21:09	00:10	Conveying Corrections	
7	1:21:09	1:21:21	00:12	Looking at Drawing	
7	1:21:21	1:21:37	00:16	Chatting with Administrator	
7	1:21:37	1:21:53	00:16	Looking at Drawing	
7	1:21:53	1:22:01	00:08	Checking Assembly	
7	1:22:01	1:22:31	00:30	Chatting with Administrator	
7	1:22:31	1:22:37	00:06	Manipulating Stands	
7	1:22:37	1:23:00	00:23	Chatting with Administrator	
7	1:23:00	1:23:51	00:51	Looking at Drawing	
7	1:23:51	1:24:19	00:28	Completing Rework	RW 5
7	1:24:19	1:24:59	00:40	Manipulating Stands	
7	1:24:59	1:25:09	00:10	Completing Rework	RW 5
7	1:25:09	1:25:43	00:34	Chatting with Administrator	
7	1:25:43	1:25:49	00:06	Measuring Assembly	
7	1:25:49	1:25:54	00:05	Completing Rework	RW 5
7	1:25:54	1:25:57	00:03	Measuring Assembly	
7	1:25:57	1:26:02	00:05	Completing Rework	RW5
7	1:26:02	1:26:20	00:18	Measuring Assembly	
8	1:26:20	1:28:40	02:20	Quality Control	
8	1:28:40	1:29:35	00:55	Conveying Corrections	
8	1:29:35	1:31:06	01:31	Measuring Assembly	
8	1:31:06	1:31:12	00:06	Completing Rework	RW 4

Cycle	Start	End	Duration	Category	Note
9	1:31:12	1:32:35	01:23	Quality Control	
9	1:32:35	1:33:14	00:39	Chatting with Administrator	CRASH
9	1:33:14	1:33:49	00:35	Quality Control	
9	1:33:49	1:34:07	00:18	Conveying Corrections	
9	1:34:07	1:34:21	00:14	Looking at Drawing	
9	1:34:21	1:34:27	00:06	Completing Rework	RW 4
9	1:34:27	1:34:50	00:23	Looking at Drawing	
9	1:34:50	1:35:13	00:23	Measuring Assembly	
9	1:35:13	1:37:42	02:29	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	03:05	03:05	Chatting with Administrator	
1	03:05	03:20	00:15	Assembly Layout	
1	03:20	03:31	00:11	Manipulating Stands	
1	03:31	04:03	00:32	Looking at Drawing	
1	04:03	04:20	00:17	Assembling Assembly	
1	04:20	05:36	01:16	Measuring Assembly	
1	05:36	05:42	00:06	Assembling Assembly	pt 1
1	05:42	06:45	01:03	Measuring Assembly	
1	06:45	07:55	01:10	Looking at Drawing	
1	07:55	08:09	00:14	Checking Assembly	
1	08:09	08:11	00:02	Adjusting Assembly	
1	08:11	08:25	00:14	Adjusting Clips	
1	08:25	08:41	00:16	Adjusting Assembly	
1	08:41	08:52	00:11	Adjusting Clips	
1	08:52	09:40	00:48	Measuring Assembly	
1	09:40	10:00	00:20	Chatting with Administrator	
1	10:00	10:44	00:44	Measuring Assembly	
1	10:44	10:47	00:03	Adjusting Assembly	
1	10:47	11:15	00:28	Assembling Assembly	pt4
1	11:15	11:22	00:07	Manipulating Stands	
1	11:22	11:54	00:32	Looking at Drawing	
1	11:54	11:58	00:04	Adjusting Assembly	
1	11:58	12:10	00:12	Measuring Assembly	
1	12:10	12:22	00:12	Adjusting Assembly	
1	12:22	12:35	00:13	Assembling Assembly	pt 5
1	12:35	13:24	00:49	Manipulating Stands	
1	13:24	13:57	00:33	Looking at Drawing	
1	13:57	13:59	00:02	Manipulating Stands	
1	13:59	14:27	00:28	Measuring Assembly	
1	14:27	14:38	00:11	Manipulating Stands	
1	14:38	15:38	01:00	Measuring Assembly	
1	15:38	15:47	00:09	Manipulating Stands	
1	15:47	16:00	00:13	Measuring Assembly	
1	16:00	16:09	00:09	Manipulating Stands	
1	16:09	16:37	00:28	Measuring Assembly	
1	16:37	16:53	00:16	Chatting with Administrator	
1	16:53	18:30	01:37	Measuring Assembly	
1	18:30	18:36	00:06	Adjusting Assembly	
1	18:36	19:50	01:14	Measuring Assembly	
1	19:50	20:04	00:14	Adjusting Assembly	
1	20:04	22:53	02:49	Measuring Assembly	
1	22:53	22:57	00:04	Adjusting Assembly	
1	22:57	24:15	01:18	Measuring Assembly	
1	24:15	24:31	00:16	Manipulating Stands	
1	24:31	24:50	00:19	Measuring Assembly	
1	24:50	25:03	00:13	Adjusting Assembly	
1	25:03	25:30	00:27	Measuring Assembly	
1	25:30	27:19	01:49	Chatting with Administrator	
1	27:19	27:48	00:29	Measuring Assembly	
1	27:48	27:54	00:06	Looking at Drawing	
1	27:54	28:00	00:06	Measuring Assembly	
1	28:00	28:20	00:20	Looking at Drawing	
1	28:20	28:38	00:18	Measuring Assembly	
1	28:38	28:59	00:21	Adjusting Assembly	
1	28:59	29:13	00:14	Chatting with Administrator	
1	29:13	29:18	00:05	Adjusting Assembly	

Totals	
Chatting with Administrator	06:27
Assembling Assembly	01:04
Adjusting Clips	00:52
Measuring Assembly	17:49
Checking Assembly	07:07
Manipulating Stands	02:00
Adjusting Assembly	02:25
Assembly Layout	00:15
Looking at Drawing	03:40
Completing Rework	00:00
Quality Control	02:44
Conveying Corrections	00:00
Total	44:23

1	29:18	29:27	00:09	Chatting with Administrator	
1	29:27	30:05	00:38	Measuring Assembly	
1	30:05	30:13	00:08	Adjusting Assembly	
1	30:13	30:21	00:08	Measuring Assembly	
1	30:21	30:24	00:03	Adjusting Assembly	
1	30:24	30:36	00:12	Looking at Drawing	
1	30:36	30:50	00:14	Measuring Assembly	
1	30:50	30:52	00:02	Adjusting Assembly	
1	30:52	30:57	00:05	Looking at Drawing	
1	30:57	31:50	00:53	Measuring Assembly	
1	31:50	32:00	00:10	Chatting with Administrator	
1	32:00	32:24	00:24	Measuring Assembly	
1	32:24	32:27	00:03	Adjusting Assembly	
1	32:27	32:35	00:08	Measuring Assembly	
1	32:35	32:47	00:12	Adjusting Assembly	
1	32:47	33:12	00:25	Measuring Assembly	
1	33:12	33:14	00:02	Adjusting Assembly	
1	33:14	33:24	00:10	Measuring Assembly	
1	33:24	33:34	00:10	Looking at Drawing	
1	33:34	36:18	02:44	Checking Assembly	
1	36:18	36:20	00:02	Adjusting Assembly	
1	36:20	36:58	00:38	Checking Assembly	
1	36:58	37:25	00:27	Adjusting Clips	
1	37:25	38:22	00:57	Checking Assembly	
1	38:22	38:27	00:05	Adjusting Assembly	
1	38:27	38:47	00:20	Checking Assembly	
1	38:47	38:53	00:06	Manipulating Stands	
1	38:53	40:13	01:20	Checking Assembly	
1	40:13	40:18	00:05	Adjusting Assembly	
1	40:18	40:45	00:27	Checking Assembly	
1	40:45	40:48	00:03	Adjusting Assembly	
1	40:48	41:15	00:27	Checking Assembly	
1	41:15	41:39	00:24	Chatting with Administrator	
2	41:39	44:23	02:44	Quality Control	

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:32	02:32	Chatting with Administrator	
1	02:32	02:40	00:08	Looking at Drawing	
1	02:40	02:52	00:12	Assembling Assembly	pt 2 4 5 *
1	02:52	03:13	00:21	Looking at Drawing	
1	03:13	03:29	00:16	Assembly Layout	
1	03:29	04:14	00:45	Manipulating Stands	
1	04:14	04:57	00:43	Looking at Drawing	
1	04:57	05:10	00:13	Assembly Layout	
1	05:10	05:20	00:10	Manipulating Stands	
1	05:20	05:52	00:32	Looking at Drawing	
1	05:52	06:10	00:18	Measuring Assembly	
1	06:10	06:42	00:32	Looking at Drawing	
1	06:42	07:45	01:03	Chatting with Administrator	
1	07:45	08:12	00:27	Manipulating Stands	
1	08:12	08:25	00:13	Measuring Assembly	
1	08:25	08:33	00:08	Looking at Drawing	
1	08:33	09:21	00:48	Measuring Assembly	
1	09:21	09:34	00:13	Adjusting Assembly	
1	09:34	09:49	00:15	Measuring Assembly	
1	09:49	09:59	00:10	Adjusting Assembly	
1	09:59	10:12	00:13	Measuring Assembly	
1	10:12	11:03	00:51	Manipulating Stands	
1	11:03	14:38	03:35	Looking at Drawing	
1	14:38	14:48	00:10	Chatting with Administrator	
1	14:48	15:12	00:24	Measuring Assembly	
1	15:12	15:23	00:11	Adjusting Assembly	
1	15:23	15:35	00:12	Manipulating Stands	
1	15:35	15:49	00:14	Measuring Assembly	
1	15:49	16:15	00:26	Adjusting Clips	
1	16:15	16:44	00:29	Looking at Drawing	
1	16:44	16:58	00:14	Manipulating Stands	

Totals	
Chatting with Administrator	08:59
Assembling Assembly	00:12
Adjusting Clips	00:53
Measuring Assembly	13:38
Checking Assembly	00:00
Manipulating Stands	05:00
Adjusting Assembly	03:20
Assembly Layout	00:29
Looking at Drawing	18:21
Completing Rework	00:35
Quality Control	10:26
Conveying Corrections	01:39
Total	1:03:32

1	16:58	17:01	00:03	Adjusting Assembly	
1	17:01	17:25	00:24	Looking at Drawing	
1	17:25	17:55	00:30	Measuring Assembly	
1	17:55	18:11	00:16	Chatting with Administrator	
1	18:11	18:38	00:27	Looking at Drawing	
1	18:38	18:55	00:17	Chatting with Administrator	
1	18:55	20:39	01:44	Looking at Drawing	
1	20:39	21:35	00:56	Chatting with Administrator	
1	21:35	22:06	00:31	Measuring Assembly	tape
1	22:06	23:00	00:54	Measuring Assembly	
1	23:00	23:20	00:20	Looking at Drawing	
1	23:20	23:50	00:30	Measuring Assembly	
1	23:50	24:27	00:37	Adjusting Assembly	
1	24:27	25:18	00:51	Measuring Assembly	
1	25:18	25:58	00:40	Measuring Assembly	tape
1	25:58	33:14	07:16	Looking at Drawing	
1	33:14	34:08	00:54	Measuring Assembly	
1	34:08	34:24	00:16	Adjusting Assembly	
1	34:24	34:41	00:17	Measuring Assembly	
1	34:41	34:52	00:11	Manipulating Stands	
1	34:52	35:00	00:08	Adjusting Assembly	
1	35:00	35:10	00:10	Measuring Assembly	
1	35:10	35:34	00:24	Manipulating Stands	
1	35:34	36:14	00:40	Measuring Assembly	
1	36:14	36:22	00:08	Adjusting Assembly	
1	36:22	36:36	00:14	Manipulating Stands	
1	36:36	36:53	00:17	Measuring Assembly	
1	36:53	36:59	00:06	Adjusting Assembly	
1	36:59	37:10	00:11	Measuring Assembly	
1	37:10	38:06	00:56	Looking at Drawing	
1	38:06	38:33	00:27	Adjusting Clips	
1	38:33	38:57	00:24	Adjusting Assembly	
1	38:57	39:07	00:10	Manipulating Stands	
1	39:07	39:10	00:03	Looking at Drawing	
1	39:10	39:37	00:27	Chatting with Administrator	
1	39:37	40:10	00:33	Measuring Assembly	
1	40:10	40:14	00:04	Manipulating Stands	
1	40:14	40:51	00:37	Measuring Assembly	
1	40:51	40:59	00:08	Manipulating Stands	
1	40:59	41:25	00:26	Looking at Drawing	
1	41:25	41:58	00:33	Manipulating Stands	
1	41:58	42:17	00:19	Measuring Assembly	
1	42:17	42:28	00:11	Chatting with Administrator	tape
1	42:28	42:35	00:07	Measuring Assembly	
1	42:35	42:47	00:12	Manipulating Stands	
1	42:47	43:10	00:23	Measuring Assembly	
1	43:10	43:21	00:11	Manipulating Stands	
1	43:21	43:35	00:14	Adjusting Assembly	
1	43:35	43:44	00:09	Chatting with Administrator	tape
1	43:44	44:00	00:16	Measuring Assembly	
1	44:00	44:17	00:17	Looking at Drawing	
1	44:17	44:36	00:19	Chatting with Administrator	
1	44:36	45:02	00:26	Adjusting Assembly	
1	45:02	45:12	00:10	Chatting with Administrator	
1	45:12	45:30	00:18	Measuring Assembly	
1	45:30	45:40	00:10	Adjusting Assembly	
1	45:40	45:45	00:05	Measuring Assembly	
1	45:45	45:53	00:08	Adjusting Assembly	
1	45:53	46:16	00:23	Measuring Assembly	
1	46:16	46:22	00:06	Adjusting Assembly	
1	46:22	47:05	00:43	Chatting with Administrator	
2	47:05	48:37	01:32	Quality Control	
2	48:37	49:12	00:35	Chatting with Administrator	
2	49:12	50:07	00:55	Quality Control	
2	50:07	50:13	00:06	Conveying Corrections	
2	50:13	50:23	00:10	Completing Rework	pt 5
2	50:23	50:35	00:12	Conveying Corrections	
2	50:35	50:41	00:06	Completing Rework	pt 2
2	50:41	50:55	00:14	Manipulating Stands	
2	50:55	51:17	00:22	Measuring Assembly	
3	51:17	52:07	00:50	Quality Control	

3	52:07	52:31	00:24	Chatting with Administrator	
3	52:31	53:26	00:55	Quality Control	
3	53:26	53:40	00:14	Conveying Corrections	
3	53:40	53:46	00:06	Completing Rework	pt 1
3	53:46	54:15	00:29	Measuring Assembly	
3	54:15	54:39	00:24	Conveying Corrections	
3	54:39	54:41	00:02	Completing Rework	pt 5
4	54:41	56:08	01:27	Quality Control	
4	56:08	56:49	00:41	Quality Control	
4	56:49	57:00	00:11	Conveying Corrections	
4	57:00	57:05	00:05	Completing Rework	pt 1
4	57:05	57:11	00:06	Measuring Assembly	
4	57:11	57:14	00:03	Completing Rework	pt 1
4	57:14	57:19	00:05	Measuring Assembly	
5	57:19	58:04	00:45	Quality Control	
5	58:04	59:49	01:45	Quality Control	
5	59:49	59:51	00:02	Conveying Corrections	
5	1:00:09	1:00:09	00:18	Chatting with Administrator	
5	1:00:39	1:00:39	00:30	Conveying Corrections	
5	1:00:42	1:00:42	00:03	Completing Rework	pt 4
5	1:00:47	1:00:47	00:05	Chatting with Administrator	
5	1:01:32	1:01:32	00:45	Measuring Assembly	
5	1:01:40	1:01:40	00:08	Chatting with Administrator	
6	1:02:29	1:02:29	00:49	Quality Control	
6	1:03:16	1:03:16	00:47	Quality Control	
6	1:03:16	1:03:32	00:16	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	03:08	03:08	Chatting with Administrator	
1	03:08	03:37	00:29	Looking at Drawing	
1	03:37	03:42	00:05	Assembling Assembly	pt 2 4 5 *
1	03:42	04:12	00:30	Looking at Drawing	
1	04:12	04:17	00:05	Adjusting Assembly	
1	04:17	04:26	00:09	Looking at Drawing	
1	04:26	04:39	00:13	Adjusting Assembly	
1	04:39	05:01	00:22	Assembly Layout	
1	05:01	05:27	00:26	Looking at Drawing	
1	05:27	05:40	00:13	Adjusting Assembly	
1	05:40	05:47	00:07	Manipulating Stands	
1	05:47	05:50	00:03	Adjusting Assembly	
1	05:50	06:24	00:34	Manipulating Stands	
1	06:24	07:06	00:42	Looking at Drawing	
1	07:06	07:50	00:44	Chatting with Administrator	
1	07:50	07:55	00:05	Looking at Drawing	
1	07:55	08:28	00:33	Measuring Assembly	
1	08:28	08:40	00:12	Manipulating Stands	
1	08:40	09:16	00:36	Measuring Assembly	
1	09:16	09:20	00:04	Adjusting Assembly	
1	09:20	09:23	00:03	Measuring Assembly	
1	09:23	09:25	00:02	Adjusting Assembly	
1	09:25	09:57	00:32	Measuring Assembly	
1	09:57	10:04	00:07	Adjusting Assembly	
1	10:04	10:10	00:06	Measuring Assembly	
1	10:10	10:15	00:05	Adjusting Assembly	
1	10:15	10:20	00:05	Manipulating Stands	
1	10:20	10:31	00:11	Measuring Assembly	
1	10:31	10:35	00:04	Adjusting Assembly	
1	10:35	10:42	00:07	Measuring Assembly	
1	10:42	11:05	00:23	Adjusting Assembly	
1	11:05	11:15	00:10	Manipulating Stands	
1	11:15	11:32	00:17	Measuring Assembly	
1	11:32	11:35	00:03	Adjusting Assembly	
1	11:35	0:11:40	00:05	Measuring Assembly	
1	11:40	14:06	02:26	Looking at Drawing	
1	14:06	14:19	00:13	Manipulating Stands	
1	14:19	14:44	00:25	Looking at Drawing	
1	14:44	14:58	00:14	Measuring Assembly	

Totals	
Chatting with Administrator	09:51
Assembling Assembly	00:05
Adjusting Clips	00:00
Measuring Assembly	10:18
Checking Assembly	00:00
Manipulating Stands	02:44
Adjusting Assembly	01:49
Assembly Layout	00:22
Looking at Drawing	10:00
Completing Rework	02:42
Quality Control	12:36
Conveying Corrections	01:22
Total	51:49

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1	14:58	15:12	00:14	Looking at Drawing	
1	15:12	16:24	01:12	Measuring Assembly	
1	16:24	16:35	00:11	Looking at Drawing	
1	16:35	17:00	00:25	Measuring Assembly	
1	17:00	17:06	00:06	Looking at Drawing	
1	17:06	18:00	00:54	Measuring Assembly	
1	18:00	18:23	00:23	Looking at Drawing	
1	18:23	18:38	00:15	Measuring Assembly	
1	18:38	18:43	00:05	Adjusting Assembly	
1	18:43	19:03	00:20	Measuring Assembly	
1	19:03	19:06	00:03	Adjusting Assembly	
1	19:06	19:11	00:05	Measuring Assembly	
1	19:11	19:13	00:02	Adjusting Assembly	
1	19:13	19:20	00:07	Measuring Assembly	
1	19:20	19:23	00:03	Adjusting Assembly	
1	19:23	19:27	00:04	Measuring Assembly	
1	19:27	19:52	00:25	Looking at Drawing	
1	19:52	20:09	00:17	Measuring Assembly	
1	20:09	20:11	00:02	Adjusting Assembly	
1	20:11	20:16	00:05	Measuring Assembly	
1	20:16	20:28	00:12	Adjusting Assembly	
1	20:28	20:49	00:21	Looking at Drawing	
1	20:49	20:55	00:06	Measuring Assembly	
1	20:55	21:23	00:28	Looking at Drawing	
1	21:23	22:36	01:13	Chatting with Administrator	
1	22:36	23:40	01:04	Chatting with Administrator	
1	23:40	24:43	01:03	Chatting with Administrator	
2	24:43	26:26	01:43	Quality Control	
2	26:26	26:46	00:20	Conveying Corrections	
2	26:46	27:40	00:54	Chatting with Administrator	
2	27:40	27:53	00:13	Manipulating Stands	
2	27:53	28:01	00:08	Chatting with Administrator	
2	28:01	28:13	00:12	Looking at Drawing	
2	28:13	28:48	00:35	Measuring Assembly	
2	28:48	28:58	00:10	Looking at Drawing	
2	28:58	29:31	00:33	Completing Rework	pt 4 5
2	29:31	29:45	00:14	Measuring Assembly	
2	29:45	30:06	00:21	Looking at Drawing	
2	30:06	30:16	00:10	Measuring Assembly	
2	30:16	30:31	00:15	Looking at Drawing	
2	30:31	30:52	00:21	Measuring Assembly	
2	30:52	31:25	00:33	Completing Rework	pt 5
2	31:25	31:41	00:16	Manipulating Stands	
2	31:41	32:06	00:25	Measuring Assembly	
2	32:06	32:13	00:07	Completing Rework	pt 4
2	32:13	32:20	00:07	Manipulating Stands	
2	32:20	32:31	00:11	Completing Rework	pt 4
2	32:31	32:40	00:09	Manipulating Stands	
2	32:40	32:50	00:10	Completing Rework	pt 4
2	32:50	34:00	01:10	Looking at Drawing	
2	34:00	34:32	00:32	Completing Rework	pt 4
2	34:32	34:41	00:09	Manipulating Stands	
2	34:41	34:52	00:11	Measuring Assembly	
2	34:52	35:00	00:08	Looking at Drawing	
2	35:00	35:23	00:23	Measuring Assembly	
2	35:23	35:27	00:04	Completing Rework	pt 4
2	35:27	35:51	00:24	Measuring Assembly	
2	35:51	35:56	00:05	Looking at Drawing	
2	35:56	36:12	00:16	Measuring Assembly	
2	36:12	36:16	00:04	Looking at Drawing	
2	36:16	36:35	00:19	Measuring Assembly	
2	36:35	36:40	00:05	Looking at Drawing	
2	36:40	36:56	00:16	Measuring Assembly	
2	36:56	37:12	00:16	Chatting with Administrator	
2	37:12	37:22	00:10	Looking at Drawing	
2	37:22	37:32	00:10	Measuring Assembly	
3	37:32	38:37	01:05	Quality Control	
3	38:37	39:37	01:00	Quality Control	
3	39:37	39:50	00:13	Conveying Corrections	
3	39:50	40:12	00:22	Chatting with Administrator	
3	40:12	40:35	00:23	Conveying Corrections	

3	40:35	40:40	00:05	Completing Rework	pt 1
3	40:40	40:55	00:15	Chatting with Administrator	
3	40:55	41:10	00:15	Manipulating Stands	
3	41:10	41:16	00:06	Completing Rework	pt 5
4	41:16	46:16	05:00	Quality Control	
4	46:16	47:01	00:45	Quality Control	
4	47:01	47:09	00:08	Conveying Corrections	
4	47:09	47:20	00:11	Completing Rework	pt 4
4	47:20	47:40	00:20	Chatting with Administrator	
5	47:40	48:20	00:40	Quality Control	
5	48:20	49:40	01:20	Quality Control	
5	49:40	50:00	00:20	Chatting with Administrator	
5	50:00	50:16	00:16	Conveying Corrections	
5	50:16	50:30	00:14	Manipulating Stands	
5	50:30	50:40	00:10	Completing Rework	pt 1
6	50:40	51:21	00:41	Quality Control	
6	51:21	51:43	00:22	Quality Control	
6	51:43	51:45	00:02	Conveying Corrections	
6	51:45	51:49	00:04	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:25	02:25	Chatting with Administrator	
1	02:25	03:48	01:23	Looking at Drawing	
1	03:48	03:56	00:08	Assembling Assembly	
1	03:56	04:04	00:08	Looking at Drawing	
1	04:04	04:34	00:30	Assembly Layout	
1	04:34	05:09	00:35	Assembling Assembly	
1	05:09	05:25	00:16	Looking at Drawing	
1	05:25	05:34	00:09	Adjusting Assembly	UNDOC RW 1
1	05:34	06:06	00:32	Assembling Assembly	
1	06:06	06:10	00:04	Looking at Drawing	
1	06:10	06:23	00:13	Adjusting Assembly	UNDOC RW 1
1	06:23	06:50	00:27	Manipulating Stands	
1	06:50	06:58	00:08	Adjusting Assembly	UNDOC RW 3
1	06:58	07:02	00:04	Manipulating Stands	
1	07:02	07:14	00:12	Adjusting Assembly	UNDOC RW 3
1	07:14	07:28	00:14	Manipulating Stands	
1	07:28	07:36	00:08	Adjusting Assembly	UNDOC RW 5
1	07:36	07:59	00:23	Manipulating Stands	
1	07:59	09:00	01:01	Looking at Drawing	
1	09:00	09:33	00:33	Measuring Assembly	
1	09:33	10:15	00:42	Looking at Drawing	
1	10:15	11:06	00:51	Measuring Assembly	
1	11:06	11:30	00:24	Chatting with Administrator	
2	11:30	13:31	02:01	Quality Control	
2	13:31	13:40	00:09	Conveying Corrections	
2	13:40	13:56	00:16	Completing Rework	RW 4
2	13:56	14:07	00:11	Completing Rework	RW 2
2	14:07	14:30	00:23	Completing Rework	RW 4
2	14:30	14:43	00:13	Manipulating Stands	
2	14:43	15:48	01:05	Chatting with Administrator	
2	15:48	15:54	00:06	Completing Rework	RW 3
2	15:54	16:33	00:39	Completing Rework	RW 2
2	16:33	16:40	00:07	Completing Rework	RW 3
2	16:40	16:58	00:18	Completing Rework	RW 5
2	16:58	17:06	00:08	Looking at Drawing	
2	17:06	17:11	00:05	Chatting with Administrator	
2	17:11	17:22	00:11	Completing Rework	RW 4
2	17:22	17:30	00:08	Manipulating Stands	
2	17:30	17:40	00:10	Chatting with Administrator	
3	17:40	19:05	01:25	Quality Control	
3	19:05	19:22	00:17	Chatting with Administrator	
3	19:22	19:43	00:21	Looking at Drawing	
3	19:43	19:49	00:06	Completing Rework	RW 1
3	19:49	20:23	00:34	Looking at Drawing	
4	20:23	23:02	02:39	Quality Control	
4	23:02	23:26	00:24	Conveying Corrections	

Totals	
Chatting with Administrator	07:36
Assembling Assembly	01:15
Adjusting Clips	00:00
Measuring Assembly	01:24
Checking Assembly	00:29
Manipulating Stands	04:38
Adjusting Assembly	00:50
Assembly Layout	00:30
Looking at Drawing	10:23
Completing Rework	06:32
Quality Control	13:30
Conveying Corrections	02:15
Total	49:22

4	23:26	23:39	00:13	Chatting with Administrator	
4	23:39	24:06	00:27	Manipulating Stands	
4	24:06	24:14	00:08	Conveying Corrections	
4	24:14	24:20	00:06	Completing Rework	RW 5
4	24:20	24:30	00:10	Looking at Drawing	
4	24:30	24:40	00:10	Completing Rework	RW 5
4	24:40	24:47	00:07	Completing Rework	RW 4
4	24:47	24:56	00:09	Manipulating Stands	
4	24:56	25:25	00:29	Looking at Drawing	
4	25:25	25:30	00:05	Chatting with Administrator	
4	25:30	25:50	00:20	Looking at Drawing	
5	25:50	27:28	01:38	Quality Control	
5	27:28	27:38	00:10	Chatting with Administrator	
5	27:38	28:14	00:36	Conveying Corrections	
5	28:14	28:19	00:05	Completing Rework	RW 2
5	28:19	28:25	00:06	Conveying Corrections	
5	28:25	29:16	00:51	Chatting with Administrator	
5	29:16	29:49	00:33	Manipulating Stands	
5	29:49	30:00	00:11	Chatting with Administrator	
5	30:00	30:26	00:26	Looking at Drawing	
5	30:26	30:29	00:03	Completing Rework	RW 5
5	30:29	30:40	00:11	Completing Rework	RW 1
5	30:40	30:44	00:04	Manipulating Stands	
5	30:44	31:04	00:20	Looking at Drawing	
5	31:04	31:13	00:09	Completing Rework	RW 4
5	31:13	31:27	00:14	Looking at Drawing	
5	31:27	31:31	00:04	Completing Rework	RW 5
5	31:31	32:00	00:29	Checking Assembly	
5	32:00	32:13	00:13	Completing Rework	RW 4
5	32:13	32:19	00:06	Completing Rework	RW 5
5	32:19	32:30	00:11	Completing Rework	RW 4
5	32:30	33:12	00:42	Looking at Drawing	
5	33:12	33:22	00:10	Completing Rework	RW 4
5	33:22	33:28	00:06	Completing Rework	RW 5
5	33:28	33:32	00:04	Completing Rework	RW 1
5	33:32	33:49	00:17	Manipulating Stands	
5	33:49	34:07	00:18	Completing Rework	RW 1
5	34:07	34:22	00:15	Looking at Drawing	
5	34:22	34:27	00:05	Completing Rework	RW 5
5	34:27	34:36	00:09	Completing Rework	RW 5
5	34:36	34:51	00:15	Looking at Drawing	
5	34:51	35:00	00:09	Completing Rework	RW 3
5	35:00	35:10	00:10	Completing Rework	RW 4
5	35:10	36:00	00:50	Looking at Drawing	
5	36:00	36:10	00:10	Completing Rework	RW 5
5	36:10	36:38	00:28	Looking at Drawing	
6	36:38	38:13	01:35	Quality Control	
6	38:13	38:23	00:10	Conveying Corrections	
6	38:23	38:39	00:16	Manipulating Stands	
6	38:39	38:56	00:17	Conveying Corrections	
6	38:56	39:07	00:11	Completing Rework	RW 2
6	39:07	39:23	00:16	Completing Rework	RW 1
6	39:23	39:50	00:27	Looking at Drawing	
6	39:50	40:08	00:18	Completing Rework	RW 1
6	40:08	40:20	00:12	Manipulating Stands	
6	40:20	40:30	00:10	Completing Rework	RW 1
6	40:30	40:55	00:25	Looking at Drawing	
6	40:55	40:57	00:02	Completing Rework	RW 1
6	40:57	41:22	00:25	Looking at Drawing	
6	41:22	41:34	00:12	Manipulating Stands	
7	41:34	43:28	01:54	Quality Control	
7	43:28	43:37	00:09	Conveying Corrections	
7	43:37	43:42	00:05	Completing Rework	RW 2
7	43:42	43:45	00:03	Completing Rework	RW 1
7	43:45	43:56	00:11	Manipulating Stands	
7	43:56	44:01	00:05	Completing Rework	RW 4
7	44:01	44:16	00:15	Manipulating Stands	
7	44:16	44:28	00:12	Chatting with Administrator	
7	44:28	44:32	00:04	Conveying Corrections	
7	44:32	44:43	00:11	Completing Rework	RW 5
7	44:43	45:15	00:32	Chatting with Administrator	

8	45:15	46:28	01:13	Quality Control	
8	46:28	46:40	00:12	Conveying Corrections	
8	46:40	46:48	00:08	Completing Rework	RW 1
8	46:48	47:21	00:33	Manipulating Stands	
8	47:21	48:09	00:48	Chatting with Administrator	
9	48:09	49:14	01:05	Quality Control	
9	49:14	49:22	00:08	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	04:04	04:04	Chatting with Administrator	
1	04:04	04:19	00:15	Assembly Layout	
1	04:19	04:30	00:11	Looking at Drawing	
1	04:30	04:36	00:06	Adjusting Assembly	
1	04:36	04:52	00:16	Assembly Layout	
1	04:52	05:09	00:17	Looking at Drawing	
1	05:09	05:20	00:11	Manipulating Stands	
1	05:20	05:35	00:15	Looking at Drawing	
1	05:35	05:57	00:22	Assembling Assembly	
1	05:57	06:21	00:24	Measuring Assembly	
1	06:21	06:30	00:09	Looking at Drawing	
1	06:30	07:20	00:50	Measuring Assembly	
1	07:20	07:28	00:08	Manipulating Stands	
1	07:28	07:39	00:11	Measuring Assembly	
1	07:39	08:35	00:56	Looking at Drawing	
1	08:35	08:44	00:09	Adjusting Assembly	UNDOC RW 2
1	08:44	08:54	00:10	Manipulating Stands	
1	08:54	09:04	00:10	Adjusting Assembly	UNDOC RW 2
1	09:04	09:31	00:27	Looking at Drawing	
1	09:31	09:41	00:10	Assembling Assembly	
1	09:41	09:50	00:09	Looking at Drawing	
1	09:50	10:00	00:10	Chatting with Administrator	
1	10:00	10:22	00:22	Looking at Drawing	
1	10:22	10:29	00:07	Manipulating Stands	
1	10:29	11:02	00:33	Adjusting Assembly	UNDOC RW 4
1	11:02	11:18	00:16	Looking at Drawing	
1	11:18	11:56	00:38	Manipulating Stands	
1	11:56	12:02	00:06	Looking at Drawing	
1	12:02	12:09	00:07	Adjusting Assembly	UNDOC RW 4
1	12:09	12:17	00:08	Adjusting Assembly	
1	12:17	12:31	00:14	Looking at Drawing	
1	12:31	12:36	00:05	Adjusting Assembly	UNDOC RW 4
1	12:36	12:42	00:06	Looking at Drawing	
1	12:42	12:48	00:06	Adjusting Assembly	UNDOC RW 4
1	12:48	13:01	00:13	Looking at Drawing	
1	13:01	13:08	00:07	Assembling Assembly	
1	13:08	13:32	00:24	Manipulating Stands	
1	13:32	13:39	00:07	Adjusting Assembly	UNDOC RW 1
1	13:39	14:03	00:24	Manipulating Stands	
1	14:03	15:02	00:59	Measuring Assembly	
1	15:02	15:19	00:17	Adjusting Assembly	UNDOC RW 1
1	15:19	15:49	00:30	Measuring Assembly	
1	15:49	16:03	00:14	Adjusting Assembly	UNDOC RW 1
1	16:03	16:35	00:32	Measuring Assembly	
1	16:35	17:20	00:45	Adjusting Clips	
1	17:20	17:28	00:08	Adjusting Assembly	UNDOC RW 1
1	17:28	18:01	00:33	Measuring Assembly	
1	18:01	18:13	00:12	Adjusting Assembly	UNDOC RW 1
1	18:13	18:20	00:07	Adjusting Clips	
1	18:20	18:38	00:18	Measuring Assembly	
1	18:38	18:55	00:17	Looking at Drawing	
1	18:55	19:18	00:23	Measuring Assembly	
1	19:18	19:48	00:30	Adjusting Assembly	UNDOC RW 4
1	19:48	21:09	01:21	Manipulating Stands	
1	21:09	21:42	00:33	Looking at Drawing	
1	21:42	21:55	00:13	Manipulating Stands	
1	21:55	22:00	00:05	Looking at Drawing	
1	22:00	22:07	00:07	Manipulating Stands	

Totals	
Chatting with Administrator	04:47
Assembling Assembly	00:39
Adjusting Clips	00:52
Measuring Assembly	08:56
Checking Assembly	00:00
Manipulating Stands	06:27
Adjusting Assembly	03:48
Assembly Layout	00:31
Looking at Drawing	09:06
Completing Rework	01:17
Quality Control	11:10
Conveying Corrections	01:45
Total	49:18

Cycle	Start	End	Duration	Category	Note
1	22:07	22:13	00:06	Adjusting Assembly	UNDOC RW 4
1	22:13	22:20	00:07	Looking at Drawing	
1	22:20	22:34	00:14	Adjusting Assembly	UNDOC RW 3
1	22:34	23:12	00:38	Manipulating Stands	
1	23:12	23:32	00:20	Looking at Drawing	
1	23:32	23:39	00:07	Manipulating Stands	
1	23:39	24:11	00:32	Measuring Assembly	
1	24:11	24:17	00:06	Looking at Drawing	
1	24:17	25:45	01:28	Measuring Assembly	
1	25:45	25:45	00:00	Adjusting Assembly	UNDOC RW 1
1	25:45	26:05	00:20	Manipulating Stands	
1	26:05	26:13	00:08	Looking at Drawing	
1	26:13	27:08	00:55	Measuring Assembly	
1	27:08	27:24	00:16	Looking at Drawing	
1	27:24	27:38	00:14	Adjusting Assembly	UNDOC RW 4
1	27:38	27:45	00:07	Manipulating Stands	
1	27:45	28:08	00:23	Looking at Drawing	
1	28:08	28:18	00:10	Manipulating Stands	
1	28:18	28:51	00:33	Looking at Drawing	
1	28:51	28:55	00:04	Manipulating Stands	
1	28:55	29:10	00:15	Adjusting Assembly	UNDOC RW 4
1	29:10	30:20	01:10	Looking at Drawing	
1	30:20	30:24	00:04	Adjusting Assembly	UNDOC RW 5
1	30:24	31:13	00:49	Looking at Drawing	
1	31:13	32:34	01:21	Measuring Assembly	
1	32:34	32:37	00:03	Adjusting Assembly	UNDOC RW 5
1	32:37	33:15	00:38	Looking at Drawing	
1	33:15	33:32	00:17	Chatting with Administrator	
2	33:32	36:52	03:20	Quality Control	
2	36:52	37:15	00:23	Conveying Corrections	
2	37:15	37:21	00:06	Completing Rework	RW 3 stands
2	37:21	37:50	00:29	Manipulating Stands	
2	37:50	38:00	00:10	Chatting with Administrator	
2	38:00	38:14	00:14	Completing Rework	RW 4
3	38:14	39:42	01:28	Quality Control	
3	39:42	39:55	00:13	Conveying Corrections	
3	39:55	40:02	00:07	Manipulating Stands	
3	40:02	40:14	00:12	Quality Control	
3	40:14	40:40	00:26	Conveying Corrections	
3	40:40	40:46	00:06	Completing Rework	RW 3
3	40:46	41:17	00:31	Manipulating Stands	
4	41:17	42:37	01:20	Quality Control	
4	42:37	43:07	00:30	Conveying Corrections	
4	43:07	43:20	00:13	Completing Rework	RW 2
4	43:20	43:32	00:12	Completing Rework	RW 1
4	43:32	43:43	00:11	Manipulating Stands	
5	43:43	45:18	01:35	Quality Control	
5	45:18	45:25	00:07	Conveying Corrections	
5	45:25	45:30	00:05	Completing Rework	RW 1
6	45:30	46:32	01:02	Quality Control	
6	46:32	46:35	00:03	Conveying Corrections	
6	46:35	46:44	00:09	Completing Rework	RW 1
7	46:44	47:44	01:00	Quality Control	
7	47:44	47:47	00:03	Conveying Corrections	
7	47:47	47:59	00:12	Completing Rework	RW 1
8	47:59	49:12	01:13	Quality Control	
8	49:12	49:18	00:06	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:16	02:16	Chatting with Administrator	
1	02:16	02:45	00:29	Looking at Drawing	
1	02:45	03:08	00:23	Chatting with Administrator	
1	03:08	03:20	00:12	Looking at Drawing	
1	03:20	03:35	00:15	Assembly Layout	
1	03:35	03:45	00:10	Looking at Drawing	
1	03:45	04:39	00:54	Assembling Assembly	
1	04:39	04:47	00:08	Manipulating Stands	

Totals	
Chatting with Administrator	09:58
Assembling Assembly	02:50
Adjusting Clips	00:00
Measuring Assembly	05:40
Checking Assembly	00:36
Manipulating Stands	02:10
Adjusting Assembly	02:28

1	04:47	04:56	00:09	Looking at Drawing		Assembly Layout	00:15
1	04:56	05:00	00:04	Manipulating Stands		Looking at Drawing	10:23
1	05:00	05:35	00:35	Looking at Drawing		Completing Rework	00:37
1	05:35	05:41	00:06	Adjusting Assembly	PT 4	Quality Control	07:51
1	05:41	06:01	00:20	Looking at Drawing		Conveying Corrections	01:19
1	06:01	06:36	00:35	Manipulating Stands		Total	44:07
1	06:36	06:44	00:08	Adjusting Assembly	PT 5		
1	06:44	07:05	00:21	Manipulating Stands			
1	07:05	08:23	01:18	Looking at Drawing			
1	08:23	08:45	00:22	Manipulating Stands			
1	08:45	09:47	01:02	Chatting with Administrator			
1	09:47	10:00	00:13	Looking at Drawing			
1	10:00	10:13	00:13	Adjusting Assembly	PT 2		
1	10:13	10:31	00:18	Manipulating Stands			
1	10:31	11:01	00:30	Looking at Drawing			
1	11:01	11:04	00:03	Adjusting Assembly	PT 5		
1	11:04	11:22	00:18	Manipulating Stands			
1	11:22	11:27	00:05	Looking at Drawing			
1	11:27	11:31	00:04	Manipulating Stands			
1	11:31	12:05	00:34	Adjusting Assembly	DISASS 2&3		
1	12:05	13:10	01:05	Looking at Drawing			
1	13:10	13:18	00:08	Adjusting Assembly	DISASS 4&5		
1	13:18	13:51	00:33	Assembling Assembly			
1	13:51	15:12	01:21	Looking at Drawing			
1	15:12	16:42	01:30	Measuring Assembly			
1	16:42	17:17	00:35	Looking at Drawing			
1	17:17	0:17:28	00:11	Measuring Assembly			
1	17:28	17:55	00:27	Looking at Drawing			
1	17:55	18:10	00:15	Measuring Assembly			
1	18:10	18:31	00:21	Chatting with Administrator			
1	18:31	21:05	02:34	Measuring Assembly			
1	21:05	21:22	00:17	Looking at Drawing			
1	21:22	21:25	00:03	Adjusting Assembly	DISASS 2&3		
1	21:25	22:23	00:58	Assembling Assembly			
1	22:23	22:44	00:21	Looking at Drawing			
1	22:44	22:50	00:06	Assembling Assembly			
1	22:50	23:00	00:10	Looking at Drawing			
1	23:00	23:04	00:04	Assembling Assembly			
1	23:04	23:40	00:36	Looking at Drawing			
1	23:40	23:42	00:02	Assembling Assembly			
1	23:42	23:55	00:13	Looking at Drawing			
1	23:55	24:01	00:06	Adjusting Assembly	PT 1		
1	24:01	24:15	00:14	Looking at Drawing			
1	24:15	24:17	00:02	Adjusting Assembly	PT 1		
1	24:17	24:30	00:13	Looking at Drawing			
1	24:30	26:22	01:52	Chatting with Administrator			
1	26:22	26:24	00:02	Adjusting Assembly	PT 3		
1	26:24	29:03	02:39	Chatting with Administrator			
1	29:03	29:16	00:13	Assembling Assembly			
1	29:16	29:22	00:06	Adjusting Assembly	PT 4		
1	29:22	29:30	00:08	Adjusting Assembly	PT 5		
1	29:30	29:47	00:17	Adjusting Assembly	PT 4		
1	29:47	29:52	00:05	Adjusting Assembly	PT 2		
1	29:52	29:54	00:02	Adjusting Assembly	PT 1		
1	29:54	30:01	00:07	Adjusting Assembly	PT 5		
1	30:01	30:29	00:28	Chatting with Administrator			
1	30:29	30:52	00:23	Measuring Assembly			
1	30:52	31:17	00:25	Chatting with Administrator			
1	31:17	31:53	00:36	Checking Assembly			
1	31:53	31:55	00:02	Adjusting Assembly	PT 5		
1	31:55	32:42	00:47	Measuring Assembly			
1	32:42	32:46	00:04	Adjusting Assembly	PT 5		
1	32:46	32:59	00:13	Looking at Drawing			
1	32:59	33:11	00:12	Adjusting Assembly	PT 1		
2	33:11	35:52	02:41	Quality Control			
2	35:52	36:15	00:23	Conveying Corrections			
2	36:15	36:20	00:05	Completing Rework	PT 1		
2	36:20	36:24	00:04	Completing Rework	PT 4		
2	36:24	36:36	00:12	Chatting with Administrator			
3	36:36	38:16	01:40	Quality Control			
3	38:16	38:30	00:14	Conveying Corrections			

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3	38:30	38:44	00:14	Completing Rework	PT 3
3	38:44	39:10	00:26	Conveying Corrections	
3	39:10	39:18	00:08	Completing Rework	PT 5
3	39:18	39:55	00:37	Looking at Drawing	
4	39:55	41:38	01:43	Quality Control	
4	41:38	41:52	00:14	Conveying Corrections	
4	41:52	41:55	00:03	Completing Rework	PT 3
4	41:55	41:57	00:02	Conveying Corrections	
4	41:57	42:00	00:03	Completing Rework	PT 1
5	42:00	43:47	01:47	Quality Control	
5	43:47	44:07	00:20	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:21	02:21	Chatting with Administrator	
1	02:21	02:50	00:29	Assembly Layout	
1	02:50	03:01	00:11	Looking at Drawing	
1	03:01	03:30	00:29	Assembly Layout	
1	03:30	03:38	00:08	Looking at Drawing	
1	03:38	03:42	00:04	Assembly Layout	
1	03:42	03:56	00:14	Chatting with Administrator	
1	03:56	04:19	00:23	Assembling Assembly	
1	04:19	04:35	00:16	Manipulating Stands	
1	04:35	04:41	00:06	Assembling Assembly	
1	04:41	05:19	00:38	Manipulating Stands	
1	05:19	05:41	00:22	Looking at Drawing	
1	05:41	06:17	00:36	Manipulating Stands	
1	06:17	06:35	00:18	Looking at Drawing	
1	06:35	06:45	00:10	Chatting with Administrator	
1	06:45	06:54	00:09	Assembling Assembly	
1	06:54	07:38	00:44	Manipulating Stands	
1	07:38	07:42	00:04	Adjusting Assembly	UNDOC RW 2
1	07:42	08:33	00:51	Looking at Drawing	
1	08:33	08:48	00:15	Adjusting Assembly	UNDOC RW 2
1	08:48	09:43	00:55	Assembling Assembly	
1	09:43	09:50	00:07	Manipulating Stands	
1	09:50	10:11	00:21	Looking at Drawing	
1	10:11	10:36	00:25	Adjusting Assembly	UNDOC RW 4
1	10:36	11:12	00:36	Looking at Drawing	
1	11:12	11:19	00:07	Adjusting Assembly	UNDOC RW 4
1	11:19	11:43	00:24	Looking at Drawing	
1	11:43	12:30	00:47	Manipulating Stands	
1	12:30	12:57	00:27	Looking at Drawing	
1	12:57	13:11	00:14	Manipulating Stands	
1	13:11	13:28	00:17	Looking at Drawing	
1	13:28	13:38	00:10	Assembling Assembly	
1	13:38	14:02	00:24	Looking at Drawing	
1	14:02	16:16	02:14	Measuring Assembly	
1	16:16	16:23	00:07	Adjusting Assembly	UNDOC RW 1
1	16:23	0:16:39	00:16	Adjusting Clips	
1	16:39	16:53	00:14	Adjusting Assembly	UNDOC RW 2
1	16:53	16:58	00:05	Adjusting Clips	
1	16:58	17:32	00:34	Manipulating Stands	
1	17:32	18:00	00:28	Measuring Assembly	
1	18:00	18:28	00:28	Manipulating Stands	
1	18:28	18:41	00:13	Measuring Assembly	
1	18:41	18:45	00:04	Manipulating Stands	
1	18:45	18:51	00:06	Measuring Assembly	
1	18:51	19:10	00:19	Looking at Drawing	
1	19:10	19:49	00:39	Adjusting Clips	
1	19:49	20:42	00:53	Measuring Assembly	
1	20:42	20:55	00:13	Looking at Drawing	
1	20:55	21:04	00:09	Manipulating Stands	
1	21:04	21:20	00:16	Looking at Drawing	
1	21:20	21:42	00:22	Adjusting Assembly	UNDOC RW 3
1	21:42	21:56	00:14	Manipulating Stands	
1	21:56	22:13	00:17	Adjusting Assembly	UNDOC RW 3
1	22:13	22:31	00:18	Manipulating Stands	

Totals	
Chatting with Administrator	04:35
Assembling Assembly	02:21
Adjusting Clips	01:41
Measuring Assembly	25:14
Checking Assembly	00:00
Manipulating Stands	08:15
Adjusting Assembly	05:25
Assembly Layout	01:02
Looking at Drawing	17:15
Completing Rework	01:03
Quality Control	05:03
Conveying Corrections	00:53
Total	12:47

Adjusting Clips

1	22:31	22:40	00:09	Measuring Assembly	
1	22:40	23:13	00:33	Looking at Drawing	
1	23:13	23:40	00:27	Adjusting Clips	
1	23:40	23:50	00:10	Looking at Drawing	
1	23:50	23:56	00:06	Chatting with Administrator	
1	23:56	24:48	00:52	Looking at Drawing	
1	24:48	25:06	00:18	Adjusting Assembly	UNDOC RW 4
1	25:06	25:26	00:20	Looking at Drawing	
1	25:26	25:58	00:32	Manipulating Stands	
1	25:58	26:15	00:17	Adjusting Assembly	UNDOC RW 4
1	26:15	26:25	00:10	Looking at Drawing	
1	26:25	26:41	00:16	Adjusting Assembly	UNDOC RW 4 (DIS 3/4)
1	26:41	26:49	00:08	Adjusting Assembly	UNDOC RW 2
1	26:49	26:58	00:09	Adjusting Assembly	DIS ASS 5
1	26:58	27:18	00:20	Adjusting Assembly	
1	27:18	27:32	00:14	Adjusting Clips	
1	27:32	28:19	00:47	Adjusting Assembly	UNDOC RW 2
1	28:19	28:42	00:23	Assembling Assembly	REASS
1	28:42	28:55	00:13	Adjusting Assembly	UNDOC RW 2
1	28:55	29:16	00:21	Manipulating Stands	
1	29:16	30:51	01:35	Looking at Drawing	
1	30:51	31:06	00:15	Assembling Assembly	
1	31:06	33:01	01:55	Looking at Drawing	
1	33:01	33:51	00:50	Measuring Assembly	
1	33:51	35:07	01:16	Looking at Drawing	
1	35:07	35:31	00:24	Measuring Assembly	
1	35:31	38:09	02:38	Looking at Drawing	
1	38:09	39:10	01:01	Measuring Assembly	
1	39:10	40:17	01:07	Looking at Drawing	
1	40:17	40:50	00:33	Measuring Assembly	
1	40:50	41:46	00:56	Looking at Drawing	
1	41:46	43:36	01:50	Measuring Assembly	
1	43:36	44:25	00:49	Chatting with Administrator	
1	44:25	45:25	01:00	Measuring Assembly	
1	45:25	45:41	00:16	Adjusting Assembly	UNDOC RW 3
1	45:41	46:10	00:29	Measuring Assembly	
1	46:10	46:55	00:45	Manipulating Stands	
1	46:55	47:26	00:31	Measuring Assembly	
1	47:26	47:40	00:14	Adjusting Assembly	UNDOC RW 3
1	47:40	48:25	00:45	Manipulating Stands	
1	48:25	49:06	00:41	Measuring Assembly	
1	49:06	49:15	00:09	Adjusting Assembly	UNDOC RW 3
1	49:15	49:53	00:38	Measuring Assembly	
1	49:53	49:57	00:04	Manipulating Stands	
1	49:57	51:55	01:58	Measuring Assembly	
1	51:55	52:06	00:11	Looking at Drawing	
1	52:06	52:20	00:14	Measuring Assembly	
1	52:20	52:31	00:11	Adjusting Assembly	UNDOC RW 4
1	52:31	52:48	00:17	Manipulating Stands	
1	52:48	53:33	00:45	Measuring Assembly	
1	53:33	53:40	00:07	Adjusting Assembly	UNDOC RW 4
1	53:40	53:48	00:08	Manipulating Stands	
1	53:48	54:45	00:57	Measuring Assembly	
1	54:45	54:51	00:06	Manipulating Stands	
1	54:51	55:29	00:38	Measuring Assembly	
1	55:29	55:37	00:08	Manipulating Stands	
1	55:37	56:53	01:16	Measuring Assembly	
1	56:53	56:57	00:04	Adjusting Assembly	UNDOC RW 4
1	56:57	58:03	01:06	Measuring Assembly	
1	58:03	58:28	00:25	Looking at Drawing	
1	58:28	1:00:22	01:54	Measuring Assembly	
1	00:22	1:00:27	00:05	Adjusting Assembly	UNDOC RW 5
1	00:27	1:01:11	00:44	Measuring Assembly	
1	01:11	1:01:40	00:29	Chatting with Administrator	
2	01:40	1:04:20	02:40	Quality Control	
2	04:20	1:04:36	00:16	Conveying Corrections	
2	04:36	1:06:36	02:00	Measuring Assembly	
2	06:36	1:07:11	00:35	Completing Rework	RW 5
2	07:11	1:07:48	00:37	Measuring Assembly	
2	07:48	1:08:04	00:16	Chatting with Administrator	*CAUGHT NEXT RW
3	08:04	1:09:07	01:03	Quality Control	

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3	09:07	1:09:44	00:37	Conveying Corrections	
3	09:44	1:10:12	00:28	Completing Rework	ST 45
3	10:12	1:11:17	01:05	Measuring Assembly	
4	11:17	1:12:37	01:20	Quality Control	
4	12:37	1:12:47	00:10	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	03:20	03:20	Chatting with Administrator	
1	03:20	03:29	00:09	Assembly Layout	
1	03:29	03:36	00:07	Chatting with Administrator	
1	03:36	03:48	00:12	Assembling Assembly	pt 2 4 5 *
1	03:48	04:28	00:40	Looking at Drawing	
1	04:28	04:31	00:03	Assembling Assembly	
1	04:31	05:18	00:47	Looking at Drawing	
1	05:18	05:21	00:03	Assembling Assembly	
1	05:21	05:58	00:37	Assembling Assembly	
1	05:58	06:12	00:14	Looking at Drawing	
1	06:12	06:30	00:18	Assembling Assembly	
1	06:30	07:51	01:21	Looking at Drawing	
1	07:51	07:53	00:02	Manipulating Stands	
1	07:53	07:58	00:05	Adjusting Clips	
1	07:58	08:24	00:26	Looking at Drawing	
1	08:24	08:59	00:35	Assembling Assembly	
1	08:59	09:21	00:22	Looking at Drawing	
1	09:21	10:00	00:39	Assembling Assembly	
1	10:00	10:41	00:41	Looking at Drawing	
1	10:41	11:14	00:33	Assembling Assembly	
1	11:14	11:37	00:23	Looking at Drawing	
1	11:37	13:30	01:53	Chatting with Administrator	
1	13:30	13:35	00:05	Assembling Assembly	
1	13:35	13:46	00:11	Adjusting Clips	
1	13:46	13:58	00:12	Assembling Assembly	
1	13:58	15:02	01:04	Looking at Drawing	
1	15:02	15:32	00:30	Assembling Assembly	
1	15:32	18:17	02:45	Looking at Drawing	
1	18:17	18:31	00:14	Assembling Assembly	
1	18:31	20:58	02:27	Looking at Drawing	
1	20:58	21:13	00:15	Assembling Assembly	
1	21:13	25:03	03:50	Looking at Drawing	
1	25:03	25:14	00:11	Assembling Assembly	
1	25:14	28:16	03:02	Looking at Drawing	
1	28:16	28:28	00:12	Assembling Assembly	
1	28:28	31:37	03:09	Looking at Drawing	
1	31:37	31:50	00:13	Measuring Assembly	
1	31:50	33:28	01:38	Looking at Drawing	
1	33:28	33:55	00:27	Assembling Assembly	
1	33:55	38:50	04:55	Looking at Drawing	
1	38:50	39:04	00:14	Chatting with Administrator	
2	39:04	46:00	06:56	Quality Control	technical difficulty
2	46:00	46:20	00:20	Chatting with Administrator	
2	46:20	47:24	01:04	Conveying Corrections	
2	47:24	47:55	00:31	Chatting with Administrator	
2	47:55	48:30	00:35	Conveying Corrections	
2	48:30	48:40	00:10	Manipulating Stands	
2	48:40	48:54	00:14	Completing Rework	RW 3
2	48:54	49:05	00:11	Completing Rework	RW 5
2	49:05	49:40	00:35	Completing Rework	RW 3
2	49:40	49:53	00:13	Completing Rework	RW 5
2	49:53	50:33	00:40	Manipulating Stands	
2	50:33	50:35	00:02	Completing Rework	RW 5
2	50:35	51:14	00:39	Adjusting Clips	
2	51:14	52:10	00:56	Completing Rework	RW 2
2	52:10	52:21	00:11	Completing Rework	RW 5
2	52:21	52:40	00:19	Completing Rework	RW 3
2	52:40	52:50	00:10	Completing Rework	RW 5
2	52:50	52:56	00:06	Adjusting Clips	
2	52:56	53:04	00:08	Manipulating Stands	

Totals	
Chatting with Administrator	06:25
Assembling Assembly	05:06
Adjusting Clips	02:01
Measuring Assembly	00:13
Checking Assembly	12:37
Manipulating Stands	02:09
Adjusting Assembly	00:00
Assembly Layout	00:09
Looking at Drawing	31:25
Completing Rework	10:31
Quality Control	17:16
Conveying Corrections	04:01
Total	1:31:53

2	53:04	53:15	00:11	Looking at Drawing	
2	53:15	53:24	00:09	Adjusting Clips	
2	53:24	53:32	00:08	Completing Rework	RW 5
2	53:32	53:35	00:03	Manipulating Stands	
2	53:35	53:42	00:07	Checking Assembly	
2	53:42	53:57	00:15	Completing Rework	RW 3
2	53:57	54:00	00:03	Manipulating Stands	
2	54:00	54:15	00:15	Checking Assembly	
2	54:15	54:48	00:33	Looking at Drawing	
2	54:48	55:19	00:31	Checking Assembly	
2	55:19	56:02	00:43	Looking at Drawing	
2	56:02	56:12	00:10	Completing Rework	RW 3
2	56:12	56:15	00:03	Checking Assembly	
2	56:15	56:18	00:03	Completing Rework	RW 5
2	56:18	56:30	00:12	Checking Assembly	
2	56:30	57:27	00:57	Looking at Drawing	
2	57:27	57:40	00:13	Checking Assembly	
2	57:40	57:44	00:04	Completing Rework	RW 4
2	57:44	58:46	01:02	Checking Assembly	
2	58:46	58:50	00:04	Completing Rework	RW 3
2	58:50	59:07	00:17	Checking Assembly	
2	59:07	59:14	00:07	Completing Rework	RW 5
2	59:14	59:33	00:19	Checking Assembly	
2	59:33	59:38	00:05	Looking at Drawing	
2	59:38	1:00:00	00:22	Checking Assembly	
2	1:00:00	1:00:32	00:32	Looking at Drawing	
2	1:00:32	1:00:38	00:06	Completing Rework	RW 5
2	1:00:38	1:00:43	00:05	Checking Assembly	
2	1:00:43	1:00:47	00:04	Completing Rework	RW 5
2	1:00:47	1:01:04	00:17	Checking Assembly	
2	1:01:04	1:01:09	00:05	Completing Rework	RW 5
2	1:01:09	1:01:20	00:11	Checking Assembly	
2	1:01:20	1:02:00	00:40	Looking at Drawing	
2	1:02:00	1:03:44	01:44	Checking Assembly	
3	1:03:44	1:06:26	02:42	Quality Control	
3	1:06:26	1:07:25	00:59	Conveying Corrections	
3	1:07:25	1:07:35	00:10	Completing Rework	RW 5
3	1:07:35	1:07:47	00:12	Completing Rework	RW 3
3	1:07:47	1:07:57	00:10	Checking Assembly	
3	1:07:57	1:08:23	00:26	Adjusting Clips	
3	1:08:23	1:08:29	00:06	Completing Rework	RW 3
3	1:08:29	1:08:34	00:05	Manipulating Stands	
3	1:08:34	1:08:44	00:10	Completing Rework	RW 3
3	1:08:44	1:09:15	00:31	Completing Rework	RW 5
3	1:09:15	1:09:20	00:05	Checking Assembly	
3	1:09:20	1:09:30	00:10	Completing Rework	RW 3
3	1:09:30	1:09:36	00:06	Checking Assembly	
3	1:09:36	1:09:45	00:09	Completing Rework	RW 3
3	1:09:45	1:09:50	00:05	Completing Rework	RW 5
3	1:09:50	1:10:02	00:12	Manipulating Stands	
3	1:10:02	1:10:08	00:06	Completing Rework	RW 3
3	1:10:08	1:10:15	00:07	Completing Rework	RW 5
3	1:10:15	1:10:26	00:11	Manipulating Stands	
3	1:10:26	1:10:38	00:12	Checking Assembly	
3	1:10:38	1:10:44	00:06	Completing Rework	RW 5
3	1:10:44	1:10:53	00:09	Checking Assembly	
3	1:10:53	1:11:02	00:09	Completing Rework	RW 3
3	1:11:02	1:11:06	00:04	Checking Assembly	
3	1:11:06	1:11:12	00:06	Completing Rework	RW 3
3	1:11:12	1:11:20	00:08	Checking Assembly	
3	1:11:20	1:11:22	00:02	Manipulating Stands	
3	1:11:22	1:11:31	00:09	Completing Rework	RW 3
3	1:11:31	1:11:34	00:03	Manipulating Stands	
3	1:11:34	1:11:40	00:06	Completing Rework	RW 5
3	1:11:40	1:11:57	00:17	Manipulating Stands	
3	1:11:57	1:12:09	00:12	Checking Assembly	
3	1:12:09	1:12:13	00:04	Completing Rework	RW 5
3	1:12:13	1:12:46	00:33	Checking Assembly	
3	1:12:46	1:12:57	00:11	Adjusting Clips	
3	1:12:57	1:13:27	00:30	Checking Assembly	
4	1:13:27	1:16:22	02:55	Quality Control	

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Cycle	Start	End	Duration	Category	Note
4	1:16:22	1:16:44	00:22	Conveying Corrections	
4	1:16:44	1:16:46	00:02	Completing Rework	RW 5
5	1:16:46	1:16:55	00:09	Quality Control	
5	1:16:55	1:19:12	02:17	Completing Rework	RW 1
5	1:19:12	1:19:23	00:11	Adjusting Clips	
5	1:19:23	1:19:29	00:06	Completing Rework	RW 1
5	1:19:29	1:19:32	00:03	Adjusting Clips	
5	1:19:32	1:19:43	00:11	Completing Rework	RW 1
5	1:19:43	1:19:48	00:05	Manipulating Stands	
5	1:19:48	1:19:55	00:07	Checking Assembly	
5	1:19:55	1:20:01	00:06	Completing Rework	RW 1
5	1:20:01	1:20:50	00:49	Checking Assembly	
5	1:20:50	1:21:00	00:10	Completing Rework	RW 1
5	1:21:00	1:22:32	01:32	Checking Assembly	
5	1:22:32	1:22:59	00:27	Completing Rework	RW 2
5	1:22:59	1:23:18	00:19	Checking Assembly	
5	1:23:18	1:23:26	00:08	Completing Rework	RW 1
5	1:23:26	1:23:30	00:04	Completing Rework	RW 5
5	1:23:30	1:23:32	00:02	Manipulating Stands	
5	1:23:32	1:23:43	00:11	Completing Rework	RW 1
5	1:23:43	1:24:08	00:25	Checking Assembly	
5	1:24:08	1:24:14	00:06	Completing Rework	RW 3
5	1:24:14	1:25:52	01:38	Checking Assembly	
6	1:25:52	1:27:30	01:38	Quality Control	
6	1:27:30	1:27:39	00:09	Conveying Corrections	
6	1:27:39	1:27:40	00:01	Completing Rework	RW 4
7	1:27:40	1:28:02	00:22	Quality Control	
7	1:28:02	1:28:33	00:31	Conveying Corrections	
7	1:28:33	1:28:37	00:04	Completing Rework	RW 2
8	1:28:37	1:28:57	00:20	Quality Control	experiment admin helped rework and adjusting clip
8	1:28:57	1:29:03	00:06	Manipulating Stands	
8	1:29:03	1:29:11	00:08	Quality Control	
8	1:29:11	1:29:16	00:05	Completing Rework	RW 1
9	1:29:16	1:29:33	00:17	Quality Control	
9	1:29:33	1:30:23	00:50	Quality Control	
9	1:30:23	1:30:26	00:03	Conveying Corrections	
9	1:30:26	1:30:28	00:02	Completing Rework	RW 5
9	1:30:28	1:30:46	00:18	Conveying Corrections	
9	1:30:46	1:30:54	00:08	Completing Rework	RW 2
10	1:30:54	1:31:53	00:59	Quality Control	

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:14	00:14	Chatting with Administrator	
1	00:14	01:18	01:04	Assembly Layout	
1	01:18	02:40	01:22	Chatting with Administrator	
1	02:40	03:01	00:21	Assembly Layout	
1	03:01	03:16	00:15	Manipulating Stands	
1	03:16	03:21	00:05	Assembling Assembly	pt 2
1	03:21	03:34	00:13	Manipulating Stands	
1	03:34	04:10	00:36	Assembling Assembly	
1	04:10	04:35	00:25	Manipulating Stands	
1	04:35	05:38	01:03	Measuring Assembly	
1	05:38	05:55	00:17	Manipulating Stands	
1	05:55	06:02	00:07	Measuring Assembly	
1	06:02	06:11	00:09	Manipulating Stands	
1	06:11	06:20	00:09	Measuring Assembly	
1	06:20	06:32	00:12	Manipulating Stands	
1	06:32	06:40	00:08	Measuring Assembly	
1	06:40	07:16	00:36	Looking at Drawing	
1	07:16	07:30	00:14	Manipulating Stands	
1	07:30	08:07	00:37	Looking at Drawing	
1	08:07	08:12	00:05	Measuring Assembly	
1	08:12	08:53	00:41	Looking at Drawing	
1	08:53	09:00	00:07	Adjusting Assembly	UNDOC RW 4
1	09:00	09:12	00:12	Adjusting Assembly	UNDOC RW 5
1	09:12	09:42	00:30	Looking at Drawing	
1	09:42	09:56	00:14	Adjusting Assembly	UNDOC RW 5

Totals	
Chatting with Administrator	04:55
Assembling Assembly	00:41
Adjusting Clips	00:00
Measuring Assembly	08:07
Checking Assembly	00:00
Manipulating Stands	06:13
Adjusting Assembly	00:33
Assembly Layout	01:25
Looking at Drawing	08:40
Completing Rework	02:56
Quality Control	07:55
Conveying Corrections	02:47
Total	44:12

1	09:56	10:32	00:36	Manipulating Stands	
1	10:32	10:36	00:04	Looking at Drawing	
1	10:36	10:57	00:21	Manipulating Stands	
1	10:57	11:09	00:12	Measuring Assembly	
1	11:09	11:28	00:19	Looking at Drawing	
1	11:28	11:40	00:12	Measuring Assembly	
1	11:40	12:13	00:33	Looking at Drawing	
1	12:13	12:25	00:12	Measuring Assembly	
1	12:25	12:56	00:31	Looking at Drawing	
1	12:56	13:09	00:13	Measuring Assembly	
1	13:09	13:30	00:21	Looking at Drawing	
1	13:30	13:46	00:16	Measuring Assembly	
1	13:46	14:00	00:14	Looking at Drawing	
1	14:00	14:37	00:37	Chatting with Administrator	
2	14:37	16:56	02:19	Quality Control	
2	16:56	17:24	00:28	Conveying Corrections	
2	17:24	17:30	00:06	Quality Control	
2	17:30	17:42	00:12	Conveying Corrections	
2	17:42	18:14	00:32	Chatting with Administrator	
2	18:14	18:31	00:17	Quality Control	
2	18:31	18:48	00:17	Conveying Corrections	
2	18:48	19:02	00:14	Completing Rework	RW 4
2	19:02	19:55	00:53	Manipulating Stands	
2	19:55	21:30	01:35	Measuring Assembly	
2	21:30	21:35	00:05	Completing Rework	RW 5
2	21:35	21:43	00:08	Measuring Assembly	
2	21:43	22:05	00:22	Manipulating Stands	
2	22:05	22:09	00:04	Completing Rework	RW 5
2	22:09	22:59	00:50	Looking at Drawing	
2	22:59	23:13	00:14	Measuring Assembly	
2	23:13	23:27	00:14	Looking at Drawing	
2	23:27	23:42	00:15	Measuring Assembly	
2	23:42	23:50	00:08	Chatting with Administrator	
2	23:50	24:04	00:14	Measuring Assembly	
2	24:04	24:23	00:19	Completing Rework	RW 1
2	24:23	24:56	00:33	Manipulating Stands	
2	24:56	25:15	00:19	Completing Rework	RW 4
2	25:15	25:31	00:16	Manipulating Stands	
2	25:31	25:40	00:09	Measuring Assembly	
2	25:40	25:49	00:09	Manipulating Stands	
2	25:49	25:58	00:09	Measuring Assembly	
2	25:58	26:45	00:47	Manipulating Stands	
2	26:45	26:52	00:07	Completing Rework	RW 1
2	26:52	27:05	00:13	Measuring Assembly	
2	27:05	27:23	00:18	Looking at Drawing	
2	27:23	27:36	00:13	Completing Rework	RW 4
2	27:36	28:14	00:38	Looking at Drawing	
2	28:14	28:28	00:14	Completing Rework	RW 4
2	28:28	28:41	00:13	Completing Rework	RW 5
2	28:41	29:00	00:19	Manipulating Stands	
2	29:00	29:17	00:17	Looking at Drawing	
2	29:17	30:07	00:50	Measuring Assembly	
2	30:07	30:15	00:08	Looking at Drawing	
2	30:15	30:31	00:16	Measuring Assembly	
2	30:31	31:08	00:37	Looking at Drawing	
2	31:08	31:29	00:21	Measuring Assembly	
2	31:29	31:34	00:05	Completing Rework	RW 5
2	31:34	32:04	00:30	Measuring Assembly	
2	32:04	32:10	00:06	Completing Rework	RW 5
2	32:10	32:46	00:36	Measuring Assembly	
2	32:46	33:12	00:26	Looking at Drawing	
2	33:12	33:25	00:13	Chatting with Administrator	
3	33:25	34:33	01:08	Quality Control	
3	34:33	34:50	00:17	Conveying Corrections	
3	34:50	35:16	00:26	Chatting with Administrator	
3	35:16	35:50	00:34	Conveying Corrections	
3	35:50	36:02	00:12	Manipulating Stands	RW STANS
3	36:02	36:25	00:23	Conveying Corrections	
3	36:25	36:52	00:27	Chatting with Administrator	
3	36:52	37:03	00:11	Conveying Corrections	
3	37:03	37:12	00:09	Completing Rework	RW 4

3	37:12	37:42	00:30	Looking at Drawing	
3	37:42	37:51	00:09	Completing Rework	RW 5
3	37:51	38:07	00:16	Chatting with Administrator	
4	38:07	39:34	01:27	Quality Control	
4	39:34	39:54	00:20	Conveying Corrections	
4	39:54	40:04	00:10	Completing Rework	RW 4
4	40:04	40:20	00:16	Looking at Drawing	
4	40:20	40:35	00:15	Completing Rework	RW 4
4	40:35	40:52	00:17	Chatting with Administrator	
4	40:52	40:57	00:05	Completing Rework	RW 5
4	40:57	41:16	00:19	Chatting with Administrator	
5	41:16	42:51	01:35	Quality Control	
5	42:51	42:53	00:02	Conveying Corrections	
5	42:53	42:59	00:06	Completing Rework	RW 1
6	42:59	43:10	00:11	Quality Control	
6	43:10	43:13	00:03	Conveying Corrections	
6	43:13	43:16	00:03	Completing Rework	RW 5
7	43:16	44:08	00:52	Quality Control	
7	44:08	44:12	00:04	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	01:07	01:07	Chatting with Administrator	
1	01:07	01:46	00:39	Looking at Drawing	
1	01:46	02:00	00:14	Assembling Assembly	
1	02:00	02:20	00:20	Looking at Drawing	
1	02:20	02:30	00:10	Assembling Assembly	
1	02:30	02:36	00:06	Manipulating Stands	
1	02:36	02:51	00:15	Looking at Drawing	
1	02:51	03:04	00:13	Manipulating Stands	
1	03:04	03:23	00:19	Looking at Drawing	
1	03:23	03:35	00:12	Manipulating Stands	
1	03:35	03:51	00:16	Looking at Drawing	
1	03:51	04:00	00:09	Assembling Assembly	
1	04:00	04:08	00:08	Looking at Drawing	
1	04:08	04:57	00:49	Manipulating Stands	
1	04:57	05:03	00:06	Assembling Assembly	
1	05:03	06:28	01:25	Looking at Drawing	
1	06:28	06:55	00:27	Manipulating Stands	
1	06:55	07:03	00:08	Looking at Drawing	
1	07:03	07:26	00:23	Measuring Assembly	
1	07:26	08:06	00:40	Looking at Drawing	
1	08:06	08:52	00:46	Manipulating Stands	
1	08:52	09:36	00:44	Looking at Drawing	
1	09:36	10:12	00:36	Measuring Assembly	
1	10:12	10:30	00:18	Manipulating Stands	
1	10:30	10:39	00:09	Measuring Assembly	
1	10:39	10:49	00:10	Manipulating Stands	
1	10:49	11:06	00:17	Measuring Assembly	
1	11:06	11:12	00:06	Manipulating Stands	
1	11:12	11:28	00:16	Measuring Assembly	
1	11:28	11:39	00:11	Looking at Drawing	
1	11:39	11:52	00:13	Manipulating Stands	
1	11:52	12:04	00:12	Measuring Assembly	
1	12:04	12:44	00:40	Looking at Drawing	
1	12:44	12:54	00:10	Measuring Assembly	
1	12:54	13:11	00:17	Manipulating Stands	
1	13:11	13:46	00:35	Adjusting Assembly	UNDOC RW 4
1	13:46	15:35	01:49	Looking at Drawing	
1	15:35	18:55	03:20	Chatting with Administrator	
1	18:55	20:22	01:27	Looking at Drawing	
1	20:22	21:44	01:22	Measuring Assembly	
1	21:44	21:53	00:09	Looking at Drawing	
1	21:53	22:35	00:42	Manipulating Stands	
1	22:35	22:40	00:05	Adjusting Assembly	UNDOC RW 3
1	22:40	23:39	00:59	Looking at Drawing	
1	23:39	24:00	00:21	Measuring Assembly	
1	24:00	25:13	01:13	Looking at Drawing	

Totals	
Chatting with Administrator	04:50
Assembling Assembly	00:39
Adjusting Clips	00:43
Measuring Assembly	05:33
Checking Assembly	00:00
Manipulating Stands	04:33
Adjusting Assembly	00:59
Assembly Layout	00:00
Looking at Drawing	14:20
Completing Rework	01:24
Quality Control	08:52
Conveying Corrections	01:31
Total	43:24

Cycle	Start	End	Duration	Category	Note
1	25:13	25:30	00:17	Measuring Assembly	
1	25:30	26:05	00:35	Looking at Drawing	
1	26:05	27:15	01:10	Measuring Assembly	
1	27:15	29:08	01:53	Looking at Drawing	
1	29:08	29:12	00:04	Adjusting Assembly	UNDOC RW 5
1	29:12	29:42	00:30	Looking at Drawing	
1	29:42	29:57	00:15	Adjusting Assembly	UNDOC RW 5
1	29:57	30:17	00:20	Measuring Assembly	
1	30:17	30:36	00:19	Chatting with Administrator	
2	30:36	33:58	03:22	Quality Control	
2	33:58	34:10	00:12	Conveying Corrections	
2	34:10	34:34	00:24	Completing Rework	RW 4
2	34:34	34:54	00:20	Conveying Corrections	
2	34:54	35:06	00:12	Completing Rework	RW 3
2	35:06	35:13	00:07	Conveying Corrections	
2	35:13	35:56	00:43	Adjusting Clips	
2	35:56	36:08	00:12	Completing Rework	RW 3
3	36:08	37:20	01:12	Quality Control	
3	37:20	37:30	00:10	Conveying Corrections	
3	37:30	37:38	00:08	Completing Rework	RW 5
3	37:38	37:59	00:21	Conveying Corrections	
3	37:59	38:13	00:14	Manipulating Stands	
3	38:13	38:22	00:09	Completing Rework	RW 1
4	38:22	40:05	01:43	Quality Control	
4	40:05	40:18	00:13	Conveying Corrections	
4	40:18	40:20	00:02	Completing Rework	RW 2
4	40:20	40:27	00:07	Completing Rework	RW 1
5	40:27	41:35	01:08	Quality Control	
5	41:35	41:40	00:05	Conveying Corrections	
5	41:40	41:46	00:06	Completing Rework	RW 1
5	41:46	41:49	00:03	Conveying Corrections	
5	41:49	41:53	00:04	Completing Rework	RW 5
6	41:53	43:20	01:27	Quality Control	
6	43:20	43:24	00:04	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:19	00:19	Chatting with Administrator	
1	00:19	01:12	00:53	Looking at Drawing	
1	01:12	01:22	00:10	Assembling Assembly	
1	01:22	01:30	00:08	Looking at Drawing	
1	01:30	01:32	00:02	Assembling Assembly	
1	01:32	01:42	00:10	Looking at Drawing	
1	01:42	01:44	00:02	Assembling Assembly	
1	01:44	02:21	00:37	Looking at Drawing	
1	02:21	02:41	00:20	Manipulating Stands	
1	02:41	03:13	00:32	Measuring Assembly	
1	03:13	03:23	00:10	Manipulating Stands	
1	03:23	03:28	00:05	Adjusting Assembly	UNDOC RW 2
1	03:28	03:41	00:13	Measuring Assembly	
1	03:41	04:00	00:19	Chatting with Administrator	
1	04:00	04:07	00:07	Looking at Drawing	
1	04:07	04:22	00:15	Adjusting Clips	
1	04:22	05:05	00:43	Looking at Drawing	
1	05:05	05:17	00:12	Manipulating Stands	
1	05:17	05:40	00:23	Looking at Drawing	
1	05:40	05:42	00:02	Manipulating Stands	
1	05:42	06:32	00:50	Looking at Drawing	
1	06:32	06:43	00:11	Assembling Assembly	
1	06:43	06:58	00:15	Manipulating Stands	
1	06:58	07:08	00:10	Assembling Assembly	
1	07:08	07:21	00:13	Looking at Drawing	
1	07:21	07:24	00:03	Assembling Assembly	
1	07:24	07:50	00:26	Manipulating Stands	
1	07:50	09:45	01:55	Measuring Assembly	
1	09:45	10:09	00:24	Looking at Drawing	
1	10:09	10:18	00:09	Assembling Assembly	UNDOC RW 4
1	10:18	10:23	00:05	Manipulating Stands	

Totals	
Chatting with Administrator	02:19
Assembling Assembly	00:54
Adjusting Clips	01:25
Measuring Assembly	04:04
Checking Assembly	00:06
Manipulating Stands	02:00
Adjusting Assembly	00:46
Assembly Layout	00:00
Looking at Drawing	08:03
Completing Rework	00:33
Quality Control	04:43
Conveying Corrections	00:34
Total	25:27

1	10:23	10:32	00:09	Adjusting Assembly	UNDOC RW 4
1	10:32	11:04	00:32	Looking at Drawing	
1	11:04	11:17	00:13	Measuring Assembly	
1	11:17	11:23	00:06	Adjusting Assembly	UNDOC RW 4
1	11:23	11:26	00:03	Measuring Assembly	
1	11:26	11:29	00:03	Adjusting Assembly	UNDOC RW 4
1	11:29	11:43	00:14	Looking at Drawing	
1	11:43	11:56	00:13	Adjusting Clips	
1	11:56	11:58	00:02	Adjusting Assembly	UNDOC RW 4
1	11:58	12:04	00:06	Checking Assembly	
1	12:04	12:23	00:19	Adjusting Clips	
1	12:23	12:40	00:17	Looking at Drawing	
1	12:40	12:47	00:07	Assembling Assembly	
1	12:47	13:22	00:35	Looking at Drawing	
1	13:22	13:33	00:11	Measuring Assembly	
1	13:33	14:02	00:29	Looking at Drawing	
1	14:02	14:09	00:07	Measuring Assembly	
1	14:09	14:12	00:03	Adjusting Assembly	UNDOC RW 5
1	14:12	14:28	00:16	Looking at Drawing	
1	14:28	14:49	00:21	Manipulating Stands	
1	14:49	15:07	00:18	Looking at Drawing	
1	15:07	15:39	00:32	Measuring Assembly	
1	15:39	15:40	00:01	Adjusting Assembly	UNDOC RW 5
1	15:40	15:58	00:18	Measuring Assembly	
1	15:58	16:01	00:03	Adjusting Assembly	UNDOC RW 5
1	16:01	16:24	00:23	Looking at Drawing	
1	16:24	16:38	00:14	Adjusting Assembly	UNDOC RW 5
1	16:38	16:42	00:04	Looking at Drawing	
1	16:42	16:56	00:14	Adjusting Clips	
1	16:56	17:23	00:27	Looking at Drawing	
1	17:23	18:48	01:25	Chatting with Administrator	
2	18:48	20:40	01:52	Quality Control	
2	20:40	20:49	00:09	Conveying Corrections	
2	20:49	21:06	00:17	Adjusting Clips	
2	21:06	21:13	00:07	Completing Rework	RW 4
2	21:13	21:15	00:02	Conveying Corrections	
2	21:15	21:22	00:07	Adjusting Clips	
2	21:22	21:27	00:05	Conveying Corrections	
2	21:27	21:36	00:09	Completing Rework	RW 4
2	21:36	21:39	00:03	Conveying Corrections	
2	21:39	21:52	00:13	Completing Rework	RW 3
2	21:52	22:01	00:09	Manipulating Stands	
2	22:01	22:12	00:11	Chatting with Administrator	
3	22:12	24:02	01:50	Quality Control	
3	24:02	24:17	00:15	Conveying Corrections	
3	24:17	24:21	00:04	Completing Rework	RW 5
4	24:21	25:22	01:01	Quality Control	
4	25:22	25:27	00:05	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	03:10	03:10	Chatting with Administrator	
1	03:10	03:32	00:22	Looking at Drawing	
1	03:32	03:52	00:20	Assembly Layout	
1	03:52	04:05	00:13	Looking at Drawing	
1	04:05	04:33	00:28	Assembly Layout	
1	04:33	04:45	00:12	Looking at Drawing	
1	04:45	05:32	00:47	Assembling Assembly	
1	05:32	05:42	00:10	Looking at Drawing	
1	05:42	06:01	00:19	Measuring Assembly	
1	06:01	06:45	00:44	Manipulating Stands	
1	06:45	08:10	01:25	Measuring Assembly	
1	08:10	08:21	00:11	Manipulating Stands	
1	08:21	08:35	00:14	Measuring Assembly	
1	08:35	08:52	00:17	Manipulating Stands	
1	08:52	09:06	00:14	Assembling Assembly	
1	09:06	11:00	01:54	Looking at Drawing	
1	11:00	11:16	00:16	Assembling Assembly	

Totals	
Chatting with Administrator	06:23
Assembling Assembly	02:00
Adjusting Clips	00:04
Measuring Assembly	14:16
Checking Assembly	00:25
Manipulating Stands	12:19
Adjusting Assembly	01:49
Assembly Layout	00:48
Looking at Drawing	10:27
Completing Rework	01:02
Quality Control	06:30
Conveying Corrections	01:28
Total	57:31

1	11:16	12:08	00:52	Looking at Drawing	
1	12:08	12:16	00:08	Assembling Assembly	
1	12:16	12:22	00:06	Looking at Drawing	
1	12:22	12:46	00:24	Assembling Assembly	
1	12:46	13:05	00:19	Looking at Drawing	
1	13:05	13:16	00:11	Assembling Assembly	pt 2
1	13:16	13:23	00:07	Looking at Drawing	
1	13:23	13:40	00:17	Manipulating Stands	
1	13:40	14:30	00:50	Measuring Assembly	
1	14:30	16:20	01:50	Manipulating Stands	
1	16:20	17:00	00:40	Looking at Drawing	
1	17:00	17:17	00:17	Measuring Assembly	
1	17:17	17:35	00:18	Looking at Drawing	
1	17:35	17:45	00:10	Manipulating Stands	
1	17:45	18:30	00:45	Looking at Drawing	
1	18:30	18:40	00:10	Measuring Assembly	
1	18:40	19:52	01:12	Looking at Drawing	
1	19:52	21:04	01:12	Manipulating Stands	
1	21:04	22:00	00:56	Measuring Assembly	
1	22:00	22:30	00:30	Manipulating Stands	
1	22:30	26:20	03:50	Measuring Assembly	
1	26:20	27:04	00:44	Manipulating Stands	
1	27:04	27:25	00:21	Measuring Assembly	
1	27:25	0:27:35	00:10	Manipulating Stands	
1	27:35	27:40	00:05	Measuring Assembly	
1	27:40	28:22	00:42	Manipulating Stands	
1	28:22	31:00	02:38	Looking at Drawing	
1	31:00	31:17	00:17	Measuring Assembly	
1	31:17	31:33	00:16	Looking at Drawing	
1	31:33	32:00	00:27	Measuring Assembly	
1	32:00	32:23	00:23	Looking at Drawing	
1	32:23	33:09	00:46	Measuring Assembly	
1	33:09	33:17	00:08	Adjusting Assembly	undoc rw 3
1	33:17	33:30	00:13	Measuring Assembly	
1	33:30	33:40	00:10	Manipulating Stands	
1	33:40	34:10	00:30	Measuring Assembly	
1	34:10	34:25	00:15	Adjusting Assembly	undoc rw 3
1	34:25	35:00	00:35	Manipulating Stands	
1	35:00	35:10	00:10	Chatting with Administrator	
1	35:10	35:57	00:47	Measuring Assembly	
1	35:57	36:04	00:07	Manipulating Stands	
1	36:04	36:10	00:06	Measuring Assembly	
1	36:10	36:19	00:09	Manipulating Stands	
1	36:19	37:00	00:41	Measuring Assembly	
1	37:00	37:28	00:28	Adjusting Assembly	undoc rw 5
1	37:28	37:45	00:17	Measuring Assembly	
1	37:45	37:50	00:05	Manipulating Stands	
1	37:50	38:20	00:30	Adjusting Assembly	undoc rw 5
1	38:20	38:32	00:12	Manipulating Stands	
1	38:32	39:14	00:42	Measuring Assembly	
1	39:14	39:22	00:08	Adjusting Assembly	undoc rw 5
1	39:22	39:27	00:05	Measuring Assembly	
1	39:27	39:33	00:06	Adjusting Assembly	undoc rw 5
1	39:33	39:37	00:04	Measuring Assembly	
1	39:37	39:42	00:05	Adjusting Assembly	undoc rw 5
1	39:42	39:56	00:14	Measuring Assembly	
1	39:56	40:05	00:09	Adjusting Assembly	undoc rw 5
1	40:05	40:45	00:40	Measuring Assembly	
1	40:45	40:55	00:10	Manipulating Stands	
1	40:55	41:55	01:00	Chatting with Administrator	
2	41:55	44:12	02:17	Quality Control	
2	44:12	44:49	00:37	Conveying Corrections	
2	44:49	45:14	00:25	Chatting with Administrator	
2	45:14	45:25	00:11	Completing Rework	rw 4
2	45:25	45:35	00:10	Manipulating Stands	
2	45:35	45:43	00:08	Completing Rework	rw 5
2	45:43	46:08	00:25	Manipulating Stands	
2	46:08	46:22	00:14	Chatting with Administrator	
2	46:22	46:36	00:14	Conveying Corrections	
2	46:36	46:56	00:20	Chatting with Administrator	
2	46:56	47:00	00:04	Adjusting Clips	

2	47:00	47:17	00:17	Completing Rework	rw 3
2	47:17	47:57	00:40	Manipulating Stands	
2	47:57	48:10	00:13	Checking Assembly	
2	48:10	48:15	00:05	Conveying Corrections	
2	48:15	48:20	00:05	Completing Rework	rw 5
2	48:20	48:35	00:15	Chatting with Administrator	
3	48:35	50:35	02:00	Quality Control	
3	50:35	50:42	00:07	Conveying Corrections	
3	50:42	50:47	00:05	Chatting with Administrator	
3	50:47	52:19	01:32	Manipulating Stands	
3	52:19	52:25	00:06	Chatting with Administrator	
3	52:25	53:10	00:45	Manipulating Stands	
3	53:10	53:22	00:12	Checking Assembly	
3	53:22	53:32	00:10	Conveying Corrections	
3	53:32	53:38	00:06	Completing Rework	rw 1
3	53:38	54:10	00:32	Manipulating Stands	
3	54:10	54:27	00:17	Chatting with Administrator	
4	54:27	55:27	01:00	Quality Control	
4	55:27	55:32	00:05	Conveying Corrections	
4	55:32	55:37	00:05	Completing Rework	rw 5
5	55:37	55:50	00:13	Quality Control	
5	55:50	56:00	00:10	Conveying Corrections	
5	56:00	56:05	00:05	Completing Rework	rw 2
5	56:05	56:15	00:10	Chatting with Administrator	
5	56:15	56:20	00:05	Completing Rework	rw 1
6	56:20	57:20	01:00	Quality Control	
6	57:20	57:31	00:11	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:49	02:49	Chatting with Administrator	
1	02:49	04:35	01:46	Looking at Drawing	
1	04:35	04:52	00:17	Assembling Assembly	
1	04:52	05:08	00:16	Manipulating Stands	
1	05:08	05:18	00:10	Looking at Drawing	
1	05:18	05:24	00:06	Assembling Assembly	
1	05:24	05:36	00:12	Manipulating Stands	
1	05:36	05:47	00:11	Looking at Drawing	
1	05:47	06:26	00:39	Manipulating Stands	
1	06:26	07:10	00:44	Chatting with Administrator	
1	07:10	08:19	01:09	Measuring Assembly	
1	08:19	08:59	00:40	Looking at Drawing	
1	08:59	09:39	00:40	Manipulating Stands	
1	09:39	10:30	00:51	Looking at Drawing	
1	10:30	11:38	01:08	Chatting with Administrator	
1	11:38	15:35	03:57	Looking at Drawing	
1	15:35	15:45	00:10	Adjusting Assembly	undoc rw 3
1	15:45	16:00	00:15	Manipulating Stands	
1	16:00	18:04	02:04	Looking at Drawing	
1	18:04	18:14	00:10	Manipulating Stands	
1	18:14	18:30	00:16	Adjusting Assembly	undoc rw 2
1	18:30	18:50	00:20	Checking Assembly	
1	18:50	19:13	00:23	Looking at Drawing	
1	19:13	19:21	00:08	Manipulating Stands	
1	19:21	20:15	00:54	Looking at Drawing	
1	20:15	21:51	01:36	Measuring Assembly	
1	21:51	22:02	00:11	Adjusting Assembly	undoc rw 4
1	22:02	22:15	00:13	Manipulating Stands	
1	22:15	22:25	00:10	Measuring Assembly	
1	22:25	24:00	01:35	Looking at Drawing	
1	24:00	24:21	00:21	Manipulating Stands	
1	24:21	24:36	00:15	Adjusting Assembly	undoc rw 1
1	24:36	24:50	00:14	Manipulating Stands	
1	24:50	25:00	00:10	Adjusting Assembly	undoc rw 1
1	25:00	25:15	00:15	Manipulating Stands	
1	25:15	25:20	00:05	Adjusting Assembly	undoc rw 1
1	25:20	25:27	00:07	Measuring Assembly	
1	25:27	25:50	00:23	Looking at Drawing	

Totals	
Chatting with Administrator	06:25
Assembling Assembly	00:36
Adjusting Clips	00:00
Measuring Assembly	06:13
Checking Assembly	03:42
Manipulating Stands	07:46
Adjusting Assembly	03:18
Assembly Layout	00:00
Looking at Drawing	18:11
Completing Rework	00:00
Quality Control	02:05
Conveying Corrections	00:00
Total	48:16

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1	25:50	26:00	00:10	Measuring Assembly	
1	26:00	27:03	01:03	Looking at Drawing	
1	27:03	27:16	00:13	Assembling Assembly	
1	27:16	27:50	00:34	Looking at Drawing	
1	27:50	28:13	00:23	Checking Assembly	
1	28:13	28:36	00:23	Looking at Drawing	
1	28:36	28:41	00:05	Adjusting Assembly	undoc rw 5
1	28:41	29:04	00:23	Manipulating Stands	
1	29:04	29:42	00:38	Measuring Assembly	
1	29:42	30:15	00:33	Manipulating Stands	
1	30:15	30:40	00:25	Adjusting Assembly	undoc rw 2
1	30:40	31:05	00:25	Manipulating Stands	
1	31:05	31:35	00:30	Measuring Assembly	
1	31:35	31:50	00:15	Chatting with Administrator	
1	31:50	32:02	00:12	Adjusting Assembly	undoc rw 1
1	32:02	32:29	00:27	Measuring Assembly	
1	32:29	32:45	00:16	Manipulating Stands	
1	32:45	33:12	00:27	Measuring Assembly	
1	33:12	33:25	00:13	Looking at Drawing	
1	33:25	33:52	00:27	Manipulating Stands	
1	33:52	34:02	00:10	Adjusting Assembly	undoc rw1
1	34:02	34:31	00:29	Manipulating Stands	
1	34:31	34:45	00:14	Measuring Assembly	
1	34:45	34:55	00:10	Checking Assembly	
1	34:55	35:35	00:40	Looking at Drawing	
1	35:35	36:20	00:45	Manipulating Stands	
1	36:20	36:25	00:05	Looking at Drawing	
1	36:25	36:30	00:05	Checking Assembly	
1	36:30	36:40	00:10	Manipulating Stands	
1	36:40	37:05	00:25	Measuring Assembly	
1	37:05	38:10	01:05	Looking at Drawing	
1	38:10	38:22	00:12	Manipulating Stands	
1	38:22	38:30	00:08	Adjusting Assembly	undoc rw 4
1	38:30	38:46	00:16	Manipulating Stands	
1	38:46	39:05	00:19	Looking at Drawing	
1	39:05	39:22	00:17	Manipulating Stands	
1	39:22	39:45	00:23	Looking at Drawing	
1	39:45	39:50	00:05	Checking Assembly	
1	39:50	40:00	00:10	Manipulating Stands	
1	40:00	40:20	00:20	Measuring Assembly	
1	40:20	40:45	00:25	Checking Assembly	
1	40:45	41:49	01:04	Adjusting Assembly	undoc rw 5
1	41:49	43:22	01:33	Checking Assembly	
1	43:22	43:29	00:07	Adjusting Assembly	undoc rw 5
1	43:29	44:10	00:41	Checking Assembly	
1	44:10	44:42	00:32	Looking at Drawing	
1	44:42	45:42	01:00	Chatting with Administrator	
2	45:42	47:47	02:05	Quality Control	
2	47:47	48:16	00:29	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	03:32	03:32	Chatting with Administrator	
1	03:32	03:48	00:16	Assembly Layout	
1	03:48	03:57	00:09	Looking at Drawing	
1	03:57	04:12	00:15	Chatting with Administrator	
1	04:12	04:25	00:13	Assembling Assembly	
1	04:25	05:59	01:34	Measuring Assembly	
1	05:59	06:15	00:16	Looking at Drawing	
1	06:15	06:44	00:29	Assembling Assembly	
1	06:44	06:57	00:13	Adjusting Clips	
1	06:57	07:05	00:08	Assembling Assembly	
1	07:05	07:13	00:08	Adjusting Clips	
1	07:13	07:26	00:13	Assembling Assembly	
1	07:26	07:59	00:33	Looking at Drawing	
1	07:59	08:06	00:07	Assembling Assembly	
1	08:06	09:14	01:08	Chatting with Administrator	
1	09:14	09:22	00:08	Manipulating Stands	

Totals	
Chatting with Administrator	08:03
Assembling Assembly	01:45
Adjusting Clips	01:32
Measuring Assembly	12:40
Checking Assembly	02:55
Manipulating Stands	04:42
Adjusting Assembly	03:36
Assembly Layout	00:16
Looking at Drawing	10:12
Completing Rework	00:09
Quality Control	03:59
Conveying Corrections	00:47
Total	50:36

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1	09:22	09:27	00:05	Assembling Assembly		
1	09:27	09:36	00:09	Looking at Drawing		
1	09:36	09:43	00:07	Manipulating Stands		
1	09:43	09:54	00:11	Assembling Assembly		
1	09:54	10:00	00:06	Adjusting Clips		
1	10:00	10:11	00:11	Assembling Assembly		
1	10:11	10:19	00:08	Adjusting Clips		
1	10:19	10:27	00:08	Assembling Assembly		
1	10:27	11:29	01:02	Chatting with Administrator		
1	11:29	11:44	00:15	Measuring Assembly		
1	11:44	12:07	00:23	Manipulating Stands		
1	12:07	12:12	00:05	Adjusting Assembly	udrw 1	
1	12:12	12:24	00:12	Looking at Drawing		
1	12:24	13:00	00:36	Measuring Assembly		
1	13:00	13:27	00:27	Looking at Drawing		
1	13:27	13:39	00:12	Adjusting Assembly		3
1	13:39	13:58	00:19	Manipulating Stands		
1	13:58	15:05	01:07	Looking at Drawing		
1	15:05	15:30	00:25	Measuring Assembly		
1	15:30	15:40	00:10	Adjusting Assembly	udrw 4	
1	15:40	15:47	00:07	Looking at Drawing		
1	15:47	15:57	00:10	Adjusting Assembly	udrw 4	
1	15:57	16:20	00:23	Manipulating Stands		
1	16:20	16:35	00:15	Looking at Drawing		
1	16:35	16:53	00:18	Adjusting Clips		
1	16:53	17:00	00:07	Adjusting Assembly	udrw 4	
1	17:00	17:04	00:04	Adjusting Clips		
1	17:04	17:16	00:12	Adjusting Assembly	unrw 5	
1	17:16	17:21	00:05	Manipulating Stands		
1	17:21	17:47	00:26	Looking at Drawing		
1	17:47	17:53	00:06	Adjusting Assembly	udrw 1	
1	17:53	18:06	00:13	Manipulating Stands		
1	18:06	18:39	00:33	Measuring Assembly		
1	18:39	18:41	00:02	Adjusting Assembly		2
1	18:41	18:49	00:08	Manipulating Stands		
1	18:49	19:13	00:24	Measuring Assembly		
1	19:13	19:15	00:02	Adjusting Assembly	udrw 1	
1	19:15	19:29	00:14	Measuring Assembly		
1	19:29	20:27	00:58	Looking at Drawing		
1	20:27	21:05	00:38	Measuring Assembly		
1	21:05	21:13	00:08	Adjusting Assembly	udrw 4	
1	21:13	21:20	00:07	Manipulating Stands		
1	21:20	21:27	00:07	Adjusting Assembly	unrw 5	
1	21:27	21:52	00:25	Measuring Assembly		
1	21:52	22:14	00:22	Looking at Drawing		
1	22:14	23:51	01:37	Measuring Assembly		
1	23:51	24:25	00:34	Looking at Drawing		
1	24:25	24:31	00:06	Measuring Assembly		
1	24:31	24:44	00:13	Looking at Drawing		
1	24:44	24:50	00:06	Adjusting Assembly	udrw 4	
1	24:50	25:08	00:18	Manipulating Stands		
1	25:08	25:24	00:16	Chatting with Administrator		
1	25:24	25:27	00:03	Measuring Assembly		
1	25:27	25:35	00:08	Chatting with Administrator		
1	25:35	25:51	00:16	Adjusting Assembly	udrw 4	
1	25:51	26:10	00:19	Manipulating Stands		
1	26:10	26:17	00:07	Adjusting Assembly	undrw1	
1	26:17	26:28	00:11	Measuring Assembly		
1	26:28	26:40	00:12	Adjusting Assembly	udrw 4	
1	26:40	27:13	00:33	Manipulating Stands		
1	27:13	27:28	00:15	Adjusting Assembly	udrw 4	
1	27:28	27:32	00:04	Manipulating Stands		
1	27:32	27:50	00:18	Measuring Assembly		
1	27:50	28:10	00:20	Looking at Drawing		
1	28:10	28:22	00:12	Measuring Assembly		
1	28:22	28:30	00:08	Adjusting Assembly	udrw 4	
1	28:30	28:41	00:11	Manipulating Stands		
1	28:41	28:55	00:14	Measuring Assembly		
1	28:55	29:08	00:13	Manipulating Stands		
1	29:08	29:10	00:02	Measuring Assembly		
1	29:10	29:38	00:28	Manipulating Stands		

1	29:38	29:50	00:12	Adjusting Assembly	udrw 4
1	29:50	30:42	00:52	Measuring Assembly	
1	30:42	30:47	00:05	Adjusting Assembly	udrw 4
1	30:47	31:00	00:13	Measuring Assembly	
1	31:00	31:30	00:30	Looking at Drawing	
1	31:30	31:50	00:20	Measuring Assembly	
1	31:50	32:02	00:12	Looking at Drawing	
1	32:02	32:06	00:04	Measuring Assembly	
1	32:06	32:10	00:04	Adjusting Assembly	unrw 5
1	32:10	32:25	00:15	Looking at Drawing	
1	32:25	32:42	00:17	Checking Assembly	
1	32:42	33:17	00:35	Adjusting Clips	
1	33:17	33:25	00:08	Adjusting Assembly	unrw5
1	33:25	33:30	00:05	Manipulating Stands	
1	33:30	33:42	00:12	Measuring Assembly	
1	33:42	34:28	00:46	Looking at Drawing	
1	34:28	34:50	00:22	Adjusting Assembly	udrw 4
1	34:50	34:55	00:05	Looking at Drawing	
1	34:55	35:00	00:05	Adjusting Assembly	unrw 5
1	35:00	35:16	00:16	Manipulating Stands	
1	35:16	35:41	00:25	Looking at Drawing	
1	35:41	35:50	00:09	Manipulating Stands	
1	35:50	36:05	00:15	Checking Assembly	
1	36:05	36:35	00:30	Looking at Drawing	
1	36:35	37:25	00:50	Measuring Assembly	
1	37:25	38:10	00:45	Looking at Drawing	
1	38:10	38:25	00:15	Adjusting Assembly	unrw 5
1	38:25	38:55	00:30	Measuring Assembly	
1	38:55	39:35	00:40	Checking Assembly	
1	39:35	39:43	00:08	Looking at Drawing	
1	39:43	41:35	01:52	Measuring Assembly	
1	41:35	41:44	00:09	Manipulating Stands	
1	41:44	43:27	01:43	Checking Assembly	
2	43:27	45:55	02:28	Quality Control	
2	45:55	46:58	01:03	Chatting with Administrator	
2	46:58	47:45	00:47	Conveying Corrections	
2	47:45	48:13	00:28	Looking at Drawing	
2	48:13	48:22	00:09	Completing Rework	rw 4
2	48:22	48:26	00:04	Manipulating Stands	
2	48:26	49:01	00:35	Chatting with Administrator	
3	49:01	50:32	01:31	Quality Control	
3	50:32	50:36	00:04	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:59	02:59	Chatting with Administrator	
1	02:59	03:25	00:26	Looking at Drawing	
1	03:25	03:32	00:07	Assembly Layout	
1	03:32	03:55	00:23	Looking at Drawing	
1	03:55	04:00	00:05	Assembling Assembly	pt 2
1	04:00	04:10	00:10	Looking at Drawing	
1	04:10	04:17	00:07	Manipulating Stands	
1	04:17	04:22	00:05	Looking at Drawing	
1	04:22	04:33	00:11	Manipulating Stands	
1	04:33	04:58	00:25	Looking at Drawing	
1	04:58	05:07	00:09	Measuring Assembly	
1	05:07	05:17	00:10	Manipulating Stands	
1	05:17	05:32	00:15	Measuring Assembly	
1	05:32	06:02	00:30	Looking at Drawing	
1	06:02	06:06	00:04	Assembling Assembly	pt 3
1	06:06	06:32	00:26	Looking at Drawing	
1	06:32	06:52	00:20	Manipulating Stands	
1	06:52	07:27	00:35	Looking at Drawing	
1	07:27	08:00	00:33	Measuring Assembly	
1	08:00	08:15	00:15	Looking at Drawing	
1	08:15	08:30	00:15	Measuring Assembly	
1	08:30	09:30	01:00	Looking at Drawing	
1	09:30	09:33	00:03	Manipulating Stands	

Totals	
Chatting with Administrator	11:16
Assembling Assembly	00:14
Adjusting Clips	00:00
Measuring Assembly	10:42
Checking Assembly	01:20
Manipulating Stands	03:27
Adjusting Assembly	00:53
Assembly Layout	00:07
Looking at Drawing	07:24
Completing Rework	00:41
Quality Control	06:15
Conveying Corrections	00:31
Total	42:50

1	09:33	09:41	00:08	Adjusting Assembly	pt four
1	09:41	09:47	00:06	Looking at Drawing	
1	09:47	09:58	00:11	Measuring Assembly	
1	09:58	10:02	00:04	Adjusting Assembly	pt four
1	10:02	10:24	00:22	Measuring Assembly	
1	10:24	10:27	00:03	Adjusting Assembly	pt four
1	10:27	10:33	00:06	Measuring Assembly	
1	10:33	10:39	00:06	Adjusting Assembly	pt four
1	10:39	10:43	00:04	Measuring Assembly	
1	10:43	10:48	00:05	Adjusting Assembly	pt four
1	10:48	10:57	00:09	Measuring Assembly	
1	10:57	11:55	00:58	Looking at Drawing	
1	11:55	12:06	00:11	Measuring Assembly	
1	12:06	12:18	00:12	Manipulating Stands	
1	12:18	12:33	00:15	Measuring Assembly	
1	12:33	12:41	00:08	Looking at Drawing	
1	12:41	13:43	01:02	Chatting with Administrator	
1	13:43	14:11	00:28	Manipulating Stands	
1	14:11	14:30	00:19	Looking at Drawing	
1	14:30	14:50	00:20	Measuring Assembly	
1	14:50	15:00	00:10	Manipulating Stands	
1	15:00	15:16	00:16	Measuring Assembly	
1	15:16	15:26	00:10	Manipulating Stands	
1	15:26	15:35	00:09	Measuring Assembly	
1	15:35	15:40	00:05	Manipulating Stands	
1	15:40	15:50	00:10	Measuring Assembly	
1	15:50	15:53	00:03	Manipulating Stands	
1	15:53	16:00	00:07	Measuring Assembly	
1	16:00	16:21	00:21	Looking at Drawing	
1	16:21	16:46	00:25	Manipulating Stands	
1	16:46	16:49	00:03	Measuring Assembly	
1	16:49	16:57	00:08	Measuring Assembly	
1	16:57	17:02	00:05	Manipulating Stands	
1	17:02	17:10	00:08	Measuring Assembly	
1	17:10	17:14	00:04	Manipulating Stands	
1	17:14	17:29	00:15	Measuring Assembly	
1	17:29	17:35	00:06	Manipulating Stands	
1	17:35	18:10	00:35	Measuring Assembly	
1	18:10	18:20	00:10	Manipulating Stands	
1	18:20	18:30	00:10	Measuring Assembly	
1	18:30	18:43	00:13	Looking at Drawing	
1	18:43	19:10	00:27	Measuring Assembly	
1	19:10	19:37	00:27	Looking at Drawing	
1	19:37	19:48	00:11	Measuring Assembly	
1	19:48	19:52	00:04	Adjusting Assembly	pt four
1	19:52	19:59	00:07	Measuring Assembly	
1	19:59	20:05	00:06	Adjusting Assembly	pt four
1	20:05	21:50	01:45	Measuring Assembly	
1	21:50	21:56	00:06	Adjusting Assembly	pt four
1	21:56	22:00	00:04	Measuring Assembly	
1	22:00	22:11	00:11	Measuring Assembly	
1	22:11	22:35	00:24	Looking at Drawing	
1	22:35	22:40	00:05	Assembling Assembly	pt 5
1	22:40	23:20	00:40	Measuring Assembly	
1	23:20	24:24	01:04	Chatting with Administrator	
1	24:24	25:10	00:46	Measuring Assembly	
1	25:10	25:15	00:05	Adjusting Assembly	pt 5
1	25:15	25:32	00:17	Measuring Assembly	
1	25:32	25:38	00:06	Adjusting Assembly	pt 5
1	25:38	25:50	00:12	Measuring Assembly	
1	25:50	27:15	01:25	Chatting with Administrator	
1	27:15	27:28	00:13	Measuring Assembly	
1	27:28	27:37	00:09	Manipulating Stands	
1	27:37	27:59	00:22	Measuring Assembly	
1	27:59	28:12	00:13	Looking at Drawing	
1	28:12	28:18	00:06	Measuring Assembly	
1	28:18	28:50	00:32	Chatting with Administrator	
1	28:50	30:10	01:20	Checking Assembly	
1	30:10	30:40	00:30	Measuring Assembly	
1	30:40	32:10	01:30	Chatting with Administrator	
2	32:10	35:17	03:07	Quality Control	

2	35:17	35:48	00:31	Chatting with Administrator	
2	35:48	35:59	00:11	Conveying Corrections	
2	35:59	36:10	00:11	Chatting with Administrator	
2	36:10	36:15	00:05	Completing Rework	rw 5
2	36:15	36:25	00:10	Chatting with Administrator	
2	36:25	36:38	00:13	Conveying Corrections	
2	36:38	36:49	00:11	Chatting with Administrator	
2	36:49	37:10	00:21	Completing Rework	rw 1
2	37:10	37:20	00:10	Manipulating Stands	
2	37:20	37:33	00:13	Chatting with Administrator	
2	37:33	37:40	00:07	Manipulating Stands	
3	37:40	38:43	01:03	Quality Control	
3	38:43	38:50	00:07	Conveying Corrections	
3	38:50	39:05	00:15	Chatting with Administrator	
3	39:05	39:12	00:07	Completing Rework	rw 1
3	39:12	39:18	00:06	Manipulating Stands	
3	39:18	39:26	00:08	Completing Rework	rw 1
3	39:26	39:32	00:06	Manipulating Stands	
4	39:32	41:37	02:05	Quality Control	
4	41:37	42:50	01:13	Chatting with Administrator	

Appendix F

Fitters with App Raw Data

				F-A-01		

Cycle	Start	End	Duration	Category	Note
1	00:00	00:52	00:52	Looking at Drawing	
1	00:52	01:40	00:48	Chatting with Administrator	
1	01:40	01:55	00:15	Looking at Drawing	
1	01:55	02:11	00:16	Assembling Assembly	pt 5
1	02:11	02:30	00:19	Model Segmentation	
1	02:30	02:45	00:15	Looking at 3D Model	
1	02:45	02:55	00:10	Adjusting Assembly	pt 5
1	02:55	03:05	00:10	Looking at Drawing	
1	03:05	03:40	00:35	Chatting with Administrator	
2	03:40	04:17	00:37	Scan Acquisition	
2	04:17	05:03	00:46	Scan Processing	
2	05:03	05:05	00:02	Output Analysis	
2	05:05	05:18	00:13	Chatting with Administrator	
2	05:18	05:25	00:07	Completing Rework	RW 5
3	05:25	05:50	00:25	Scan Acquisition	
3	05:50	06:35	00:45	Scan Processing	
3	06:35	06:38	00:03	Output Analysis	
3	06:38	07:00	00:22	Scan Processing	
3	07:00	07:02	00:02	Output Analysis	
3	07:02	07:16	00:14	Chatting with Administrator	
3	07:16	07:30	00:14	Looking at Drawing	
3	07:30	07:45	00:15	Assembling Assembly	pt 1
3	07:45	08:01	00:16	Assembling Assembly	pt 2
3	08:01	08:16	00:15	Adjusting Assembly	pt 1
3	08:16	08:20	00:04	Looking at Drawing	
3	08:20	08:45	00:25	Chatting with Administrator	
4	08:45	09:24	00:39	Scan Acquisition	
4	09:24	10:08	00:44	Scan Processing	
4	10:08	10:40	00:32	Chatting with Administrator	
4	10:40	10:45	00:05	Output Analysis	
4	10:45	11:15	00:30	Looking at Drawing	
4	11:15	11:28	00:13	Completing Rework	rw 2
4	11:28	11:45	00:17	Chatting with Administrator	
4	11:45	11:58	00:13	Manipulating Stands	
4	11:58	12:25	00:27	Measuring Assembly	
4	12:25	12:35	00:10	Completing Rework	rw 2
4	12:35	12:40	00:05	Manipulating Stands	
4	12:40	12:50	00:10	Measuring Assembly	
4	12:50	12:55	00:05	Manipulating Stands	
4	12:55	12:59	00:04	Completing Rework	rw 2
4	12:59	13:03	00:04	Measuring Assembly	
4	13:03	13:08	00:05	Manipulating Stands	
4	13:08	13:21	00:13	Measuring Assembly	
4	13:21	13:26	00:05	Completing Rework	rw 5
5	13:26	13:58	00:32	Scan Acquisition	
5	13:58	15:17	01:19	Scan Processing	
5	15:17	15:19	00:02	Output Analysis	
5	15:19	16:33	01:14	Chatting with Administrator	

Totals	
Chatting with Administrator	04:18
Assembling Assembly	00:47
Adjusting Clips	00:00
Measuring Assembly	00:54
Checking Assembly	00:00
Manipulating Stands	00:28
Adjusting Assembly	00:25
Assembly Layout	00:00
Looking at Drawing	02:05
Completing Rework	00:39
Model Segmentation	00:19
Looking at 3D Model	00:15
Scan Acquisition	02:13
Scan Processing	03:56
Output Analysis	00:14
Total	16:33

				F-A-02		

Cycle	Start	End	Duration	Category	Note
1	00:00	00:16	00:16	Looking at Drawing	
1	00:16	00:30	00:14	Assembly Layout	
1	00:30	00:39	00:09	Adjusting Clips	
1	00:39	00:59	00:20	Looking at Drawing	
1	00:59	01:02	00:03	Assembling Assembly	pt 2
1	01:02	01:32	00:30	Manipulating Stands	

Totals	
Chatting with Administrator	10:13
Assembling Assembly	00:55
Adjusting Clips	00:18
Measuring Assembly	03:37
Checking Assembly	00:07

1	01:32	01:42	00:10	Looking at Drawing	
1	01:42	01:48	00:06	Chatting with Administrator	
1	01:48	01:57	00:09	Adjusting Clips	
1	01:57	02:15	00:18	Measuring Assembly	
1	02:15	02:26	00:11	Chatting with Administrator	
1	02:26	02:47	00:21	Measuring Assembly	
1	02:47	03:00	00:13	Manipulating Stands	
1	03:00	03:40	00:40	Measuring Assembly	
1	03:40	03:46	00:06	Manipulating Stands	
1	03:46	03:55	00:09	Looking at Drawing	
1	03:55	05:15	01:20	Looking at 3D Model	
1	05:15	07:20	02:05	Chatting with Administrator	feedback
1	07:20	08:40	01:20	Looking at 3D Model	
1	08:40	09:10	00:30	Chatting with Administrator	
1	09:10	09:21	00:11	Looking at Drawing	
1	09:21	09:28	00:07	Adjusting Assembly	pt 2
1	09:28	09:39	00:11	Measuring Assembly	
1	09:39	10:02	00:23	Chatting with Administrator	
1	10:02	10:09	00:07	Measuring Assembly	
1	10:09	10:14	00:05	Adjusting Assembly	pt 2
1	10:14	11:02	00:48	Measuring Assembly	
1	11:02	11:08	00:06	Adjusting Assembly	pt 2
1	11:08	11:18	00:10	Measuring Assembly	
1	11:18	11:25	00:07	Chatting with Administrator	
1	11:25	11:38	00:13	Model Segmentation	
1	11:38	12:33	00:55	Chatting with Administrator	
2	12:33	13:18	00:45	Scan Acquisition	
2	13:18	14:10	00:52	Scan Processing	
2	14:10	16:55	02:45	Chatting with Administrator	
2	16:55	17:00	00:05	Output Analysis	
2	17:00	17:38	00:38	Chatting with Administrator	
2	17:38	17:47	00:09	Model Segmentation	
2	17:47	17:58	00:11	Looking at Drawing	
2	17:58	19:16	01:18	Chatting with Administrator	
2	19:16	19:40	00:24	Manipulating Stands	
2	19:40	19:51	00:11	Looking at Drawing	
2	19:51	19:59	00:08	Assembly Layout	
2	19:59	20:20	00:21	Manipulating Stands	
2	20:20	20:33	00:13	Assembly Layout	
2	20:33	21:10	00:37	Assembling Assembly	pt 3
2	21:10	21:20	00:10	Looking at Drawing	
2	21:20	21:27	00:07	Chatting with Administrator	
2	21:27	21:38	00:11	Manipulating Stands	
2	21:38	21:46	00:08	Adjusting Assembly	pt 3
2	21:46	22:05	00:19	Manipulating Stands	
2	22:05	22:10	00:05	Adjusting Assembly	pt 3
2	22:10	22:20	00:10	Chatting with Administrator	
2	22:20	22:27	00:07	Measuring Assembly	
2	22:27	22:49	00:22	Looking at Drawing	
2	22:49	22:59	00:10	Adjusting Assembly	pt four
2	22:59	23:11	00:12	Measuring Assembly	
2	23:11	23:35	00:24	Looking at Drawing	
2	23:35	23:45	00:10	Manipulating Stands	
2	23:45	23:50	00:05	Looking at Drawing	
2	23:50	23:56	00:06	Adjusting Assembly	pt four
2	23:56	24:08	00:12	Measuring Assembly	
2	24:08	24:15	00:07	Checking Assembly	
2	24:15	24:30	00:15	Looking at Drawing	
2	24:30	24:42	00:12	Adjusting Assembly	pt four
2	24:42	25:00	00:18	Chatting with Administrator	
2	25:00	26:44	01:44	Looking at 3D Model	
2	26:44	26:51	00:07	Adjusting Assembly	pt four
2	26:51	28:00	01:09	Looking at Drawing	
2	28:00	28:40	00:40	Chatting with Administrator	
3	28:40	29:28	00:48	Scan Acquisition	
3	29:28	30:08	00:40	Scan Processing	
3	30:08	30:10	00:02	Output Analysis	
3	30:10	30:17	00:07	Completing Rework	rw 4
4	30:17	31:03	00:46	Scan Acquisition	
4	31:03	31:49	00:46	Scan Processing	
4	31:49	31:58	00:09	Output Analysis	

Manipulating Stands	02:26
Adjusting Assembly	01:22
Assembly Layout	00:35
Looking at Drawing	04:10
Completing Rework	00:07
Model Segmentation	00:22
Looking at 3D Model	04:24
Scan Acquisition	03:34
Scan Processing	05:41
Output Analysis	00:20
Total	38:11

Cycle	Start	End	Duration	Category	Note
4	31:58	32:10	00:12	Manipulating Stands	
4	32:10	32:26	00:16	Scan Acquisition	
4	32:26	34:15	01:49	Scan Processing	
4	34:15	34:18	00:03	Output Analysis	
4	34:18	34:35	00:17	Looking at Drawing	
4	34:35	34:50	00:15	Assembling Assembly	pt 5
4	34:50	34:58	00:08	Measuring Assembly	
4	34:58	35:06	00:08	Adjusting Assembly	pt 5
4	35:06	35:18	00:12	Measuring Assembly	
4	35:18	35:22	00:04	Adjusting Assembly	pt 5
4	35:22	35:33	00:11	Measuring Assembly	
4	35:33	35:37	00:04	Adjusting Assembly	pt 5
5	35:37	36:36	00:59	Scan Acquisition	
5	36:36	38:10	01:34	Scan Processing	
5	38:10	38:11	00:01	Output Analysis	

F-A-03

Cycle	Start	End	Duration	Category	Note
1	00:00	00:50	00:50	Chatting with Administrator	
1	00:50	01:15	00:25	Model Segmentation	
1	01:15	01:50	00:35	Looking at 3D Model	
1	01:50	02:15	00:25	Chatting with Administrator	
1	02:15	02:40	00:25	Manipulating Stands	
1	02:40	02:53	00:13	Assembling Assembly	pt 2
1	02:53	03:07	00:14	Looking at Drawing	
1	03:07	03:40	00:33	Chatting with Administrator	
1	03:40	03:53	00:13	Looking at Drawing	
1	03:53	04:50	00:57	Chatting with Administrator	
1	04:50	04:59	00:09	Manipulating Stands	
1	04:59	05:12	00:13	Looking at Drawing	
1	05:12	05:18	00:06	Chatting with Administrator	
1	05:18	06:03	00:45	Measuring Assembly	
1	06:03	06:45	00:42	Chatting with Administrator	
1	06:45	07:04	00:19	Measuring Assembly	
1	07:04	07:15	00:11	Manipulating Stands	
1	07:15	07:30	00:15	Measuring Assembly	
1	07:30	07:39	00:09	Manipulating Stands	
1	07:39	07:55	00:16	Measuring Assembly	
1	07:55	08:20	00:25	Chatting with Administrator	
2	08:20	09:00	00:40	Scan Acquisition	
2	09:00	09:40	00:40	Scan Processing	
2	09:40	09:42	00:02	Output Analysis	
2	09:42	10:25	00:43	Chatting with Administrator	
2	10:25	10:37	00:12	Model Segmentation	
2	10:37	11:55	01:18	Looking at 3D Model	
2	11:55	12:51	00:56	Looking at Drawing	
2	12:51	13:05	00:14	Measuring Assembly	
2	13:05	13:10	00:05	Completing Rework	rw 2
2	13:10	13:18	00:08	Measuring Assembly	
2	13:18	13:55	00:37	Looking at Drawing	
2	13:55	14:10	00:15	Chatting with Administrator	
2	14:10	14:20	00:10	Assembly Layout	
2	14:20	14:36	00:16	Looking at Drawing	
2	14:36	14:45	00:09	Chatting with Administrator	
2	14:45	15:16	00:31	Assembly Layout	
2	15:16	15:21	00:05	Completing Rework	rw 2
2	15:21	15:28	00:07	Measuring Assembly	
2	15:28	15:41	00:13	Completing Rework	rw 2
2	15:41	15:50	00:09	Measuring Assembly	
2	15:50	16:05	00:15	Manipulating Stands	
2	16:05	16:08	00:03	Measuring Assembly	
2	16:08	16:12	00:04	Completing Rework	rw 2
2	16:12	16:24	00:12	Measuring Assembly	
2	16:24	16:28	00:04	Completing Rework	rw 2
2	16:28	16:40	00:12	Measuring Assembly	
2	16:40	17:05	00:25	Chatting with Administrator	
2	17:05	17:17	00:12	Manipulating Stands	
2	17:17	17:48	00:31	Measuring Assembly	

Totals	
Chatting with Administrator	09:07
Assembling Assembly	00:51
Adjusting Clips	00:00
Measuring Assembly	06:39
Checking Assembly	00:00
Manipulating Stands	01:32
Adjusting Assembly	00:37
Assembly Layout	00:41
Looking at Drawing	04:08
Completing Rework	01:21
Model Segmentation	00:37
Looking at 3D Model	01:53
Scan Acquisition	04:18
Scan Processing	05:06
Output Analysis	00:19
Total	37:09

Cycle	Start	End	Duration	Category	Note
2	17:48	17:55	00:07	Completing Rework	rw 2
2	17:55	18:02	00:07	Measuring Assembly	
2	18:02	18:06	00:04	Completing Rework	rw 2
2	18:06	18:10	00:04	Measuring Assembly	
2	18:10	18:45	00:35	Assembling Assembly	pt 3
2	18:45	18:50	00:05	Manipulating Stands	
2	18:50	19:05	00:15	Measuring Assembly	
2	19:05	19:17	00:12	Looking at Drawing	
2	19:17	19:25	00:08	Measuring Assembly	
2	19:25	19:33	00:08	Adjusting Assembly	pt 3
2	19:33	19:43	00:10	Measuring Assembly	
2	19:43	19:47	00:04	Adjusting Assembly	pt 3
2	19:47	19:53	00:06	Measuring Assembly	
2	19:53	19:59	00:06	Adjusting Assembly	pt 3
2	19:59	20:05	00:06	Manipulating Stands	
2	20:05	20:14	00:09	Measuring Assembly	
2	20:14	20:20	00:06	Adjusting Assembly	pt 3
2	20:20	20:32	00:12	Measuring Assembly	
2	20:32	21:42	01:10	Chatting with Administrator	scan a bad
2	21:42	23:50	02:08	Chatting with Administrator	scan p bad
3	23:50	24:50	01:00	Scan Acquisition	
3	24:50	25:58	01:08	Scan Processing	
3	25:58	26:09	00:11	Output Analysis	
3	26:09	26:19	00:10	Completing Rework	rw 4
3	26:19	26:50	00:31	Looking at Drawing	
3	26:50	27:10	00:20	Measuring Assembly	
3	27:10	27:15	00:05	Completing Rework	rw 4
3	27:15	27:22	00:07	Measuring Assembly	
3	27:22	27:28	00:06	Completing Rework	rw 4
3	27:28	27:40	00:12	Measuring Assembly	
3	27:40	27:44	00:04	Completing Rework	rw 4
3	27:44	27:54	00:10	Measuring Assembly	
4	27:54	28:56	01:02	Scan Acquisition	
4	28:56	30:00	01:04	Scan Processing	
4	30:00	30:01	00:01	Output Analysis	
4	30:01	30:10	00:09	Looking at Drawing	
4	30:10	30:13	00:03	Assembling Assembly	pt 5
4	30:13	31:00	00:47	Looking at Drawing	
4	31:00	31:06	00:06	Measuring Assembly	
4	31:06	31:08	00:02	Adjusting Assembly	pt 5
4	31:08	31:41	00:33	Measuring Assembly	
4	31:41	31:47	00:06	Adjusting Assembly	pt 5
4	31:47	32:01	00:14	Measuring Assembly	
4	32:01	32:06	00:05	Adjusting Assembly	pt 5
4	32:06	32:10	00:04	Measuring Assembly	
5	32:10	33:01	00:51	Scan Acquisition	
5	33:01	34:25	01:24	Scan Processing	
5	34:25	34:40	00:15	Chatting with Administrator	
5	34:40	34:45	00:05	Output Analysis	
5	34:45	34:58	00:13	Measuring Assembly	
5	34:58	35:02	00:04	Completing Rework	rw 5
5	35:02	35:16	00:14	Measuring Assembly	
5	35:16	35:26	00:10	Completing Rework	rw 5
5	35:26	35:30	00:04	Measuring Assembly	
6	35:30	36:15	00:45	Scan Acquisition	
6	36:15	37:05	00:50	Scan Processing	
6	37:05	37:09	00:04	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:12	00:12	Chatting with Administrator	
1	00:12	00:42	00:30	Looking at 3D Model	
1	00:42	01:01	00:19	Looking at Drawing	
1	01:01	01:10	00:09	Looking at 3D Model	
1	01:10	01:15	00:05	Looking at Drawing	
1	01:15	01:25	00:10	Looking at 3D Model	
1	01:25	01:36	00:11	Chatting with Administrator	
1	01:36	01:47	00:11	Looking at 3D Model	

Totals	
Chatting with Administrator	11:05
Assembling Assembly	00:38
Adjusting Clips	00:39
Measuring Assembly	00:50
Checking Assembly	00:00
Manipulating Stands	00:28
Adjusting Assembly	01:26

1	01:47	01:51	00:04	Assembly Layout	
1	01:51	02:10	00:19	Looking at 3D Model	
1	02:10	02:15	00:05	Assembly Layout	
1	02:15	02:22	00:07	Looking at 3D Model	
1	02:22	02:30	00:08	Assembly Layout	
1	02:30	02:38	00:08	Assembling Assembly	pt 5
1	02:38	02:40	00:02	Looking at 3D Model	
1	02:40	03:01	00:21	Chatting with Administrator	
1	03:01	03:18	00:17	Looking at 3D Model	
1	03:18	03:30	00:12	Assembling Assembly	pt five
1	03:30	03:58	00:28	Looking at Drawing	
1	03:58	04:03	00:05	Adjusting Assembly	pt five
1	04:03	04:25	00:22	Looking at 3D Model	
1	04:25	05:45	01:20	Looking at Drawing	
1	05:45	06:00	00:15	Looking at 3D Model	
1	06:00	06:07	00:07	Looking at Drawing	
1	06:07	06:26	00:19	Assembly Layout	
1	06:26	06:57	00:31	Looking at Drawing	
1	06:57	07:36	00:39	Looking at 3D Model	
1	07:36	07:46	00:10	Adjusting Assembly	pt five
1	07:46	07:58	00:12	Adjusting Assembly	pt three
1	07:58	08:07	00:09	Looking at 3D Model	
1	08:07	09:05	00:58	Looking at Drawing	
1	09:05	09:46	00:41	Chatting with Administrator	
1	09:46	10:25	00:39	Looking at 3D Model	
1	10:25	10:35	00:10	Assembly Layout	
1	10:35	10:50	00:15	Looking at 3D Model	
1	10:50	11:07	00:17	Looking at Drawing	
1	11:07	11:40	00:33	Measuring Assembly	
1	11:40	11:52	00:12	Adjusting Assembly	pt three
1	11:52	12:00	00:08	Looking at Drawing	
1	12:00	12:13	00:13	Adjusting Assembly	pt three
1	12:13	12:24	00:11	Looking at 3D Model	
1	12:24	12:28	00:04	Adjusting Assembly	pt three
1	12:28	12:35	00:07	Measuring Assembly	
1	12:35	12:40	00:05	Adjusting Assembly	pt three
1	12:40	12:50	00:10	Measuring Assembly	
1	12:50	12:55	00:05	Adjusting Assembly	pt three
1	12:55	13:07	00:12	Looking at 3D Model	
1	13:07	13:30	00:23	Looking at Drawing	
1	13:30	13:45	00:15	Chatting with Administrator	
1	13:45	13:57	00:12	Looking at Drawing	
1	13:57	14:08	00:11	Chatting with Administrator	
1	14:08	14:16	00:08	Adjusting Assembly	dis one two from rest
1	14:16	14:22	00:06	Looking at Drawing	
1	14:22	14:31	00:09	Model Segmentation	
1	14:31	15:08	00:37	Looking at 3D Model	
1	15:08	15:24	00:16	Looking at Drawing	
1	15:24	15:29	00:05	Looking at 3D Model	
1	15:29	15:43	00:14	Looking at Drawing	
1	15:43	15:52	00:09	Assembling Assembly	pt 2
1	15:52	16:07	00:15	Looking at 3D Model	
1	16:07	16:13	00:06	Adjusting Assembly	pt 2
1	16:13	16:25	00:12	Looking at Drawing	
1	16:25	16:30	00:05	Looking at 3D Model	
1	16:30	16:36	00:06	Adjusting Assembly	pt 2
1	16:36	16:45	00:09	Looking at 3D Model	
1	16:45	17:16	00:31	Looking at Drawing	
1	17:16	19:12	01:56	Chatting with Administrator	
1	19:12	19:47	00:35	Looking at Drawing	
1	19:47	20:05	00:18	Looking at 3D Model	
1	20:05	22:00	01:55	Chatting with Administrator	
1	22:00	22:40	00:40	Chatting with Administrator	
1	22:40	22:49	00:09	Manipulating Stands	
1	22:49	23:06	00:17	Model Segmentation	
1	23:06	23:48	00:42	Chatting with Administrator	
2	23:48	24:28	00:40	Scan Acquisition	scan onne two
2	24:28	25:20	00:52	Scan Processing	
2	25:20	25:22	00:02	Output Analysis	
2	25:22	26:11	00:49	Chatting with Administrator	
2	26:11	26:25	00:14	Looking at Drawing	

Assembly Layout	00:46
Looking at Drawing	06:56
Completing Rework	00:05
Model Segmentation	00:51
Looking at 3D Model	08:45
Scan Acquisition	02:53
Scan Processing	03:00
Output Analysis	00:19
Total	38:41

Cycle	Start	End	Duration	Category	Note
2	26:25	26:35	00:10	Chatting with Administrator	
2	26:35	27:00	00:25	Model Segmentation	
2	27:00	27:12	00:12	Chatting with Administrator	
3	27:12	27:54	00:42	Scan Acquisition	scan three to five
3	27:54	28:21	00:27	Scan Processing	
3	28:21	28:25	00:04	Output Analysis	
3	28:25	28:47	00:22	Chatting with Administrator	
3	28:47	29:26	00:39	Adjusting Clips	
3	29:26	29:45	00:19	Chatting with Administrator	
3	29:45	31:45	02:00	Looking at 3D Model	
3	31:45	31:55	00:10	Chatting with Administrator	
3	31:55	32:10	00:15	Looking at 3D Model	
3	32:10	32:19	00:09	Assembling Assembly	pt 3
3	32:19	32:53	00:34	Looking at 3D Model	
4	32:53	33:40	00:47	Scan Acquisition	
4	33:40	34:31	00:51	Scan Processing	
4	34:31	34:45	00:14	Chatting with Administrator	
4	34:45	34:56	00:11	Output Analysis	
4	34:56	35:25	00:29	Chatting with Administrator	
4	35:25	35:30	00:05	Completing Rework	rw 3
4	35:30	35:49	00:19	Manipulating Stands	
4	35:49	36:14	00:25	Chatting with Administrator	
5	36:14	36:58	00:44	Scan Acquisition	
5	36:58	37:48	00:50	Scan Processing	
5	37:48	37:50	00:02	Output Analysis	
5	37:50	38:41	00:51	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:35	00:35	Looking at Drawing	
1	00:35	00:46	00:11	Chatting with Administrator	
1	00:46	01:07	00:21	Assembly Layout	
1	01:07	01:22	00:15	Manipulating Stands	
1	01:22	01:27	00:05	Assembling Assembly	pt 2
1	01:27	02:18	00:51	Assembly Layout	
1	02:18	02:46	00:28	Looking at Drawing	
1	02:46	03:00	00:14	Assembly Layout	
1	03:00	03:15	00:15	Manipulating Stands	
1	03:15	03:34	00:19	Looking at Drawing	
1	03:34	04:15	00:41	Measuring Assembly	
1	04:15	04:27	00:12	Looking at Drawing	
1	04:27	04:42	00:15	Measuring Assembly	
1	04:42	04:50	00:08	Looking at Drawing	
1	04:50	05:44	00:54	Measuring Assembly	
1	05:44	05:52	00:08	Manipulating Stands	
1	05:52	06:08	00:16	Measuring Assembly	
1	06:08	06:12	00:04	Manipulating Stands	
1	06:12	06:19	00:07	Measuring Assembly	
1	06:19	06:23	00:04	Manipulating Stands	
1	06:23	06:33	00:10	Measuring Assembly	
1	06:33	06:38	00:05	Manipulating Stands	
1	06:38	06:44	00:06	Measuring Assembly	
1	06:44	07:47	01:03	Looking at Drawing	
1	07:47	08:03	00:16	Measuring Assembly	
1	08:03	09:22	01:19	Chatting with Administrator	
1	09:22	09:41	00:19	Measuring Assembly	
1	09:41	09:48	00:07	Assembling Assembly	pt 3
1	09:48	10:03	00:15	Manipulating Stands	
1	10:03	10:18	00:15	Measuring Assembly	
1	10:18	10:28	00:10	Manipulating Stands	
1	10:28	10:35	00:07	Measuring Assembly	
1	10:35	11:00	00:25	Chatting with Administrator	
1	11:00	11:15	00:15	Measuring Assembly	
1	11:15	11:30	00:15	Adjusting Assembly	pt four
1	11:30	11:40	00:10	Measuring Assembly	
1	11:40	11:50	00:10	Looking at Drawing	
1	11:50	11:58	00:08	Adjusting Assembly	pt four
1	11:58	12:01	00:03	Adjusting Assembly	pt 5

Totals	
Chatting with Administrator	06:09
Assembling Assembly	00:18
Adjusting Clips	00:00
Measuring Assembly	08:37
Checking Assembly	00:00
Manipulating Stands	02:47
Adjusting Assembly	01:01
Assembly Layout	01:26
Looking at Drawing	05:47
Completing Rework	01:01
Model Segmentation	00:00
Looking at 3D Model	00:28
Scan Acquisition	03:46
Scan Processing	02:21
Output Analysis	01:27
Total	35:08

Cycle	Start	End	Duration	Category	Note
1	12:01	12:18	00:17	Looking at Drawing	
1	12:18	12:30	00:12	Measuring Assembly	
1	12:30	12:50	00:20	Looking at Drawing	
1	12:50	13:17	00:27	Measuring Assembly	
1	13:17	13:43	00:26	Adjusting Assembly	pt four
1	13:43	13:52	00:09	Adjusting Assembly	pt four
1	13:52	13:59	00:07	Measuring Assembly	
1	13:59	14:08	00:09	Looking at Drawing	
1	14:08	14:39	00:31	Measuring Assembly	
1	14:39	14:45	00:06	Assembling Assembly	pt 5
1	14:45	14:52	00:07	Measuring Assembly	
1	14:52	15:00	00:08	Looking at Drawing	
1	15:00	15:35	00:35	Measuring Assembly	
1	15:35	16:30	00:55	Looking at Drawing	
2	16:30	18:20	01:50	Scan Acquisition	
2	18:20	19:00	00:40	Chatting with Administrator	
2	19:00	20:08	01:08	Scan Processing	
2	20:08	20:11	00:03	Output Analysis	
2	20:11	20:18	00:07	Completing Rework	rw 1
2	20:18	20:31	00:13	Manipulating Stands	
2	20:31	20:43	00:12	Chatting with Administrator	
2	20:43	21:12	00:29	Manipulating Stands	
2	21:12	21:50	00:38	Chatting with Administrator	
2	21:50	21:57	00:07	Looking at 3D Model	
2	21:57	22:39	00:42	Chatting with Administrator	
2	22:39	22:45	00:06	Manipulating Stands	
2	22:45	23:06	00:21	Looking at Drawing	
2	23:06	23:25	00:19	Measuring Assembly	
2	23:25	23:33	00:08	Manipulating Stands	
2	23:33	23:40	00:07	Measuring Assembly	
2	23:40	23:50	00:10	Completing Rework	rw 5
2	23:50	24:16	00:26	Measuring Assembly	
2	24:16	24:18	00:02	Completing Rework	rw 5
2	24:18	24:35	00:17	Manipulating Stands	
3	24:35	25:31	00:56	Scan Acquisition	
3	25:31	26:10	00:39	Scan Processing	
3	26:10	26:16	00:06	Output Analysis	
3	26:16	26:22	00:06	Completing Rework	rw 1
3	26:22	26:33	00:11	Manipulating Stands	
3	26:33	26:56	00:23	Chatting with Administrator	
3	26:56	27:25	00:29	Scan Processing	
3	27:25	27:32	00:07	Manipulating Stands	
3	27:32	27:42	00:10	Output Analysis	
3	27:42	27:56	00:14	Completing Rework	rw 5
3	27:56	28:38	00:42	Looking at Drawing	
3	28:38	28:44	00:06	Completing Rework	rw 5
3	28:44	29:05	00:21	Looking at 3D Model	
3	29:05	29:10	00:05	Completing Rework	rw 5
3	29:10	30:52	01:42	Measuring Assembly	
3	30:52	30:57	00:05	Completing Rework	rw 5
3	30:57	31:10	00:13	Measuring Assembly	
4	31:10	32:10	01:00	Scan Acquisition	
4	32:10	32:15	00:05	Scan Processing	
4	32:15	33:23	01:08	Output Analysis	
4	33:23	33:29	00:06	Completing Rework	rw 1
4	33:29	35:08	01:39	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:20	02:20	Chatting with Administrator	
1	02:20	02:40	00:20	Looking at 3D Model	
1	02:40	02:50	00:10	Assembling Assembly	pt 2
1	02:50	02:56	00:06	Chatting with Administrator	
1	02:56	03:05	00:09	Looking at Drawing	
1	03:05	03:15	00:10	Adjusting Assembly	pt 2
1	03:15	03:20	00:05	Looking at Drawing	
1	03:20	03:25	00:05	Manipulating Stands	
1	03:25	03:35	00:10	Adjusting Clips	

Totals	
Chatting with Administrator	07:36
Assembling Assembly	00:46
Adjusting Clips	00:10
Measuring Assembly	02:35
Checking Assembly	00:00
Manipulating Stands	01:38
Adjusting Assembly	00:54
Assembly Layout	00:00

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1	03:35	03:45	00:10	Manipulating Stands	
1	03:45	03:54	00:09	Looking at Drawing	
1	03:54	03:58	00:04	Looking at 3D Model	
1	03:58	04:05	00:07	Model Segmentation	
1	04:05	04:14	00:09	Looking at 3D Model	
1	04:14	04:31	00:17	Model Segmentation	
1	04:31	04:38	00:07	Looking at Drawing	
1	04:38	04:55	00:17	Chatting with Administrator	
1	04:55	05:32	00:37	Measuring Assembly	
1	05:32	05:38	00:06	Adjusting Assembly	pt 2
1	05:38	05:50	00:12	Measuring Assembly	
1	05:50	05:55	00:05	Adjusting Assembly	pt 2
1	05:55	06:02	00:07	Measuring Assembly	
1	06:02	06:08	00:06	Adjusting Assembly	pt 2
1	06:08	06:15	00:07	Measuring Assembly	
1	06:15	06:22	00:07	Adjusting Assembly	pt 2
1	06:22	06:30	00:08	Measuring Assembly	
1	06:30	06:52	00:22	Looking at 3D Model	
1	06:52	07:12	00:20	Looking at Drawing	
1	07:12	07:35	00:23	Chatting with Administrator	
2	07:35	08:02	00:27	Scan Acquisition	
2	08:02	08:30	00:28	Scan Processing	
2	08:30	08:46	00:16	Chatting with Administrator	
2	08:46	08:47	00:01	Output Analysis	
2	08:47	09:00	00:13	Chatting with Administrator	
2	09:00	09:27	00:27	Measuring Assembly	
2	09:27	09:49	00:22	Looking at Drawing	
2	09:49	09:50	00:01	Output Analysis	
2	09:50	09:54	00:04	Completing Rework	rw 2
2	09:54	10:05	00:11	Chatting with Administrator	
3	10:05	10:30	00:25	Scan Acquisition	
3	10:30	11:16	00:46	Scan Processing	
3	11:16	11:18	00:02	Output Analysis	
3	11:18	11:24	00:06	Looking at 3D Model	
3	11:24	11:40	00:16	Model Segmentation	
3	11:40	11:53	00:13	Looking at 3D Model	
3	11:53	11:59	00:06	Model Segmentation	
3	11:59	12:25	00:26	Looking at 3D Model	
3	12:25	12:50	00:25	Assembling Assembly	pt 3
3	12:50	13:10	00:20	Chatting with Administrator	
3	13:10	13:21	00:11	Looking at Drawing	
3	13:21	13:55	00:34	Manipulating Stands	
3	13:55	14:12	00:17	Looking at 3D Model	
3	14:12	14:18	00:06	Manipulating Stands	
3	14:18	14:30	00:12	Measuring Assembly	
3	14:30	14:50	00:20	Adjusting Assembly	pt 3
3	14:50	15:20	00:30	Manipulating Stands	
3	15:20	15:54	00:34	Measuring Assembly	
3	15:54	16:15	00:21	Looking at 3D Model	
3	16:15	16:49	00:34	Chatting with Administrator	
3	16:49	17:00	00:11	Measuring Assembly	
3	17:00	18:04	01:04	Chatting with Administrator	
3	18:04	18:23	00:19	Looking at 3D Model	
3	18:23	18:57	00:34	Chatting with Administrator	
3	18:57	19:17	00:20	Looking at Drawing	
3	19:17	19:28	00:11	Assembling Assembly	pt 5
3	19:28	19:38	00:10	Chatting with Administrator	
3	19:38	19:57	00:19	Looking at Drawing	
3	19:57	20:05	00:08	Chatting with Administrator	
4	20:05	20:47	00:42	Scan Acquisition	
4	20:47	21:30	00:43	Scan Processing	
4	21:30	21:55	00:25	Chatting with Administrator	
4	21:55	22:06	00:11	Output Analysis	
4	22:06	22:17	00:11	Completing Rework	rw 1
4	22:17	22:30	00:13	Manipulating Stands	
5	22:30	22:56	00:26	Scan Acquisition	
5	22:56	23:41	00:45	Scan Processing	
5	23:41	23:43	00:02	Output Analysis	
5	23:43	23:57	00:14	Chatting with Administrator	
5	23:57	24:43	00:46	Scan Processing	
5	24:43	24:48	00:05	Output Analysis	

Looking at Drawing	02:02
Completing Rework	00:24
Model Segmentation	00:46
Looking at 3D Model	02:37
Scan Acquisition	02:32
Scan Processing	05:45
Output Analysis	00:25
Total	28:10

Cycle	Start	End	Duration	Category	Note
5	24:48	25:55	01:07	Scan Processing	
5	25:55	25:58	00:03	Output Analysis	
5	25:58	26:10	00:12	Scan Processing	
5	26:10	26:19	00:09	Completing Rework	rw 1
5	26:19	26:30	00:11	Chatting with Administrator	
6	26:30	27:02	00:32	Scan Acquisition	
6	27:02	27:46	00:44	Scan Processing	
6	27:46	27:56	00:10	Chatting with Administrator	
6	27:56	28:10	00:14	Scan Processing	

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Cycle	Start	End	Duration	Category	Note
1	00:00	01:05	01:05	Chatting with Administrator	
1	01:05	01:40	00:35	Looking at Drawing	
1	01:40	02:09	00:29	Chatting with Administrator	
1	02:09	02:16	00:07	Looking at Drawing	
1	02:16	02:30	00:14	Assembling Assembly	PT 2
1	02:30	03:00	00:30	Looking at Drawing	
1	03:00	03:08	00:08	Adjusting Assembly	
1	03:08	03:45	00:37	Chatting with Administrator	
1	03:45	04:08	00:23	Adjusting Clips	
1	04:08	04:32	00:24	Looking at Drawing	
1	04:32	05:00	00:28	Looking at 3D Model	
1	05:00	05:10	00:10	Checking Assembly	
1	05:10	05:40	00:30	Looking at Drawing	
1	05:40	05:48	00:08	Assembling Assembly	pt 5
1	05:48	06:13	00:25	Looking at Drawing	
1	06:13	06:35	00:22	Manipulating Stands	
1	06:35	06:50	00:15	Looking at 3D Model	
1	06:50	07:01	00:11	Chatting with Administrator	
1	07:01	08:15	01:14	Manipulating Stands	
1	08:15	08:45	00:30	Looking at 3D Model	
1	08:45	08:57	00:12	Looking at Drawing	
1	08:57	09:02	00:05	Adjusting Assembly	pt 5
1	09:02	09:24	00:22	Model Segmentation	
1	09:24	10:00	00:36	Looking at 3D Model	
1	10:00	10:05	00:05	Chatting with Administrator	
1	10:05	10:10	00:05	Adjusting Assembly	adj 5
1	10:10	10:37	00:27	Looking at Drawing	
1	10:37	10:42	00:05	Adjusting Assembly	adj 5
1	10:42	11:20	00:38	Measuring Assembly	
1	11:20	11:37	00:17	Manipulating Stands	
1	11:37	11:40	00:03	Measuring Assembly	
1	11:40	11:47	00:07	Manipulating Stands	
1	11:47	11:52	00:05	Measuring Assembly	
1	11:52	12:00	00:08	Manipulating Stands	
1	12:00	12:38	00:38	Chatting with Administrator	
1	12:38	12:52	00:14	Measuring Assembly	
1	12:52	12:55	00:03	Adjusting Assembly	pt 5
1	12:55	13:09	00:14	Measuring Assembly	
1	13:09	13:10	00:01	Chatting with Administrator	
1	13:10	13:30	00:20	Looking at Drawing	
1	13:30	13:37	00:07	Measuring Assembly	
1	13:37	14:10	00:33	Manipulating Stands	
1	14:10	14:18	00:08	Adjusting Assembly	pt 5
1	14:18	14:30	00:12	Measuring Assembly	
1	14:30	14:38	00:08	Adjusting Assembly	pt 5
1	14:38	14:55	00:17	Chatting with Administrator	
2	14:55	15:35	00:40	Scan Acquisition	
2	15:35	16:12	00:37	Scan Processing	
2	16:12	16:15	00:03	Output Analysis	
2	16:15	16:30	00:15	Model Segmentation	
2	16:30	16:51	00:21	Chatting with Administrator	
2	16:51	16:51	00:00	Chatting with Administrator	
2	16:51	17:35	00:44	Looking at 3D Model	
2	17:35	17:50	00:15	Adjusting Assembly	pt 2
2	17:50	18:04	00:14	Assembling Assembly	pt 2
2	18:04	18:14	00:10	Manipulating Stands	

Totals	
Chatting with Administrator	10:58
Assembling Assembly	00:22
Adjusting Clips	00:23
Measuring Assembly	01:33
Checking Assembly	00:10
Manipulating Stands	02:41
Adjusting Assembly	00:42
Assembly Layout	00:00
Looking at Drawing	03:30
Completing Rework	00:00
Model Segmentation	00:22
Looking at 3D Model	01:49
Scan Acquisition	00:40
Scan Processing	00:37
Output Analysis	00:00
Total	23:47

2	18:14	19:12	00:58	Looking at 3D Model	
2	19:12	19:18	00:06	Manipulating Stands	
2	19:18	19:44	00:26	Adjusting Assembly	pt 2
2	19:44	19:50	00:06	Chatting with Administrator	
2	19:50	20:15	00:25	Looking at 3D Model	
2	20:15	20:20	00:05	Adjusting Clips	
2	20:20	20:55	00:35	Looking at 3D Model	
2	20:55	21:25	00:30	Adjusting Assembly	pt 2
2	21:25	21:50	00:25	Manipulating Stands	
2	21:50	22:02	00:12	Adjusting Assembly	pt 2
2	22:02	22:56	00:54	Looking at Drawing	
2	22:56	23:10	00:14	Chatting with Administrator	
2	23:10	23:22	00:12	Looking at Drawing	
2	23:22	23:29	00:07	Adjusting Assembly	pt ONE
2	23:29	23:40	00:11	Looking at Drawing	
2	23:40	25:00	01:20	Manipulating Stands	
2	25:00	25:10	00:10	Chatting with Administrator	
2	25:10	25:44	00:34	Chatting with Administrator	
2	25:44	25:50	00:06	Chatting with Administrator	
2	25:50	26:00	00:10	Chatting with Administrator	
2	26:00	26:30	00:30	Chatting with Administrator	
2	26:30	26:50	00:20	Chatting with Administrator	
2	26:50	30:30	03:40	Chatting with Administrator	
3	30:30	31:00	00:30	Scan Acquisition	
3	31:00	33:50	02:50	Scan Processing	
3	33:50	34:00	00:10	Manipulating Stands	
3	34:00	35:17	01:17	Scan Processing	
3	35:17	35:40	00:23	Chatting with Administrator	
3	35:40	35:59	00:19	Completing Rework	rw 2
3	35:59	37:00	01:01	Chatting with Administrator	
3	37:00	37:30	00:30	Manipulating Stands	
3	37:30	38:08	00:38	Scan Acquisition	
3	38:08	38:50	00:42	Scan Processing	
3	38:50	39:05	00:15	Output Analysis	
3	39:05	39:14	00:09	Completing Rework	rw 2
3	39:14	39:22	00:08	Manipulating Stands	
4	39:22	39:32	00:10	Completing Rework	rw 2
4	39:32	40:11	00:39	Scan Acquisition	
4	40:11	40:42	00:31	Scan Processing	
4	40:42	40:46	00:04	Output Analysis	
4	40:46	40:52	00:06	Manipulating Stands	
5	40:52	40:57	00:05	Completing Rework	rw 1
6	40:57	41:28	00:31	Scan Acquisition	
6	41:28	41:45	00:17	Scan Processing	
6	41:45	41:46	00:01	Output Analysis	

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Cycle	Start	End	Duration	Category	Note		Totals	
1	00:00	02:45	02:45	Chatting with Administrator			Chatting with Administrator	05:39
1	02:45	02:56	00:11	Looking at 3D Model			Assembling Assembly	00:30
1	02:56	03:02	00:06	Assembly Layout			Adjusting Clips	01:20
1	03:02	03:12	00:10	Assembling Assembly	pt 2		Measuring Assembly	00:00
1	03:12	03:30	00:18	Adjusting Clips			Checking Assembly	00:00
1	03:30	03:36	00:06	Looking at 3D Model			Manipulating Stands	01:07
1	03:36	03:44	00:08	Adjusting Assembly	PT 2		Adjusting Assembly	00:08
1	03:44	04:03	00:19	Chatting with Administrator			Assembly Layout	00:06
2	04:03	04:20	00:17	Scan Acquisition			Looking at Drawing	00:00
2	04:20	05:00	00:40	Scan Processing			Completing Rework	00:30
2	05:00	05:20	00:20	Chatting with Administrator			Model Segmentation	00:13
2	05:20	05:22	00:02	Output Analysis			Looking at 3D Model	01:32
2	05:22	05:35	00:13	Model Segmentation			Scan Acquisition	04:20
2	05:35	06:00	00:25	Looking at 3D Model			Scan Processing	06:02
2	06:00	06:20	00:20	Chatting with Administrator			Output Analysis	00:18
2	06:20	06:30	00:10	Assembling Assembly	pt 3		Total	21:45
2	06:30	06:39	00:09	Adjusting Clips				
2	06:39	06:55	00:16	Chatting with Administrator				
3	06:55	07:26	00:31	Scan Acquisition				
3	07:26	08:05	00:39	Scan Processing				
3	08:05	08:30	00:25	Chatting with Administrator				

3	08:30	08:43	00:13	Scan Processing	
3	08:43	08:46	00:03	Output Analysis	
3	08:46	08:57	00:11	Scan Processing	
3	08:57	09:18	00:21	Chatting with Administrator	
3	09:18	09:20	00:02	Output Analysis	
3	09:20	09:25	00:05	Chatting with Administrator	
3	09:25	09:32	00:07	Adjusting Clips	
3	09:32	09:36	00:04	Completing Rework	rw 4
3	09:36	09:45	00:09	Adjusting Clips	
4	09:45	10:47	01:02	Scan Acquisition	
4	10:47	11:46	00:59	Scan Processing	
4	11:46	12:00	00:14	Chatting with Administrator	
4	12:00	12:20	00:20	Scan Processing	
4	12:20	13:04	00:44	Manipulating Stands	
4	13:04	13:10	00:06	Output Analysis	
4	13:10	13:20	00:10	Looking at 3D Model	
4	13:20	13:36	00:16	Adjusting Clips	
4	13:36	13:40	00:04	Completing Rework	rw 4
4	13:40	13:45	00:05	Manipulating Stands	
4	13:45	14:04	00:19	Chatting with Administrator	
4	14:04	14:13	00:09	Adjusting Clips	
4	14:13	14:20	00:07	Completing Rework	rw 3
4	14:20	14:25	00:05	Adjusting Clips	
5	14:25	15:10	00:45	Scan Acquisition	
5	15:10	16:19	01:09	Scan Processing	
5	16:19	16:20	00:01	Output Analysis	
5	16:20	17:00	00:40	Looking at 3D Model	
5	17:00	17:10	00:10	Assembling Assembly	pt 5
5	17:10	17:17	00:07	Adjusting Clips	
6	17:17	18:07	00:50	Scan Acquisition	
6	18:07	19:10	01:03	Scan Processing	
6	19:10	19:20	00:10	Chatting with Administrator	
6	19:20	19:22	00:02	Output Analysis	
6	19:22	19:37	00:15	Completing Rework	rw 5
6	19:37	19:55	00:18	Manipulating Stands	
7	19:55	20:50	00:55	Scan Acquisition	
7	20:50	21:38	00:48	Scan Processing	
7	21:38	21:40	00:02	Output Analysis	
7	21:40	21:45	00:05	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	01:08	01:08	Chatting with Administrator	
1	01:08	01:18	00:10	Assembling Assembly	pt2
1	01:18	01:30	00:12	Looking at 3D Model	
1	01:30	01:36	00:06	Adjusting Assembly	pt 2
1	01:36	01:54	00:18	Looking at 3D Model	
1	01:54	02:00	00:06	Assembling Assembly	pt 3
1	02:00	02:05	00:05	Looking at 3D Model	
1	02:05	02:15	00:10	Adjusting Assembly	pt 3
1	02:15	02:26	00:11	Looking at 3D Model	
1	02:26	02:33	00:07	Assembling Assembly	pt 5
1	02:33	02:44	00:11	Chatting with Administrator	
1	02:44	03:16	00:32	Manipulating Stands	
1	03:16	04:00	00:44	Chatting with Administrator	
1	04:00	04:50	00:50	Chatting with Administrator	
1	04:50	05:11	00:21	Manipulating Stands	
2	05:11	05:50	00:39	Scan Acquisition	
2	05:50	06:10	00:20	Chatting with Administrator	
2	06:10	07:00	00:50	Scan Processing	
2	07:00	07:30	00:30	Chatting with Administrator	
2	07:30	08:00	00:30	Scan Processing	
2	08:00	08:30	00:30	Chatting with Administrator	
2	08:30	08:50	00:20	Scan Processing	
2	08:50	08:55	00:05	Output Analysis	
2	08:55	09:05	00:10	Chatting with Administrator	
2	09:05	09:09	00:04	Output Analysis	
2	09:09	09:19	00:10	Completing Rework	rw 4

Totals	
Chatting with Administrator	05:35
Assembling Assembly	00:23
Adjusting Clips	00:00
Measuring Assembly	00:00
Checking Assembly	00:00
Manipulating Stands	01:02
Adjusting Assembly	00:16
Assembly Layout	00:00
Looking at Drawing	00:00
Completing Rework	00:26
Model Segmentation	00:00
Looking at 3D Model	01:26
Scan Acquisition	02:27
Scan Processing	06:22
Output Analysis	00:15
Total	18:12

Cycle	Start	End	Duration	Category	Note
2	09:19	09:29	00:10	Looking at 3D Model	
2	09:29	09:38	00:09	Manipulating Stands	
3	09:38	10:18	00:40	Scan Acquisition	
3	10:18	12:55	02:37	Scan Processing	
3	12:55	13:10	00:15	Chatting with Administrator	
3	13:10	13:40	00:30	Looking at 3D Model	
3	13:40	13:46	00:06	Output Analysis	
3	13:46	14:02	00:16	Completing Rework	rw 2
3	14:02	14:17	00:15	Chatting with Administrator	
4	14:17	15:25	01:08	Scan Acquisition	
4	15:25	17:30	02:05	Scan Processing	
4	17:30	18:12	00:42	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:35	00:35	Chatting with Administrator	
1	00:35	01:15	00:40	Looking at 3D Model	
1	01:15	01:25	00:10	Chatting with Administrator	
1	01:25	02:15	00:50	Looking at 3D Model	
1	02:15	02:31	00:16	Looking at Drawing	
1	02:31	03:34	01:03	Looking at 3D Model	
1	03:34	03:45	00:11	Chatting with Administrator	
1	03:45	04:04	00:19	Looking at 3D Model	
1	04:04	04:08	00:04	Looking at Drawing	
1	04:08	04:21	00:13	Assembling Assembly	pt2
1	04:21	04:27	00:06	Looking at Drawing	
1	04:27	04:41	00:14	Adjusting Assembly	pt2
1	04:41	04:56	00:15	Looking at 3D Model	
1	04:56	05:24	00:28	Looking at Drawing	
1	05:24	05:31	00:07	Assembling Assembly	pt5
1	05:31	06:10	00:39	Looking at Drawing	
1	06:10	08:15	02:05	Looking at 3D Model	
1	08:15	08:27	00:12	Adjusting Assembly	pt5
1	08:27	08:49	00:22	Checking Assembly	
1	08:49	09:00	00:11	Adjusting Clips	
1	09:00	09:06	00:06	Checking Assembly	
1	09:06	09:20	00:14	Chatting with Administrator	
1	09:20	09:30	00:10	Model Segmentation	
1	09:30	09:50	00:20	Chatting with Administrator	
2	09:50	10:22	00:32	Scan Acquisition	
2	10:22	11:05	00:43	Scan Processing	
2	11:05	11:08	00:03	Output Analysis	
2	11:08	11:25	00:17	Chatting with Administrator	
2	11:25	11:34	00:09	Model Segmentation	
2	11:34	12:30	00:56	Looking at 3D Model	
2	12:30	12:49	00:19	Completing Rework	rw 2
2	12:49	13:28	00:39	Checking Assembly	
2	13:28	13:40	00:12	Adjusting Clips	
2	13:40	13:49	00:09	Chatting with Administrator	
3	13:49	14:33	00:44	Scan Acquisition	
3	14:33	15:57	01:24	Scan Processing	
3	15:57	15:59	00:02	Output Analysis	
3	15:59	16:14	00:15	Chatting with Administrator	
3	16:14	17:18	01:04	Looking at 3D Model	
3	17:18	18:00	00:42	Chatting with Administrator	
4	18:00	18:22	00:22	Scan Acquisition	
4	18:22	18:43	00:21	Assembling Assembly	pt3
4	18:43	19:07	00:24	Checking Assembly	
4	19:07	19:28	00:21	Manipulating Stands	
4	19:28	19:57	00:29	Looking at Drawing	
4	19:57	20:30	00:33	Looking at 3D Model	
4	20:30	20:45	00:15	Chatting with Administrator	
4	20:45	21:19	00:34	Looking at 3D Model	
4	21:19	21:30	00:11	Chatting with Administrator	
4	21:30	21:57	00:27	Looking at 3D Model	
4	21:57	22:07	00:10	Chatting with Administrator	
4	22:07	22:45	00:38	Assembling Assembly	pt3
4	22:45	23:17	00:32	Checking Assembly	

Totals	
Chatting with Administrator	03:35
Assembling Assembly	01:19
Adjusting Clips	00:39
Measuring Assembly	00:00
Checking Assembly	02:03
Manipulating Stands	01:06
Adjusting Assembly	00:26
Assembly Layout	00:00
Looking at Drawing	02:02
Completing Rework	00:19
Model Segmentation	00:19
Looking at 3D Model	08:46
Scan Acquisition	01:38
Scan Processing	02:07
Output Analysis	00:05
Total	24:24

Cycle	Start	End	Duration	Category	Note
4	23:17	23:33	00:16	Adjusting Clips	
4	23:33	23:39	00:06	Chatting with Administrator	
4	23:39	24:24	00:45	Manipulating Stands	

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:18	00:18	Looking at 3D Model	
1	00:18	00:24	00:06	Chatting with Administrator	
1	00:24	00:32	00:08	Looking at 3D Model	
1	00:32	00:45	00:13	Chatting with Administrator	
1	00:45	00:55	00:10	Model Segmentation	
1	00:55	01:13	00:18	Looking at 3D Model	
1	01:13	01:18	00:05	Assembling Assembly	pt 2
1	01:18	01:50	00:32	Chatting with Administrator	
1	01:50	02:05	00:15	Looking at Drawing	
1	02:05	02:18	00:13	Adjusting Assembly	pt 2
1	02:18	02:27	00:09	Looking at Drawing	
1	02:27	03:10	00:43	Chatting with Administrator	
1	03:10	04:08	00:58	Measuring Assembly	
1	04:08	04:20	00:12	Looking at Drawing	
1	04:20	04:28	00:08	Measuring Assembly	
1	04:28	05:12	00:44	Adjusting Clips	
1	05:12	05:50	00:38	Looking at Drawing	
1	05:50	06:08	00:18	Measuring Assembly	
1	06:08	06:22	00:14	Looking at Drawing	
1	06:22	06:38	00:16	Adjusting Clips	
1	06:38	07:05	00:27	Measuring Assembly	
1	07:05	07:40	00:35	Chatting with Administrator	
2	07:40	08:30	00:50	Scan Acquisition	
2	08:30	08:52	00:22	Chatting with Administrator	
2	08:52	09:40	00:48	Scan Processing	
2	09:40	09:46	00:06	Output Analysis	
2	09:46	10:23	00:37	Scan Processing	
2	10:23	10:27	00:04	Output Analysis	
2	10:27	10:40	00:13	Chatting with Administrator	
2	10:40	10:50	00:10	Adjusting Clips	
2	10:50	11:08	00:18	Looking at 3D Model	
2	11:08	11:20	00:12	Looking at Drawing	
2	11:20	11:24	00:04	Completing Rework	RW 2
2	11:24	11:40	00:16	Measuring Assembly	
2	11:40	11:42	00:02	Completing Rework	rw 2
2	11:42	11:55	00:13	Measuring Assembly	
2	11:55	12:09	00:14	Adjusting Clips	
3	12:09	12:57	00:48	Scan Acquisition	
3	12:57	13:43	00:46	Scan Processing	
3	13:43	13:44	00:01	Output Analysis	
3	13:44	14:09	00:25	Chatting with Administrator	
3	14:09	14:33	00:24	Model Segmentation	
3	14:33	15:25	00:52	Looking at 3D Model	
3	15:25	16:10	00:45	Assembling Assembly	pt 3
3	16:10	16:15	00:05	Adjusting Assembly	pt 3
3	16:15	16:21	00:06	Looking at 3D Model	
3	16:21	16:47	00:26	Looking at Drawing	
3	16:47	17:14	00:27	Measuring Assembly	
3	17:14	17:28	00:14	Looking at Drawing	
3	17:28	17:47	00:19	Measuring Assembly	
3	17:47	18:04	00:17	Looking at Drawing	
3	18:04	18:24	00:20	Looking at 3D Model	
3	18:24	18:30	00:06	Chatting with Administrator	
3	18:30	18:50	00:20	Looking at Drawing	
3	18:50	19:23	00:33	Measuring Assembly	
3	19:23	19:42	00:19	Looking at 3D Model	
3	19:42	19:52	00:10	Measuring Assembly	
3	19:52	20:00	00:08	Adjusting Assembly	pt 3
3	20:00	20:03	00:03	Measuring Assembly	
3	20:03	20:30	00:27	Adjusting Clips	
3	20:30	20:50	00:20	Measuring Assembly	
3	20:50	20:57	00:07	Adjusting Assembly	pt 3

Totals	
Chatting with Administrator	03:44
Assembling Assembly	01:13
Adjusting Clips	02:19
Measuring Assembly	05:13
Checking Assembly	00:00
Manipulating Stands	00:45
Adjusting Assembly	01:02
Assembly Layout	00:00
Looking at Drawing	02:57
Completing Rework	00:06
Model Segmentation	00:34
Looking at 3D Model	04:33
Scan Acquisition	02:33
Scan Processing	05:01
Output Analysis	00:21
Total	30:21

3	20:57	21:05	00:08	Measuring Assembly	
4	21:05	21:34	00:29	Scan Acquisition	
4	21:34	22:00	00:26	Scan Processing	
4	22:00	22:27	00:27	Chatting with Administrator	
4	22:27	23:55	01:28	Looking at 3D Model	
4	23:55	24:18	00:23	Assembling Assembly	pt 5
4	24:18	24:21	00:03	Measuring Assembly	
4	24:21	24:26	00:05	Adjusting Assembly	pt 5
4	24:26	24:43	00:17	Measuring Assembly	
4	24:43	24:49	00:06	Adjusting Assembly	pt 5
4	24:49	24:58	00:09	Measuring Assembly	
4	24:58	25:15	00:17	Adjusting Clips	
4	25:15	25:41	00:26	Looking at 3D Model	
4	25:41	25:52	00:11	Adjusting Clips	
4	25:52	26:00	00:08	Adjusting Assembly	pt 5
4	26:00	26:32	00:32	Manipulating Stands	
4	26:32	26:44	00:12	Measuring Assembly	
4	26:44	26:49	00:05	Adjusting Assembly	pt 5
4	26:49	26:56	00:07	Measuring Assembly	
4	26:56	27:01	00:05	Adjusting Assembly	pt 5
4	27:01	27:06	00:05	Measuring Assembly	
4	27:06	27:19	00:13	Manipulating Stands	
5	27:19	27:45	00:26	Scan Acquisition	
5	27:45	30:09	02:24	Scan Processing	
5	30:09	30:19	00:10	Output Analysis	
5	30:19	30:21	00:02	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:18	00:18	Looking at 3D Model	
1	00:18	01:10	00:52	Chatting with Administrator	
1	01:10	01:29	00:19	Looking at 3D Model	
1	01:29	01:43	00:14	Assembling Assembly	pt 5
1	01:43	01:59	00:16	Measuring Assembly	
1	01:59	02:11	00:12	Adjusting Clips	
1	02:11	02:33	00:22	Looking at 3D Model	
1	02:33	02:40	00:07	Chatting with Administrator	
1	02:40	02:51	00:11	Looking at 3D Model	
1	02:51	03:00	00:09	Assembling Assembly	pt 2
1	03:00	03:12	00:12	Manipulating Stands	
1	03:12	03:20	00:08	Chatting with Administrator	
1	03:20	03:45	00:25	Looking at Drawing	
1	03:45	04:13	00:28	Chatting with Administrator	
1	04:13	04:19	00:06	Looking at 3D Model	
1	04:19	05:30	01:11	Measuring Assembly	
1	05:30	05:35	00:05	Adjusting Assembly	pt 2
1	05:35	05:45	00:10	Measuring Assembly	
1	05:45	05:48	00:03	Adjusting Assembly	pt 2
1	05:48	06:10	00:22	Measuring Assembly	
1	06:10	06:13	00:03	Adjusting Assembly	pt 2
1	06:13	06:34	00:21	Measuring Assembly	
1	06:34	06:49	00:15	Adjusting Clips	
1	06:49	06:57	00:08	Checking Assembly	
1	06:57	07:03	00:06	Looking at 3D Model	
1	07:03	07:13	00:10	Checking Assembly	
1	07:13	07:16	00:03	Adjusting Clips	
1	07:16	07:18	00:02	Adjusting Assembly	pt 2
1	07:18	07:48	00:30	Measuring Assembly	
1	07:48	08:11	00:23	Chatting with Administrator	
1	08:11	09:30	01:19	Measuring Assembly	
1	09:30	09:33	00:03	Adjusting Assembly	pt 2
1	09:33	10:48	01:15	Chatting with Administrator	
1	10:48	10:58	00:10	Measuring Assembly	
1	10:58	11:06	00:08	Adjusting Assembly	pt 2
1	11:06	11:27	00:21	Measuring Assembly	
1	11:27	11:35	00:08	Adjusting Clips	
1	11:35	11:58	00:23	Looking at 3D Model	
1	11:58	12:05	00:07	Chatting with Administrator	

Totals	
Chatting with Administrator	06:00
Assembling Assembly	00:46
Adjusting Clips	00:53
Measuring Assembly	05:55
Checking Assembly	00:36
Manipulating Stands	01:23
Adjusting Assembly	00:53
Assembly Layout	00:00
Looking at Drawing	00:48
Completing Rework	00:00
Model Segmentation	00:06
Looking at 3D Model	03:05
Scan Acquisition	00:38
Scan Processing	03:26
Output Analysis	00:04
Total	24:33

Cycle	Start	End	Duration	Category	Note
1	12:05	12:11	00:06	Model Segmentation	
1	12:11	12:30	00:19	Chatting with Administrator	
2	12:30	12:51	00:21	Scan Acquisition	
2	12:51	14:03	01:12	Scan Processing	
2	14:03	14:05	00:02	Output Analysis	
2	14:05	14:55	00:50	Chatting with Administrator	
2	14:55	15:30	00:35	Looking at 3D Model	
2	15:30	15:45	00:15	Chatting with Administrator	
2	15:45	16:08	00:23	Assembling Assembly	pt 3
2	16:08	16:17	00:09	Manipulating Stands	
2	16:17	16:40	00:23	Looking at 3D Model	
2	16:40	16:58	00:18	Checking Assembly	
2	16:58	17:11	00:13	Looking at Drawing	
2	17:11	17:33	00:22	Looking at 3D Model	
2	17:33	17:43	00:10	Looking at Drawing	
2	17:43	17:57	00:14	Adjusting Assembly	pt 3
2	17:57	18:30	00:33	Manipulating Stands	
2	18:30	18:50	00:20	Chatting with Administrator	
2	18:50	19:02	00:12	Manipulating Stands	
2	19:02	19:21	00:19	Measuring Assembly	
2	19:21	19:27	00:06	Adjusting Assembly	pt 3
2	19:27	20:01	00:34	Measuring Assembly	
2	20:01	20:06	00:05	Adjusting Assembly	pt 3
2	20:06	20:22	00:16	Measuring Assembly	
2	20:22	20:26	00:04	Adjusting Assembly	pt 3
2	20:26	20:32	00:06	Measuring Assembly	
2	20:32	20:47	00:15	Adjusting Clips	
2	20:47	21:04	00:17	Manipulating Stands	
3	21:04	21:21	00:17	Scan Acquisition	
3	21:21	21:46	00:25	Chatting with Administrator	
3	21:46	24:00	02:14	Scan Processing	
3	24:00	24:02	00:02	Output Analysis	
3	24:02	24:33	00:31	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	02:16	02:16	Chatting with Administrator	
1	02:16	02:30	00:14	Looking at 3D Model	
1	02:30	02:45	00:15	Chatting with Administrator	
1	02:45	03:00	00:15	Model Segmentation	
1	03:00	04:06	01:06	Chatting with Administrator	
1	04:06	04:15	00:09	Assembling Assembly	pt 5
1	04:15	04:35	00:20	Model Segmentation	
1	04:35	05:13	00:38	Chatting with Administrator	
2	05:13	05:41	00:28	Scan Acquisition	
2	05:41	06:40	00:59	Scan Processing	
2	06:40	07:00	00:20	Chatting with Administrator	
2	07:00	07:01	00:01	Output Analysis	
2	07:01	07:19	00:18	Chatting with Administrator	
2	07:19	07:33	00:14	Looking at 3D Model	
2	07:33	07:39	00:06	Assembling Assembly	pt 2
2	07:39	07:53	00:14	Looking at 3D Model	
2	07:53	07:58	00:05	Adjusting Assembly	
2	07:58	08:45	00:47	Chatting with Administrator	
2	08:45	09:02	00:17	Looking at 3D Model	
2	09:02	09:40	00:38	Chatting with Administrator	
2	09:40	09:50	00:10	Model Segmentation	
3	09:50	10:32	00:42	Scan Acquisition	
3	10:32	11:30	00:58	Chatting with Administrator	
3	11:30	12:50	01:20	Scan Processing	
3	12:50	12:51	00:01	Output Analysis	
3	12:51	13:42	00:51	Chatting with Administrator	
3	13:42	14:07	00:25	Looking at 3D Model	
3	14:07	14:20	00:13	Assembling Assembly	pt 3
3	14:20	14:53	00:33	Manipulating Stands	
3	14:53	15:15	00:22	Chatting with Administrator	
4	15:15	16:15	01:00	Scan Acquisition	
4	16:15	17:56	01:41	Scan Processing	

Totals	
Chatting with Administrator	09:55
Assembling Assembly	00:28
Adjusting Clips	00:00
Measuring Assembly	00:00
Checking Assembly	00:00
Manipulating Stands	00:33
Adjusting Assembly	00:05
Assembly Layout	00:00
Looking at Drawing	00:00
Completing Rework	00:10
Model Segmentation	00:45
Looking at 3D Model	01:24
Scan Acquisition	02:42
Scan Processing	05:07
Output Analysis	00:12
Total	21:21

Cycle	Start	End	Duration	Category	Note
4	17:56	18:04	00:08	Output Analysis	
4	18:04	18:30	00:26	Chatting with Administrator	
4	18:30	18:40	00:10	Completing Rework	rw 3
4	18:40	18:50	00:10	Chatting with Administrator	
5	18:50	19:22	00:32	Scan Acquisition	
5	19:22	20:22	01:00	Scan Processing	
5	20:22	20:24	00:02	Output Analysis	
5	20:24	20:31	00:07	Chatting with Administrator	
5	20:31	20:38	00:07	Scan Processing	
5	20:38	21:21	00:43	Chatting with Administrator	

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Cycle	Start	End	Duration	Category	Note
1	00:00	07:17	07:17	Chatting with Administrator	
1	07:17	07:23	00:06	Looking at 3D Model	
1	07:23	07:25	00:02	Assembling Assembly	pt 2
1	07:25	07:36	00:11	Looking at 3D Model	
1	07:36	07:55	00:19	Chatting with Administrator	
1	07:55	08:33	00:38	Looking at Drawing	
1	08:33	08:55	00:22	Chatting with Administrator	
1	08:55	09:05	00:10	Looking at Drawing	
1	09:05	09:21	00:16	Measuring Assembly	
1	09:21	09:52	00:31	Looking at Drawing	
1	09:52	09:58	00:06	Adjusting Assembly	pt 2
1	09:58	10:13	00:15	Looking at Drawing	
1	10:13	10:20	00:07	Measuring Assembly	
1	10:20	10:28	00:08	Looking at Drawing	
1	10:28	10:40	00:12	Adjusting Assembly	pt 2
1	10:40	10:49	00:09	Looking at Drawing	
1	10:49	10:54	00:05	Adjusting Assembly	pt 2
1	10:54	11:05	00:11	Looking at 3D Model	
1	11:05	11:12	00:07	Adjusting Assembly	pt 2
1	11:12	11:40	00:28	Chatting with Administrator	
1	11:40	11:50	00:10	Looking at Drawing	
1	11:50	11:56	00:06	Adjusting Assembly	pt 2
1	11:56	12:15	00:19	Looking at 3D Model	
1	12:15	12:50	00:35	Chatting with Administrator	
1	12:50	13:06	00:16	Model Segmentation	
1	13:06	13:25	00:19	Looking at 3D Model	
1	13:25	13:38	00:13	Measuring Assembly	
1	13:38	13:50	00:12	Looking at 3D Model	
1	13:50	14:02	00:12	Chatting with Administrator	
1	14:02	14:36	00:34	Looking at 3D Model	
1	14:36	14:50	00:14	Chatting with Administrator	
1	14:50	15:05	00:15	Measuring Assembly	
1	15:05	15:25	00:20	Looking at 3D Model	
1	15:25	15:40	00:15	Adjusting Assembly	pt 2
1	15:40	15:50	00:10	Adjusting Clips	
1	15:50	15:53	00:03	Adjusting Assembly	pt 2
1	15:53	16:04	00:11	Looking at 3D Model	
1	16:04	16:20	00:16	Measuring Assembly	
1	16:20	16:28	00:08	Looking at 3D Model	
1	16:28	16:32	00:04	Assembly Layout	
1	16:32	16:41	00:09	Looking at 3D Model	
1	16:41	16:50	00:09	Assembling Assembly	pt 3
1	16:50	17:03	00:13	Looking at 3D Model	
1	17:03	17:09	00:06	Adjusting Assembly	pt 3
1	17:09	17:58	00:49	Measuring Assembly	
1	17:58	18:04	00:06	Adjusting Assembly	pt 2
1	18:04	18:10	00:06	Adjusting Clips	
1	18:10	18:29	00:19	Looking at 3D Model	
1	18:29	18:33	00:04	Adjusting Assembly	dis 3
1	18:33	18:48	00:15	Adjusting Assembly	pt 2
1	18:48	19:05	00:17	Checking Assembly	
1	19:05	19:19	00:14	Assembling Assembly	pt 5
1	19:19	19:40	00:21	Looking at Drawing	
1	19:40	19:53	00:13	Looking at 3D Model	
1	19:53	20:02	00:09	Looking at Drawing	

Totals	
Chatting with Administrator	10:57
Assembling Assembly	00:36
Adjusting Clips	00:16
Measuring Assembly	01:56
Checking Assembly	00:17
Manipulating Stands	00:27
Adjusting Assembly	01:25
Assembly Layout	00:04
Looking at Drawing	02:47
Completing Rework	00:21
Model Segmentation	00:49
Looking at 3D Model	05:07
Scan Acquisition	03:47
Scan Processing	04:34
Output Analysis	00:49
Total	34:12

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1	20:02	20:24	00:22	Looking at 3D Model	
1	20:24	20:35	00:11	Assembling Assembly	pt 3
1	20:35	20:51	00:16	Looking at Drawing	
1	20:51	21:06	00:15	Looking at 3D Model	
1	21:06	21:20	00:14	Chatting with Administrator	
1	21:20	21:30	00:10	Model Segmentation	
2	21:30	22:00	00:30	Scan Acquisition	
2	22:00	22:22	00:22	Scan Acquisition	
2	22:22	22:55	00:33	Scan Processing	
2	22:55	23:01	00:06	Output Analysis	
2	23:01	23:05	00:04	Completing Rework	rw 1
2	23:05	23:23	00:18	Chatting with Administrator	
3	23:23	23:57	00:34	Scan Acquisition	
3	23:57	24:30	00:33	Scan Processing	
3	24:30	24:44	00:14	Chatting with Administrator	
3	24:44	24:47	00:03	Output Analysis	
3	24:47	25:06	00:19	Output Analysis	
3	25:06	25:10	00:04	Chatting with Administrator	
4	25:10	25:47	00:37	Scan Acquisition	
4	25:47	26:03	00:16	Scan Processing	
4	26:03	26:05	00:02	Output Analysis	
4	26:05	26:22	00:17	Chatting with Administrator	
4	26:22	26:23	00:01	Completing Rework	rw 5
4	26:23	26:32	00:09	Looking at 3D Model	
4	26:32	26:55	00:23	Model Segmentation	
4	26:55	27:03	00:08	Looking at 3D Model	
5	27:03	27:29	00:26	Scan Acquisition	
5	27:29	28:28	00:59	Scan Processing	
5	28:28	28:30	00:02	Output Analysis	
5	28:30	28:40	00:10	Chatting with Administrator	
5	28:40	28:54	00:14	Looking at 3D Model	
5	28:54	29:05	00:11	Completing Rework	rw 3
5	29:05	29:17	00:12	Manipulating Stands	
6	29:17	30:02	00:45	Scan Acquisition	
6	30:02	31:33	01:31	Scan Processing	
6	31:33	31:45	00:12	Output Analysis	
6	31:45	31:50	00:05	Completing Rework	rw 2
6	31:50	32:24	00:34	Looking at 3D Model	
6	32:24	32:37	00:13	Chatting with Administrator	
6	32:37	32:52	00:15	Manipulating Stands	
7	32:52	33:25	00:33	Scan Acquisition	
7	33:25	34:07	00:42	Scan Processing	
7	34:07	34:12	00:05	Output Analysis	

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Cycle	Start	End	Duration	Category	Note
1	00:00	01:30	01:30	Chatting with Administrator	
1	01:30	01:36	00:06	Assembling Assembly	pt 2
1	01:36	01:46	00:10	Model Segmentation	
1	01:46	02:08	00:22	Chatting with Administrator	
2	02:08	03:05	00:57	Scan Acquisition	
2	03:05	03:17	00:12	Chatting with Administrator	
2	03:17	04:02	00:45	Scan Processing	
2	04:02	04:05	00:03	Output Analysis	
2	04:05	04:10	00:05	Chatting with Administrator	
2	04:10	04:18	00:08	Completing Rework	rw 2
2	04:18	04:30	00:12	Looking at 3D Model	
2	04:30	04:37	00:07	Chatting with Administrator	
2	04:37	04:45	00:08	Completing Rework	rw 2
2	04:45	05:00	00:15	Chatting with Administrator	
2	05:00	05:24	00:24	Looking at 3D Model	
2	05:24	05:38	00:14	Assembling Assembly	pt 3
2	05:38	05:47	00:09	Assembling Assembly	pt 5
2	05:47	06:00	00:13	Looking at Drawing	
2	06:00	06:10	00:10	Chatting with Administrator	
2	06:10	06:48	00:38	Looking at 3D Model	
2	06:48	07:05	00:17	Checking Assembly	
2	07:05	07:46	00:41	Looking at 3D Model	

Totals	
Chatting with Administrator	05:45
Assembling Assembly	00:29
Adjusting Clips	00:00
Measuring Assembly	00:00
Checking Assembly	00:17
Manipulating Stands	00:11
Adjusting Assembly	00:09
Assembly Layout	00:00
Looking at Drawing	00:13
Completing Rework	00:16
Model Segmentation	00:10
Looking at 3D Model	02:00
Scan Acquisition	02:07
Scan Processing	01:49
Output Analysis	00:07
Total	13:33

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Cycle	Start	End	Duration	Category	Note
2	07:46	07:55	00:09	Adjusting Assembly	pt four
2	07:55	08:00	00:05	Looking at 3D Model	
2	08:00	08:30	00:30	Chatting with Administrator	
2	08:30	08:41	00:11	Manipulating Stands	
2	08:41	08:50	00:09	Chatting with Administrator	
3	08:50	10:00	01:10	Scan Acquisition	
3	10:00	11:04	01:04	Scan Processing	
3	11:04	11:08	00:04	Output Analysis	
3	11:08	13:33	02:25	Chatting with Administrator	

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Cycle	Start		Duration	Category	Note
1	00:00	00:36	00:36	Looking at Drawing	
1	00:36	00:41	00:05	Assembling Assembly	PT 5
1	00:41	00:55	00:14	Looking at Drawing	
1	00:55	01:02	00:07	Assembling Assembly	PT 2
1	01:02	01:08	00:06	Adjusting Assembly	pt 5
1	01:08	01:30	00:22	Model Segmentation	
1	01:30	01:42	00:12	Chatting with Administrator	
2	01:42	02:09	00:27	Scan Acquisition	
2	02:09	03:01	00:52	Scan Processing	
2	03:01	03:15	00:14	Chatting with Administrator	
2	03:15	03:27	00:12	Model Segmentation	
2	03:27	03:36	00:09	Looking at 3D Model	
2	03:36	03:45	00:09	Completing Rework	rw 2
2	03:45	03:52	00:07	Completing Rework	rw 5
2	03:52	03:57	00:05	Completing Rework	rw 2
3	03:57	04:26	00:29	Scan Acquisition	
3	04:26	05:14	00:48	Scan Processing	
3	05:14	05:15	00:01	Output Analysis	
3	05:14	06:15	01:01	Chatting with Administrator	
3	06:15	06:33	00:18	Looking at 3D Model	
3	06:33	06:41	00:08	Assembling Assembly	PT 1
3	06:41	07:00	00:19	Manipulating Stands	
3	07:00	07:11	00:11	Looking at 3D Model	
3	07:11	07:17	00:06	Adjusting Assembly	pt 1
4	07:17	07:53	00:36	Scan Acquisition	
4	07:53	08:24	00:31	Scan Processing	
4	08:24	08:26	00:02	Output Analysis	
4	08:26	08:36	00:10	Chatting with Administrator	
4	08:36	08:43	00:07	Looking at 3D Model	
4	08:43	08:54	00:11	Completing Rework	rw 1
5	08:54	09:15	00:21	Scan Acquisition	
5	09:15	0:09:43	00:28	Scan Processing	
5	09:43	09:45	00:02	Output Analysis	
5	09:45	13:54	04:09	Chatting with Administrator	about scanning

Totals	
Chatting with Administrator	05:46
Assembling Assembly	00:20
Adjusting Clips	00:00
Measuring Assembly	00:00
Checking Assembly	00:00
Manipulating Stands	00:19
Adjusting Assembly	00:12
Assembly Layout	00:00
Looking at Drawing	00:50
Completing Rework	00:32
Model Segmentation	00:34
Looking at 3D Model	00:45
Scan Acquisition	01:53
Scan Processing	02:39
Output Analysis	00:05
Total	13:55

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:35	00:35	Looking at 3D Model	
1	00:35	00:49	00:14	Looking at Drawing	
1	00:49	01:01	00:12	Assembling Assembly	pt 5
1	01:01	01:20	00:19	Looking at Drawing	
1	01:20	01:25	00:05	Adjusting Assembly	pt 5
1	01:25	01:35	00:10	Looking at Drawing	
1	01:35	01:45	00:10	Chatting with Administrator	
1	01:45	02:06	00:21	Assembling Assembly	pt 2
1	02:06	02:25	00:19	Looking at Drawing	
1	02:25	02:35	00:10	Assembling Assembly	pt 2
1	02:35	02:45	00:10	Chatting with Administrator	
1	02:45	02:50	00:05	Assembling Assembly	pt 1
1	02:50	02:58	00:08	Manipulating Stands	
1	02:58	03:05	00:07	Adjusting Assembly	pt 1
1	03:05	03:10	00:05	Chatting with Administrator	
1	03:10	03:28	00:18	Chatting with Administrator	

Totals	
Chatting with Administrator	03:48
Assembling Assembly	00:48
Adjusting Clips	00:00
Measuring Assembly	00:00
Checking Assembly	00:00
Manipulating Stands	00:08
Adjusting Assembly	00:12
Assembly Layout	00:00
Looking at Drawing	01:02
Completing Rework	00:00
Model Segmentation	00:00
Looking at 3D Model	00:35
Scan Acquisition	00:28
Scan Processing	01:08
Output Analysis	00:01

2	03:28	03:56	00:28	Scan Acquisition	
2	03:56	04:22	00:26	Chatting with Administrator	
2	04:22	04:50	00:28	Scan Processing	
2	04:50	05:28	00:38	Chatting with Administrator	
2	05:28	06:08	00:40	Scan Processing	
2	06:08	06:09	00:01	Output Analysis	
2	06:09	08:10	02:01	Chatting with Administrator	app

Total	08:10

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Cycle	Start	End	Duration	Category	Note
1	00:00	00:15	00:15	Looking at Drawing	
1	00:15	00:25	00:10	Looking at 3D Model	
1	00:25	00:32	00:07	Assembling Assembly	pt 5
1	00:32	00:48	00:16	Looking at 3D Model	
1	00:48	01:00	00:12	Adjusting Assembly	pt 5
1	01:00	01:05	00:05	Looking at 3D Model	
1	01:05	01:11	00:06	Assembling Assembly	pt 2
1	01:11	01:17	00:06	Assembling Assembly	pt 1
1	01:17	01:29	00:12	Looking at 3D Model	
1	01:29	01:45	00:16	Chatting with Administrator	
2	01:45	02:08	00:23	Scan Acquisition	
2	02:08	02:58	00:50	Scan Processing	
2	02:58	03:09	00:11	Output Analysis	
2	03:09	03:13	00:04	Completing Rework	rw 5
2	03:13	03:28	00:15	Looking at 3D Model	
2	03:28	03:35	00:07	Completing Rework	rw 1
3	03:35	04:09	00:34	Scan Acquisition	
3	04:09	04:51	00:42	Scan Processing	
3	04:51	05:00	00:09	Chatting with Administrator	
3	05:00	05:02	00:02	Output Analysis	
3	05:02	05:20	00:18	Completing Rework	rw 2
3	05:20	05:50	00:30	Manipulating Stands	
3	05:50	06:20	00:30	Output Analysis	
3	06:20	06:32	00:12	Completing Rework	rw 2
3	06:32	06:40	00:08	Chatting with Administrator	
3	06:40	06:45	00:05	Adjusting Clips	
3	06:45	06:58	00:13	Completing Rework	rw 2
3	06:58	07:03	00:05	Chatting with Administrator	
3	07:03	07:23	00:20	Completing Rework	rw 2
3	07:23	07:28	00:05	Chatting with Administrator	
3	07:28	08:01	00:33	Manipulating Stands	
3	08:01	08:15	00:14	Looking at Drawing	
3	08:15	08:23	00:08	Looking at 3D Model	
3	08:23	08:34	00:11	Looking at Drawing	
3	08:34	08:51	00:17	Completing Rework	rw 3
3	08:51	08:56	00:05	Looking at Drawing	
3	08:56	09:01	00:05	Completing Rework	rw 3
4	09:01	09:31	00:30	Scan Acquisition	
4	09:31	10:10	00:39	Scan Processing	
4	10:10	10:16	00:06	Output Analysis	

Totals	
Chatting with Administrator	00:43
Assembling Assembly	00:19
Adjusting Clips	00:05
Measuring Assembly	00:00
Checking Assembly	00:00
Manipulating Stands	01:03
Adjusting Assembly	00:12
Assembly Layout	00:00
Looking at Drawing	00:45
Completing Rework	01:36
Model Segmentation	00:00
Looking at 3D Model	01:06
Scan Acquisition	01:27
Scan Processing	02:11
Output Analysis	00:49
Total	10:16

Appendix G
Fitters with Isometric Raw Data

		F-P-01			

Cycle	Start	End	Duration	Category	Note
1	00:00	00:35	00:35	Chatting with Administrator	
1	00:35	00:50	00:15	Looking at Drawing	
1	00:50	01:22	00:32	Chatting with Administrator	
1	01:22	01:40	00:18	Assembling Assembly	pt 2
1	01:40	01:48	00:08	Looking at Drawing	
1	01:48	01:55	00:07	Adjusting Assembly	
1	01:55	02:33	00:38	Chatting with Administrator	
1	02:33	03:52	01:19	Looking at Drawing	
1	03:52	04:35	00:43	Chatting with Administrator	
1	04:35	05:19	00:44	Looking at Drawing	
1	05:19	05:30	00:11	Assembling Assembly	pt 3
1	05:30	07:00	01:30	Looking at Drawing	
1	07:00	07:25	00:25	Chatting with Administrator	
1	07:25	07:28	00:03	Adjusting Assembly	pt 3
1	07:28	07:50	00:22	Chatting with Administrator	
1	07:50	07:55	00:05	Adjusting Assembly	pt 3
1	07:55	08:05	00:10	Looking at Drawing	
1	08:05	08:11	00:06	Assembling Assembly	pt 5
1	08:11	08:20	00:09	Chatting with Administrator	
1	08:20	08:25	00:05	Adjusting Assembly	pt 2
1	08:25	08:28	00:03	Adjusting Assembly	pt 3
1	08:28	08:57	00:29	Manipulating Stands	
1	08:57	09:03	00:06	Adjusting Assembly	pt 2
1	09:03	09:20	00:17	Measuring Assembly	
1	09:20	09:26	00:06	Manipulating Stands	
1	09:26	09:33	00:07	Measuring Assembly	
1	09:33	09:40	00:07	Manipulating Stands	
1	09:40	09:46	00:06	Measuring Assembly	
1	09:46	09:52	00:06	Manipulating Stands	
1	09:52	10:00	00:08	Measuring Assembly	
1	10:00	10:07	00:07	Manipulating Stands	
1	10:07	10:28	00:21	Measuring Assembly	
1	10:28	10:40	00:12	Adjusting Clips	
1	10:40	11:49	01:09	Looking at Drawing	
1	11:49	12:00	00:11	Chatting with Administrator	
1	12:00	12:20	00:20	Looking at Drawing	
1	12:20	12:30	00:10	Measuring Assembly	
1	12:30	12:40	00:10	Adjusting Assembly	pt 3
1	12:40	13:01	00:21	Manipulating Stands	
1	13:01	13:15	00:14	Chatting with Administrator	
1	13:15	13:27	00:12	Measuring Assembly	
1	13:27	13:32	00:05	Manipulating Stands	
1	13:32	13:40	00:08	Measuring Assembly	
1	13:40	13:58	00:18	Manipulating Stands	
1	13:58	14:07	00:09	Measuring Assembly	
1	14:07	14:28	00:21	Manipulating Stands	
1	14:28	14:36	00:08	Measuring Assembly	
1	14:36	14:42	00:06	Manipulating Stands	
1	14:42	14:49	00:07	Measuring Assembly	
1	14:49	15:05	00:16	Looking at Drawing	
1	15:05	15:27	00:22	Chatting with Administrator	
1	15:27	15:40	00:13	Looking at Drawing	
1	15:40	16:30	00:50	Chatting with Administrator	
1	16:30	19:04	02:34	Looking at Drawing	
1	19:04	20:00	00:56	Chatting with Administrator	
1	20:00	20:30	00:30	Looking at Drawing	
1	20:30	20:55	00:25	Chatting with Administrator	
1	20:55	21:05	00:10	Looking at Drawing	
2	21:05	21:40	00:35	Conveying Corrections	chat
2	21:40	22:47	01:07	Looking at Drawing	

Totals	
Chatting with Administrator	11:36
Assembling Assembly	00:35
Adjusting Clips	00:12
Measuring Assembly	01:53
Checking Assembly	00:00
Manipulating Stands	02:11
Adjusting Assembly	00:39
Assembly Layout	00:00
Looking at Drawing	13:46
Completing Rework	01:04
Quality Control	00:00
Conveying Corrections	01:08
Total	33:04

2	22:47	23:00	00:13	Completing Rework	rw 3
2	23:00	23:20	00:20	Looking at Drawing	
2	23:20	23:25	00:05	Completing Rework	rw 3
2	23:25	24:27	01:02	Looking at Drawing	
2	24:27	24:32	00:05	Manipulating Stands	
2	24:32	25:00	00:28	Looking at Drawing	
2	25:00	25:25	00:25	Chatting with Administrator	
2	25:25	25:50	00:25	Looking at Drawing	
2	25:50	26:00	00:10	Chatting with Administrator	
2	26:00	26:15	00:15	Looking at Drawing	
2	26:15	26:42	00:27	Chatting with Administrator	
2	26:42	27:08	00:26	Conveying Corrections	chat
2	27:08	27:45	00:37	Looking at Drawing	
2	27:45	27:54	00:09	Looking at Drawing	
2	27:54	28:03	00:09	Completing Rework	pt 3
2	28:03	28:10	00:07	Completing Rework	pt 5
2	28:10	28:24	00:14	Completing Rework	pt 2
2	28:24	28:29	00:05	Looking at Drawing	
2	28:29	28:41	00:12	Completing Rework	pt 2
2	28:41	28:48	00:07	Conveying Corrections	
2	28:48	28:52	00:04	Completing Rework	pt2
2	28:52	33:04	04:12	Chatting with Administrator	

F-P-02

Cycle	Start	End	Duration	Category	Note
1	00:00	00:22	00:22	Chatting with Administrator	
1	00:22	00:32	00:10	Assembly Layout	
1	00:32	00:47	00:15	Looking at drawing	
1	00:47	01:08	00:21	Chatting with Administrator	
1	01:08	01:20	00:12	Looking at drawing	
1	01:20	01:30	00:10	Chatting with Administrator	
1	01:30	02:00	00:30	Looking at drawing	
1	02:00	02:05	00:05	Assembling Assembly	pt 5
1	02:05	03:10	01:05	Chatting with Administrator	
1	03:10	03:24	00:14	Measuring Assembly	
1	03:24	03:40	00:16	Adjusting Assembly	pt 5
1	03:40	03:50	00:10	Measuring Assembly	
1	03:50	05:40	01:50	Chatting with Administrator	
1	05:40	06:00	00:20	Adjusting Clips	
1	06:00	06:30	00:30	Adjusting Assembly	pt 5
1	06:30	06:36	00:06	Adjusting Clips	
1	06:36	06:47	00:11	Adjusting Assembly	pt 5
1	06:47	06:52	00:05	Looking at drawing	
1	06:52	07:00	00:08	Adjusting Assembly	pt 5
1	07:00	07:05	00:05	Measuring Assembly	
1	07:05	07:11	00:06	Adjusting Assembly	pt 5
1	07:11	07:40	00:29	Measuring Assembly	
1	07:40	08:30	00:50	Chatting with Administrator	
1	08:30	08:40	00:10	Measuring Assembly	
1	08:40	09:50	01:10	Chatting with Administrator	
1	09:50	10:17	00:27	Manipulating Stands	
1	10:17	10:32	00:15	Chatting with Administrator	
1	10:32	11:00	00:28	Manipulating Stands	
1	11:00	11:15	00:15	Looking at drawing	
1	11:15	11:18	00:03	Assembling Assembly	pt 2
1	11:18	11:26	00:08	Looking at drawing	
1	11:26	11:32	00:06	Assembling Assembly	pt 2
1	11:32	11:37	00:05	Looking at drawing	
1	11:37	11:43	00:06	Assembling Assembly	pt 1
1	11:43	12:02	00:19	Manipulating Stands	
1	12:02	12:08	00:06	Adjusting Assembly	pt three
1	12:08	13:35	01:27	Chatting with Administrator	
1	13:35	14:00	00:25	Looking at drawing	
1	14:00	14:40	00:40	Measuring Assembly	
1	14:40	15:14	00:34	Manipulating Stands	
1	15:14	15:50	00:36	Looking at drawing	
1	15:50	16:13	00:23	Measuring Assembly	
1	16:13	16:30	00:17	Manipulating Stands	

Totals	
Chatting with Administrator	10:57
Assembling Assembly	00:20
Adjusting Clips	01:49
Measuring Assembly	10:09
Checking Assembly	00:00
Manipulating Stands	04:26
Adjusting Assembly	01:56
Assembly Layout	00:10
Looking at Drawing	05:53
Completing Rework	00:00
Quality Control	03:31
Conveying Corrections	00:00
Total	39:11

1	16:30	16:50	00:20	Measuring Assembly	
1	16:50	17:00	00:10	Manipulating Stands	
1	17:00	17:19	00:19	Measuring Assembly	
1	17:19	17:40	00:21	Manipulating Stands	
1	17:40	17:57	00:17	Measuring Assembly	
1	17:57	18:07	00:10	Manipulating Stands	
1	18:07	18:29	00:22	Measuring Assembly	
1	18:29	18:38	00:09	Manipulating Stands	
1	18:38	18:58	00:20	Looking at drawing	
1	18:58	19:08	00:10	Measuring Assembly	
1	19:08	19:22	00:14	Adjusting Clips	
1	19:22	19:28	00:06	Adjusting Assembly	pt 5
1	19:28	19:38	00:10	Manipulating Stands	
1	19:38	20:05	00:27	Measuring Assembly	
1	20:05	20:15	00:10	Looking at drawing	
1	20:15	20:21	00:06	Measuring Assembly	
1	20:21	20:26	00:05	Adjusting Assembly	pt 5
1	20:26	20:35	00:09	Manipulating Stands	
1	20:35	21:06	00:31	Measuring Assembly	
1	21:06	21:11	00:05	Manipulating Stands	
1	21:11	21:42	00:31	Measuring Assembly	
1	21:42	21:47	00:05	Manipulating Stands	
1	21:47	21:57	00:10	Measuring Assembly	
1	21:57	22:08	00:11	Manipulating Stands	
1	22:08	22:26	00:18	Measuring Assembly	
1	22:26	22:39	00:13	Looking at drawing	
1	22:39	22:50	00:11	Measuring Assembly	
1	22:50	22:53	00:03	Adjusting Assembly	pt 5
1	22:53	23:18	00:25	Measuring Assembly	
1	23:18	23:25	00:07	Adjusting Assembly	pt 5
1	23:25	23:47	00:22	Measuring Assembly	
1	23:47	23:55	00:08	Looking at drawing	
1	23:55	24:10	00:15	Measuring Assembly	
1	24:10	24:18	00:08	Adjusting Assembly	pt 1
1	24:18	24:31	00:13	Manipulating Stands	
1	24:31	26:00	01:29	Chatting with Administrator	
1	26:00	27:03	01:03	Looking at drawing	
1	27:03	27:52	00:49	Chatting with Administrator	
1	27:52	28:00	00:08	Manipulating Stands	
1	28:00	28:10	00:10	Chatting with Administrator	
1	28:10	28:16	00:06	Manipulating Stands	
1	28:16	28:40	00:24	Measuring Assembly	
1	28:40	28:55	00:15	Chatting with Administrator	
1	28:55	29:05	00:10	Measuring Assembly	
1	29:05	29:16	00:11	Looking at drawing	
1	29:16	29:54	00:38	Measuring Assembly	
1	29:54	30:00	00:06	Adjusting Assembly	pt 5
1	30:00	30:08	00:08	Measuring Assembly	
1	30:08	30:12	00:04	Adjusting Assembly	pt 5
1	30:12	30:20	00:08	Measuring Assembly	
1	30:20	31:07	00:47	Adjusting Clips	
1	31:07	31:20	00:13	Looking at drawing	
1	31:20	31:50	00:30	Measuring Assembly	
1	31:50	32:54	01:04	Looking at drawing	
1	32:54	33:15	00:21	Chatting with Administrator	
1	33:15	33:37	00:22	Adjusting Clips	
1	33:37	33:50	00:13	Chatting with Administrator	
1	33:50	33:58	00:08	Manipulating Stands	
1	33:58	34:21	00:23	Measuring Assembly	
1	34:21	34:25	00:04	Manipulating Stands	
1	34:25	34:36	00:11	Measuring Assembly	
1	34:36	34:43	00:07	Manipulating Stands	
1	34:43	35:15	00:32	Measuring Assembly	
1	35:15	35:20	00:05	Manipulating Stands	
1	35:20	35:30	00:10	Measuring Assembly	
1	35:30	35:40	00:10	Chatting with Administrator	
2	35:40	39:11	03:31	Quality Control	

Cycle	Start	End	Duration	Category	Note
1	00:00	09:28	09:28	Chatting with Administrator	
1	09:28	10:27	00:59	Looking at Drawing	
1	10:27	10:45	00:18	Assembling Assembly	pt 5
1	10:45	11:45	01:00	Looking at Drawing	
1	11:45	11:53	00:08	Adjusting Assembly	pt 5
1	11:53	12:04	00:11	Looking at Drawing	
1	12:04	12:17	00:13	Adjusting Assembly	pt 5
1	12:17	12:32	00:15	Looking at Drawing	
1	12:32	13:03	00:31	Measuring Assembly	
1	13:03	13:14	00:11	Adjusting Assembly	pt 5
1	13:14	13:35	00:21	Measuring Assembly	
1	13:35	13:40	00:05	Adjusting Assembly	pt 5
1	13:40	13:49	00:09	Measuring Assembly	
1	13:49	13:53	00:04	Adjusting Assembly	pt 5
1	13:53	14:34	00:41	Measuring Assembly	
1	14:34	14:38	00:04	Adjusting Assembly	pt 5
1	14:38	14:48	00:10	Measuring Assembly	
1	14:48	14:52	00:04	Adjusting Assembly	pt 5
1	14:52	15:07	00:15	Measuring Assembly	
1	15:07	15:08	00:01	Adjusting Assembly	pt 5
1	15:08	15:37	00:29	Measuring Assembly	
1	15:37	15:43	00:06	Adjusting Assembly	pt 5
1	15:43	16:24	00:41	Chatting with Administrator	
1	16:24	19:27	03:03	Chatting with Administrator	
2	19:27	21:24	01:57	Quality Control	
2	21:24	21:35	00:11	Conveying Corrections	
2	21:35	22:00	00:25	Looking at Drawing	
2	22:00	22:15	00:15	Chatting with Administrator	
2	22:15	22:48	00:33	Looking at Drawing	
2	22:48	23:10	00:22	Completing Rework	rw 5
2	23:10	23:48	00:38	Looking at Drawing	
2	23:48	23:56	00:08	Chatting with Administrator	
2	23:56	24:19	00:23	Completing Rework	rw 5
2	24:19	24:39	00:20	Assembly Layout	
2	24:39	24:59	00:20	Looking at Drawing	
2	24:59	25:05	00:06	Assembling Assembly	pt 2
2	25:05	25:15	00:10	Assembling Assembly	pt 1
2	25:15	25:46	00:31	Looking at Drawing	
2	25:46	26:02	00:16	Adjusting Assembly	pt 2
2	26:02	26:58	00:56	Chatting with Administrator	
3	26:58	29:00	02:02	Quality Control	
3	29:00	30:19	01:19	Quality Control	
3	30:19	31:09	00:50	Quality Control	
3	31:09	31:26	00:17	Conveying Corrections	
3	31:26	31:48	00:22	Chatting with Administrator	
3	31:48	32:54	01:06	Looking at Drawing	
3	32:54	33:36	00:42	Manipulating Stands	
3	33:36	33:46	00:10	Looking at Drawing	
3	33:46	34:15	00:29	Manipulating Stands	
3	34:15	34:46	00:31	Looking at Drawing	
3	34:46	35:19	00:33	Manipulating Stands	
3	35:19	36:06	00:47	Looking at Drawing	
3	36:06	36:18	00:12	Manipulating Stands	
3	36:18	37:12	00:54	Looking at Drawing	
3	37:12	37:20	00:08	Completing Rework	rw 2
3	37:20	37:25	00:05	Measuring Assembly	
3	37:25	37:58	00:33	Looking at Drawing	
3	37:58	38:04	00:06	Completing Rework	rw 2
3	38:04	38:10	00:06	Manipulating Stands	
3	38:10	38:26	00:16	Chatting with Administrator	
3	38:26	38:28	00:02	Completing Rework	rw 5
3	38:28	38:40	00:12	Measuring Assembly	
3	38:40	38:44	00:04	Completing Rework	rw 5
3	38:44	41:41	02:57	Looking at Drawing	
3	41:41	45:56	04:15	Chatting with Administrator	
3	45:56	46:03	00:07	Chatting with Administrator	
3	46:03	47:05	01:02	Looking at Drawing	

Totals	
Chatting with Administrator	20:11
Assembling Assembly	00:34
Adjusting Clips	00:00
Measuring Assembly	02:53
Checking Assembly	00:00
Manipulating Stands	02:02
Adjusting Assembly	01:12
Assembly Layout	00:20
Looking at Drawing	14:13
Completing Rework	01:25
Quality Control	06:08
Conveying Corrections	00:28
Total	49:26

3	47:05	47:45	00:40	Chatting with Administrator	
3	47:45	48:20	00:35	Looking at Drawing	
3	48:20	48:30	00:10	Completing Rework	rw 1
3	48:30	48:46	00:16	Looking at Drawing	
3	48:46	48:56	00:10	Completing Rework	rw 2
3	48:56	49:26	00:30	Looking at Drawing	

Appendix H

Productivity Analysis Data

	Cycle	Type	Information Absorption	Assembling	Processing	Tack Welding	Cutting Weld	Rework Assembly	Assembly Time	Rework Time	TOTAL
				RAW DATA – ENGINEERS WITH APP							
E-A-01	1	Final Check	0:01:12	0:00:00	0:00:26	0	0	0:00:00	-	-	0:01:38
	2	Assembly	0:00:23	0:01:10	0:02:08	1	0	0:00:00	0:05:00	-	0:08:41
	3	Both	0:01:42	0:00:34	0:03:17	2	1	0:00:19	0:05:00	0:00:00	0:10:52
	4	Rework	0:00:33	0:00:00	0:03:36	1	1	0:00:17	-	0:00:00	0:04:26
	5	Rework	0:00:14	0:00:00	0:02:30	1	1	0:00:45	-	0:00:00	0:03:29
	6	Assembly	0:00:11	0:01:01	0:02:40	1	0	0:00:00	0:05:00	0:00:00	0:08:52
	7	Rework	0:00:10	0:00:00	0:02:11	1	1	0:00:07	-	0:00:00	0:02:28
	8	Final Check	0:00:03	0:00:00	0:02:03	0	0	0:00:00	-	0:00:00	0:02:06
		TOTAL	0:04:28	0:02:45	0:18:51			0:01:28	0:15:00	0:00:00	0:42:32
E-A-02	1	Assembly	0:02:40	0:02:05	0:00:45	1	0	0:00:00	0:05:00	-	0:10:30
	2	Rework	0:00:11	0:00:00	0:05:32	1	1	0:00:31	-	0:00:00	0:06:14
	3	Assembly	0:01:35	0:01:12	0:03:46	1	0	0:00:00	0:05:00	0:00:00	0:11:33
	4	Assembly	0:02:17	0:02:00	0:02:47	1	0	0:00:00	0:05:00	0:00:00	0:12:04
	5	Final Check	0:00:15	0:00:00	0:02:17	0	0	0:00:00	-	-	0:02:32
		TOTAL	0:06:58	0:05:17	0:15:07			0:00:31	0:15:00	0:00:00	0:42:53
E-A-03	1	Assembly	0:00:19	0:00:44	0:00:32	2	0	0:00:00	0:10:00	-	0:11:35
	2	Rework	0:00:18	0:00:00	0:02:47	1	1	0:00:00	-	0:00:00	0:03:05
	3	Assembly	0:00:51	0:00:48	0:04:08	1	0	0:00:00	0:05:00	-	0:10:47
	4	Both	0:01:19	0:00:41	0:02:50	1	0	0:00:00	-	0:00:00	0:04:50
	5	Rework	0:01:43	0:00:00	0:02:35	0	0	0:00:00	-	0:00:00	0:04:18
	6	Rework	0:01:06	0:00:00	0:03:11	1	1	0:00:00	-	0:00:00	0:04:17
	7	Assembly	0:00:48	0:01:00	0:02:49	0	0	0:00:00	0:00:00	-	0:04:37
	8	Rework	0:01:40	0:00:00	0:01:55	1	1	0:00:00	-	0:00:00	0:03:35
	9	Rework	0:00:26	0:00:00	0:01:32	1	1	0:00:00	-	0:00:00	0:01:58
	10	Rework	0:01:02	0:00:00	0:03:01	1	1	0:00:00	-	0:00:00	0:04:03
	11	Rework	0:00:05	0:00:00	0:00:00	1	1	0:00:00	-	0:00:00	0:00:05
	12	Both	0:01:56	0:00:23	0:01:15	1	0	0:00:00	-	0:00:00	0:03:33
	13	Rework	0:00:14	0:00:00	0:01:28	2	2	0:00:00	-	0:00:00	0:01:42
	14	Final Check	0:00:04	0:00:00	0:02:45	0	0	0:00:00	-	-	0:02:49
		TOTAL	0:11:51	0:03:36	0:30:48			0:00:00	0:15:00	0:00:00	1:01:15
E-A-04	1	Assembly	0:00:30	0:00:30	0:00:15	1	0	0:00:00	0:05:00	-	0:06:15
	2	Assembly	0:00:43	0:01:06	0:02:57	1	0	0:00:00	0:05:00	-	0:09:46
	3	Rework	0:00:24	0:00:00	0:03:32	1	1	0:00:21	-	0:00:00	0:04:17
	4	Rework	0:00:44	0:00:00	0:02:19	2	2	0:00:53	-	0:00:00	0:03:56
	5	Rework	0:01:18	0:00:00	0:03:15	1	1	0:00:19	-	0:00:00	0:04:52
	6	Rework	0:00:05	0:00:00	0:02:45	1	1	0:00:08	-	0:00:00	0:02:58
	7	Rework	0:00:48	0:00:00	0:01:30	1	1	0:00:08	-	0:00:00	0:02:26
	8	Rework	0:00:21	0:00:00	0:02:10	1	1	0:00:07	-	0:00:00	0:02:38
	9	Rework	0:01:30	0:00:00	0:01:57	1	1	0:00:15	-	0:00:00	0:03:42
	10	Rework	0:00:36	0:00:00	0:01:35	1	1	0:00:08	-	0:00:00	0:02:19
	11	Assembly	0:02:39	0:00:25	0:01:55	1	0	0:00:00	0:05:00	-	0:09:59
	12	Rework	0:00:13	0:00:00	0:02:05	1	1	0:00:06	-	0:00:00	0:02:24
	13	Rework	0:00:36	0:00:00	0:03:45	1	1	0:00:06	-	0:00:00	0:04:27
	14	Final Check	0:00:05	0:00:00	0:01:15	0	0	0:00:00	-	-	0:01:20
		TOTAL	0:10:32	0:02:01	0:31:15			0:02:31	0:15:00	0:00:00	1:01:19
E-A-05	1	Assembly	0:02:15	0:05:50	0:00:00	3	0	0:00:00	0:15:00	-	0:23:05
	2	Rework	0:01:05	0:00:00	0:02:39	1	1	0:00:33	-	0:00:00	0:04:17
	3	Rework	0:01:00	0:00:00	0:03:10	2	2	0:00:46	-	0:00:00	0:04:56
	4	Rework	0:00:45	0:00:00	0:02:22	2	2	0:00:48	-	0:00:00	0:03:55
	5	Rework	0:00:04	0:00:00	0:03:46	1	1	0:00:22	-	0:00:00	0:04:12
	6	Rework	0:00:07	0:00:00	0:01:38	1	1	0:00:26	-	0:00:00	0:02:11
	7	Rework	0:00:41	0:00:00	0:02:32	2	2	0:00:12	-	0:00:00	0:03:25
	8	Rework	0:00:25	0:00:00	0:04:07	2	2	0:00:23	-	0:00:00	0:04:55
	9	Rework	0:00:15	0:00:00	0:01:53	2	2	0:00:11	-	0:00:00	0:02:19
	10	Rework	0:00:49	0:00:00	0:02:14	1	1	0:00:23	-	0:00:00	0:03:26
	11	Rework	0:00:18	0:00:00	0:01:41	2	2	0:00:12	-	0:00:00	0:02:11
	12	Rework	0:00:19	0:00:00	0:01:18	1	1	0:00:04	-	0:00:00	0:01:41
	13	Rework	0:00:21	0:00:00	0:01:17	2	2	0:00:30	-	0:00:00	0:02:08
	14	Rework	0:00:35	0:00:00	0:01:18	1	1	0:00:09	-	0:00:00	0:02:02
	15	Rework	0:00:25	0:00:00	0:01:04	1	1	0:00:16	-	0:00:00	0:01:45

ID	#	Type									
	16	Rework	0:00:17	0:00:00	0:01:27	1	1	0:00:10	-	0:00:00	0:01:54
	17	Rework	0:00:16	0:00:00	0:02:56	1	1	0:00:21	-	0:00:00	0:03:33
	18	Rework	0:00:01	0:00:00	0:01:10	1	1	0:00:04	-	0:00:00	0:01:15
	19	Rework	0:01:22	0:00:00	0:01:57	1	1	0:00:09	-	0:00:00	0:03:28
	20	Rework	0:00:24	0:00:00	0:01:50	2	2	0:00:23	-	0:00:00	0:02:37
	21	Rework	0:00:10	0:00:00	0:02:24	1	1	0:00:10	-	0:00:00	0:02:44
	22	Rework	0:00:26	0:00:00	0:02:21	1	1	0:00:10	-	0:00:00	0:02:57
	23	Final Check	0:00:00	0:00:00	0:01:32	0	0	0:00:00	-	-	0:01:32
		TOTAL	0:12:20	0:05:50	0:46:36			0:06:42	0:15:00	0:00:00	1:26:28
E-A-06	1	Assembly	0:03:55	0:01:14	0:02:26	1	0	0:00:00	0:05:00	-	0:12:35
	2	Assembly	0:00:15	0:00:05	0:02:05	0	0	0:00:00	0:00:00	-	0:02:25
	3	Assembly	0:02:01	0:00:52	0:02:22	1	0	0:00:00	0:05:00	-	0:10:15
	4	Rework	0:03:05	0:00:00	0:03:39	1	1	0:00:30	-	0:00:00	0:07:14
	5	Rework	0:01:32	0:00:00	0:02:42	1	1	0:00:21	-	0:00:00	0:04:35
	6	Assembly	0:01:41	0:00:49	0:02:53	1	0	0:00:00	0:05:00	-	0:10:23
	7	Rework	0:00:51	0:00:00	0:02:42	1	1	0:00:14	-	0:00:00	0:03:47
	8	Rework	0:02:20	0:00:00	0:01:45	1	1	0:00:20	-	0:00:00	0:04:25
	9	Final Check	0:00:00	0:00:00	0:02:30	0	0	0:00:00	-	-	0:02:30
		TOTAL	0:15:40	0:03:00	0:23:04			0:01:25	0:15:00	0:00:00	0:58:09
E-A-07	1	Assembly	0:01:58	0:01:27	0:00:45	2	0	0:00:00	0:10:00	-	0:14:10
	2	Both	0:01:30	0:00:50	0:04:57	2	1	0:00:57	0:05:00	-	0:13:14
	3	Rework	0:00:19	0:00:00	0:03:19	1	1	0:00:15	-	0:00:00	0:03:53
	4	Rework	0:00:05	0:00:00	0:02:15	1	1	0:00:06	-	0:00:00	0:02:26
	5	Rework	0:00:10	0:00:00	0:02:12	1	1	0:00:17	-	0:00:00	0:02:39
	6	Final Check	0:00:20	0:00:00	0:02:25	0	0	0:00:00	-	-	0:02:45
	7	Rework	0:00:24	0:00:00	0:01:40	1	1	0:00:16	-	0:00:00	0:02:20
	8	Final Check	0:00:07	0:00:00	0:02:22	0	0	0:00:00	-	-	0:02:29
		TOTAL	0:04:53	0:02:17	0:19:55			0:01:51	0:15:00	0:00:00	0:43:56
E-A-08	1	Assembly	0:04:27	0:02:39	0:00:36	1	0	0:00:00	0:05:00	-	0:12:42
	2	Assembly	0:07:34	0:11:41	0:02:23	1	0	0:00:00	0:05:00	-	0:26:38
	3	Rework	0:01:09	0:00:00	0:02:48	2	2	0:00:20	-	0:00:00	0:04:17
	4	Final Check	0:01:06	0:00:00	0:01:47	0	0	0:00:00	-	0:00:00	0:02:53
	5	Rework	0:01:20	0:00:00	0:02:14	1	1	0:01:40	-	0:00:00	0:05:14
	6	Rework	0:01:31	0:00:00	0:01:30	2	2	0:02:15	-	0:00:00	0:05:16
	7	Assembly	0:02:03	0:03:33	0:01:46	1	0	0:00:00	0:05:00	-	0:12:22
	8	Rework	0:00:55	0:00:00	0:01:40	1	1	0:00:12	-	0:00:00	0:02:47
	9	Final Check	0:00:04	0:00:00	0:01:23	0	0	0:00:00	-	-	0:01:27
		TOTAL	0:20:09	0:17:53	0:16:07			0:04:27	0:15:00	0:00:00	1:13:36
E-A-09	1	Assembly	0:01:46	0:00:13	0:00:20	1	0	0:00:00	0:05:00	-	0:07:19
	2	Assembly	0:05:24	0:01:46	0:04:02	2	0	0:00:00	0:10:00	-	0:21:12
	3	Rework	0:00:48	0:00:00	0:03:40	2	2	0:00:18	-	0:00:00	0:04:46
	4	Rework	0:01:39	0:00:00	0:01:45	1	1	0:00:16	-	0:00:00	0:03:40
	5	Rework	0:01:21	0:00:00	0:04:08	2	2	0:00:39	-	0:00:00	0:06:08
	6	Rework	0:01:26	0:00:00	0:01:42	2	2	0:00:21	-	0:00:00	0:03:29
	7	Rework	0:00:40	0:00:00	0:01:02	2	2	0:00:15	-	0:00:00	0:01:57
	8	Rework	0:02:01	0:00:00	0:02:32	2	2	0:00:52	-	0:00:00	0:05:25
	9	Rework	0:02:58	0:00:00	0:02:24	2	2	0:00:15	-	0:00:00	0:05:37
	10	Rework	0:01:01	0:00:00	0:01:55	1	1	0:00:34	-	0:00:00	0:03:30
	11	Rework	0:00:27	0:00:00	0:01:30	1	1	0:00:03	-	0:00:00	0:02:00
	12	Rework	0:00:52	0:00:00	0:01:35	1	1	0:00:02	-	0:00:00	0:02:29
	13	Final Check	0:00:04	0:00:00	0:02:22	0	0	0:00:00	-	-	0:02:26
		TOTAL	0:20:27	0:01:59	0:28:57			0:03:35	0:15:00	0:00:00	1:09:58
E-A-10	1	Assembly	0:10:28	0:13:37	0:00:00	3	0	0:00:00	0:15:00	-	0:39:05
	2	Rework	0:00:23	0:00:00	0:02:29	1	1	0:01:01	-	0:00:00	0:03:53
	3	Rework	0:01:07	0:00:00	0:03:42	2	2	0:00:45	-	0:00:00	0:05:34
	4	Rework	0:00:16	0:00:00	0:04:44	1	1	0:00:23	-	0:00:00	0:05:23
	5	Rework	0:00:25	0:00:00	0:03:52	1	1	0:02:23	-	0:00:00	0:06:40
	6	Rework	0:01:12	0:00:00	0:03:15	1	1	0:00:18	-	0:00:00	0:04:45
	7	Rework	0:01:06	0:00:00	0:03:19	1	1	0:02:51	-	0:00:00	0:07:16
	8	Rework	0:00:18	0:00:00	0:04:09	1	1	0:02:20	-	0:00:00	0:06:47
	9	Rework	0:00:22	0:00:00	0:02:30	1	1	0:00:42	-	0:00:00	0:03:34
	10	Final Check	0:00:11	0:00:00	0:02:04	0	0	0:00:00	-	0:00:00	0:02:15
	11	Rework	0:00:31	0:00:00	0:02:14	1	1	0:00:35	-	0:00:00	0:03:20
	12	Rework	0:00:36	0:00:00	0:02:13	2	2	0:00:55	-	0:00:00	0:03:44
	13	Rework	0:00:46	0:00:00	0:01:51	1	1	0:00:13	-	0:00:00	0:02:50
	14	Rework	0:00:26	0:00:00	0:06:06	1	1	0:00:14	-	0:00:00	0:06:46
	15	Final Check	0:00:00	0:00:00	0:02:03	0	0	0:00:00	-	-	0:02:03
		TOTAL	0:18:07	0:13:37	0:44:31			0:12:40	0:15:00	0:00:00	1:43:55
E-A-11	1	Assembly	0:01:13	0:01:24	0:00:22	1	0	0:00:00	0:05:00	-	0:07:59
	2	Assembly	0:02:48	0:01:34	0:02:58	1	0	0:00:00	0:05:00	-	0:12:20

	3	Rework	0:00:25	0:00:00	0:02:40	1	1	0:00:20	-	0:00:00	0:03:25
	4	Assembly	0:02:49	0:00:20	0:03:03	1	0	0:00:00	0:05:00	0:00:00	0:11:12
	5	Final Check	0:00:10	0:00:00	0:02:04	0	0	0:00:00	-	-	0:02:14
		TOTAL	0:07:25	0:03:18	0:11:07			0:00:20	0:15:00	0:00:00	0:37:10
E-A-12	1	Assembly	0:12:04	0:21:10	0:00:18	2	0	0:00:00	0:10:00	-	0:43:32
	2	Both	0:02:32	0:06:01	0:02:38	3	2	0:03:36	-	-	0:14:47
	3	Rework	0:00:32	0:00:00	0:02:24	2	2	0:00:30	-	0:00:00	0:03:26
	4	Rework	0:00:18	0:00:00	0:01:04	1	1	0:00:37	-	0:00:00	0:01:59
	5	Rework	0:00:57	0:00:00	0:02:35	2	2	0:00:58	-	0:00:00	0:04:30
	6	Rework	0:00:11	0:00:00	0:01:23	1	1	0:00:21	-	0:00:00	0:01:55
	7	Final Check	0:00:00	0:00:00	0:01:57	0	0	0:00:00	-	-	0:01:57
		TOTAL	0:16:34	0:27:12	0:12:19			0:06:02	0:10:00	0:00:00	1:12:06
E-A-13	1	Assembly	0:03:40	0:03:48	0:00:05	3	0	0:00:00	0:15:00	-	0:22:33
	2	Rework	0:04:45	0:00:00	0:02:17	4	4	0:04:39	-	0:00:00	0:11:41
	3	Rework	0:03:17	0:00:00	0:01:30	3	3	0:04:50	-	0:0;0	0:09:37
	4	Rework	0:00:16	0:00:00	0:02:22	1	1	0:03:24	-	0:00:00	0:06:02
	5	Final Check	0:00:03	0:00:00	0:01:22	0	0	0:00:00	-	-	0:01:25
		TOTAL	0:12:01	0:03:48	0:07:36			0:12:53	0:15:00	0:00:00	0:51:18
E-A-14	1	Assembly	0:03:05	0:03:33	0:00:00	3	0	0:00:00	0:15:00	-	0:21:38
	2	Rework	0:00:18	0:00:00	0:02:13	1	1	0:00:12	-	0:00:00	0:02:43
	3	Rework	0:00:49	0:00:00	0:02:01	1	1	0:00:11	-	0:00:00	0:03:01
	4	Rework	0:00:09	0:00:00	0:01:46	1	1	0:00:04	-	0:00:00	0:01:59
	5	Rework	0:00:17	0:00:00	0:01:22	1	1	0:00:09	-	0:00:00	0:01:48
	6	Rework	0:00:53	0:00:00	0:01:40	1	1	0:00:29	-	0:00:00	0:03:02
	7	Rework	0:01:10	0:00:00	0:03:35	1	1	0:00:23	-	0:00:00	0:05:08
	8	Rework	0:00:26	0:00:00	0:06:21	1	1	0:00:04	-	0:00:00	0:06:51
	9	Rework	0:00:13	0:00:00	0:05:33	1	1	0:00:08	-	0:00:00	0:05:54
	10	Rework	0:00:29	0:00:00	0:03:45	2	2	0:00:18	-	0:00:00	0:04:32
	11	Final Check	0:00:00	0:00:00	0:01:34	0	0	0:00:00	-	-	0:01:34
		TOTAL	0:07:49	0:03:33	0:29:50			0:01:58	0:15:00	0:00:00	0:58:10
E-A-15	1	Assembly	0:01:35	0:00:49	0:00:14	1	0	0:00:00	0:05:00	-	0:07:38
	2	Rework	0:00:26	0:00:00	0:02:17	1	1	0:00:14	-	0:05:00	0:07:57
	3	Rework	0:00:22	0:00:00	0:01:36	1	1	0:00:07	-	0:00:00	0:02:05
	4	Assembly	0:00:32	0:01:26	0:02:15	1	0	0:00:00	0:05:00	0:00:00	0:09:13
	5	Rework	0:01:05	0:00:00	0:04:52	1	1	0:00:34	-	0:05:00	0:11:31
	6	Assembly	0:02:20	0:00:21	0:02:04	1	0	0:00:00	0:05:00	-	0:09:45
	7	Rework	0:00:09	0:00:00	0:02:15	1	1	0:00:50	-	0:05:00	0:08:14
	8	Final Check	0:00:11	0:00:00	0:01:36	0	0	0:00:00	-	-	0:01:47
		TOTAL	0:06:40	0:02:36	0:17:09			0:01:45	0:15:00	0:15:00	0:58:10
E-A-16	1	Assembly	0:09:09	0:15:57	0:00:00	1	0	0:00:00	0:05:00	-	0:30:06
	2	Rework	0:01:40	0:00:00	0:02:14	1	1	0:01:59	-	0:00:00	0:05:53
	3	Rework	0:00:28	0:00:00	0:01:01	1	1	0:00:32	-	0:00:00	0:02:01
	4	Assembly	0:00:56	0:00:46	0:01:22	1	0	0:00:00	0:05:00	0:00:00	0:08:04
	5	Rework	0:01:26	0:00:00	0:03:01	1	1	0:01:19	-	0:00:00	0:05:46
	6	Final Check	0:00:14	0:00:00	0:02:33	0	0	0:00:00	-	-	0:02:47
	7	Rework	0:00:07	0:00:00	0:02:50	1	1	0:00:06	-	0:00:00	0:03:03
	8	Assembly	0:01:22	0:02:35	0:02:49	1	0	0:00:00	0:05:00	-	0:11:46
	9	Rework	0:00:08	0:00:00	0:02:27	1	1	0:00:13	-	0:00:00	0:02:48
	10	Rework	0:00:16	0:00:00	0:02:31	1	1	0:00:07	-	0:00:00	0:02:54
	11	Final Check	0:00:00	0:00:00	0:01:49	0	0	0:00:00	-	-	0:01:49
		TOTAL	0:15:46	0:19:18	0:22:37			0:04:16	0:15:00	0:00:00	1:16:57
E-A-17	1	Assembly	0:01:37	0:02:33	0:00:06	1	0	0:00:00	0:05:00	-	0:09:16
	2	Rework	0:00:12	0:00:00	0:01:27	1	1	0:00:11	-	0:05:00	0:06:50
	3	Rework	0:00:03	0:00:00	0:00:47	1	1	0:00:07	-	0:00:00	0:00:57
	4	Assembly	0:02:37	0:00:45	0:01:38	1	0	0:00:00	0:05:00	0:00:00	0:10:00
	5	Assembly	0:00:23	0:01:18	0:01:53	1	0	0:00:00	0:05:00	-	0:08:34
	6	Final Check	0:00:04	0:00:00	0:01:10	0	0	0:00:00	-	-	0:01:14
		TOTAL	0:04:56	0:04:36	0:07:01			0:00:18	0:15:00	0:05:00	0:36:51
E-A-18	1	Assembly	0:11:19	0:10:08	0:00:22	1	0	0:00:00	0:05:00	-	0:26:49
	2	Both	0:02:24	0:09:14	0:01:35	2	1	0:03:13	0:05:00	-	0:21:26
	3	Rework	0:00:22	0:00:00	0:04:36	1	1	0:04:26	-	0:00:00	0:09:24
	4	Assembly	0:00:04	0:01:17	0:01:59	1	0	0:00:00	0:05:00	-	0:08:20
	5	Final Check	0:00:01	0:00:00	0:01:40	0	0	0:00:00	-	-	0:01:41
		TOTAL	0:14:10	0:20:39	0:10:12			0:07:39	0:15:00	0:00:00	1:07:40
E-A-19	1	Assembly	0:15:53	0:09:44	0:00:52	3	0	0:00:00	0:15:00	-	0:41:29
	2	Rework	0:02:20	0:00:00	0:01:19	2	2	0:03:22	-	0:00:00	0:07:01
	3	Rework	0:00:40	0:00:00	0:02:53	1	1	0:00:17	-	0:00:00	0:03:50
	4	Final Check	0:00:08	0:00:00	0:04:14	0	0	0:00:00	-	-	0:04:22
		TOTAL	0:19:01	0:09:44	0:09:18			0:03:39	0:15:00	0:00:00	0:56:42
E-A-20	1	Assembly	0:00:35	0:00:24	0:00:15	1	0	0:00:00	0:05:00	-	0:06:14

	Cycle	Type	Information Absorption	Assembling	Processing	Tack Welding	Cutting Weld	Rework Assembly	Assembly Time	Rework Time	TOTAL
	2	Rework	0:00:43	0:00:00	0:01:16	1	1	0:02:57	-	0:00:00	0:04:56
	3	Assembly	0:01:19	0:00:29	0:02:08	1	0	0:00:00	0:05:00	-	0:08:56
	4	Final Check	0:00:15	0:00:00	0:02:14	0	0	0:00:00	-	-	0:02:29
	5	Rework	0:00:19	0:00:00	0:01:32	1	1	0:00:14	-	0:00:00	0:02:05
	6	Rework	0:00:22	0:00:00	0:01:38	1	1	0:00:15	-	0:00:00	0:02:15
	7	Assembly	0:00:58	0:00:20	0:01:07	1	0	0:00:00	0:05:00	-	0:07:25
	8	Rework	0:00:02	0:00:00	0:01:03	1	1	0:00:03	-	0:00:00	0:01:08
	9	Rework	0:00:00	0:00:00	0:01:30	1	1	0:00:04	-	0:00:00	0:01:34
	10	Final Check	0:00:02	0:00:00	0:01:46	0	0	0:00:00	-	-	0:01:48
		TOTAL	0:04:35	0:01:13	0:14:29			0:03:33	0:15:00	0:00:00	0:38:50

SUMMARY – ENGINEERS WITH APP								
Cycle	Information Absorption	Assembling	Processing	Rework Assembly	Assembly Time	Rework Time	Total Time	Average
E-A-01	0:04:28	0:02:45	0:18:51	0:01:28	0:15:00	0:00:00	0:42:32	0.639
E-A-02	0:06:58	0:05:17	0:15:07	0:00:31	0:15:00	0:00:00	0:42:53	0.716
E-A-03	0:11:51	0:03:36	0:30:48	0:00:00	0:15:00	0:00:00	1:01:15	0.138
E-A-04	0:10:32	0:02:01	0:31:15	0:02:31	0:15:00	0:00:00	1:01:19	0.682
E-A-05	0:12:20	0:05:50	0:46:36	0:06:42	0:15:00	0:00:00	1:26:28	0.541
E-A-06	0:15:40	0:03:00	0:23:04	0:01:25	0:15:00	0:00:00	0:58:09	0.938
E-A-07	0:04:53	0:02:17	0:19:55	0:01:51	0:15:00	0:00:00	0:43:56	0.648
E-A-08	0:20:09	0:17:53	0:16:07	0:04:27	0:15:00	0:00:00	1:13:36	0.543
E-A-09	0:20:27	0:01:59	0:28:57	0:03:35	0:15:00	0:00:00	1:09:58	0.580
E-A-10	0:18:07	0:13:37	0:44:31	0:12:40	0:15:00	0:00:00	1:43:55	0.679
E-A-11	0:07:25	0:03:18	0:11:07	0:00:20	0:15:00	0:00:00	0:37:10	0.625
E-A-12	0:16:34	0:27:12	0:12:19	0:06:02	0:10:00	0:00:00	1:12:06	0.480
E-A-13	0:12:01	0:03:48	0:07:36	0:12:53	0:15:00	0:00:00	0:51:18	0.795
E-A-14	0:07:49	0:03:33	0:29:50	0:01:58	0:15:00	0:00:00	0:58:10	0.891
E-A-15	0:06:40	0:02:36	0:17:09	0:01:45	0:15:00	0:15:00	0:58:10	0.539
E-A-16	0:15:46	0:19:18	0:22:37	0:04:16	0:15:00	0:00:00	1:16:57	0.441
E-A-17	0:04:56	0:04:36	0:07:01	0:00:18	0:15:00	0:05:00	0:36:51	0.663
E-A-18	0:14:10	0:20:39	0:10:12	0:07:39	0:15:00	0:00:00	1:07:40	0.857
E-A-19	0:19:01	0:09:44	0:09:18	0:03:39	0:15:00	0:00:00	0:56:42	0.879
E-A-20	0:04:35	0:01:13	0:14:29	0:03:33	0:15:00	0:00:00	0:38:50	0.843

RAW DATA – ENGINEERS WITH PAPER											
	Cycle	Type	Information Absorption	Assembling	Processing	Tack Welding	Cutting Weld	Rework Assembly	Assembly Time	Rework Time	TOTAL
E-P-01	1	Assembly	0:12:17	0:18:07	0:00:00	3	0	0:00:00	0:15:00	-	0:45:24
	2	Rework	0:00:54	0:00:00	0:02:00	2	2	0:00:47	-	2:10:00	2:13:41
	3	Rework	0:00:08	0:00:00	0:02:16	1	1	0:00:27	-	1:05:00	1:07:51
	4	Rework	0:00:00	0:00:00	0:02:01	1	1	0:00:48	-	1:05:00	1:07:49
	5	Final Check	0:00:00	0:00:00	0:02:45	0	0	0:00:00	-	-	0:02:45
		TOTAL	0:13:19	0:18:07	0:09:02	7	4	0:02:02	0:15:00	4:20:00	5:17:30
E-P-02	1	Assembly	0:04:40	0:18:17	0:00:00	3	0	0:00:00	0:15:00	-	0:37:57
	2	Final Check	0:00:00	0:00:00	0:04:23	0	0	0:00:00	-	-	0:04:23
		TOTAL	0:04:40	0:18:17	0:04:23	3	0	0:00:00	0:15:00	0:00:00	0:42:20
E-P-03	1	Assembly	0:10:38	0:19:47	0:00:00	3	0	0:00:00	0:15:00	-	0:45:25
	2	Rework	0:01:04	0:00:00	0:02:14	3	3	0:08:31	-	3:15:00	3:26:49
	3	Rework	0:00:19	0:00:00	0:03:45	2	2	0:01:32	-	2:10:00	2:15:36
	4	Rework	0:00:34	0:00:00	0:02:13	0	0	0:02:28	-	0:00:00	0:05:15
	5	Rework	0:00:07	0:00:00	0:02:57	2	2	0:01:41	-	2:10:00	2:14:45
	6	Rework	0:00:25	0:00:00	0:01:39	1	1	0:01:57	-	1:05:00	1:09:01
	7	Rework	0:00:06	0:00:00	0:01:30	1	1	0:02:34	-	1:05:00	1:09:10
	8	Rework	0:00:12	0:00:00	0:00:45	1	1	0:01:59	-	1:05:00	1:07:56

	9	Rework	0:00:17	0:00:00	0:00:43	1	1	0:01:17	-	1:05:00	1:07:17
	10	Rework	0:00:18	0:00:00	0:01:48	1	1	0:02:58	-	1:05:00	1:10:04
	11	Rework	0:00:13	0:00:00	0:02:22	1	1	0:00:50	-	1:05:00	1:08:25
	12	Rework	0:00:11	0:00:00	0:01:21	1	1	0:00:36	-	1:05:00	1:07:08
	13	Final Check	0:00:17	0:00:00	0:01:10	0	0	0:00:00	-	-	0:01:27
	14	Rework	0:00:04	0:00:00	0:01:36	1	1	0:00:08	-	1:05:00	1:06:48
	15	Rework	0:00:10	0:00:00	0:01:25	1	1	0:00:14	-	1:05:00	1:06:49
	16	Rework	0:00:28	0:00:00	0:01:36	1	1	0:00:07	-	1:05:00	1:07:11
	17	Rework	0:00:34	0:00:00	0:04:11	1	1	0:00:39	-	1:05:00	1:10:24
	18	Final Check	0:00:00	0:00:00	0:01:48	0	0	0:00:00	-	-	0:01:48
		TOTAL	0:15:57	0:19:47	0:33:03	21	18	0:27:31	0:15:00	19:30:00	21:21:18
E-P-04	1	Assembly	0:07:38	0:05:08	0:00:00	3	0	0:00:00	0:15:00	-	0:27:46
	2	Rework	0:13:20	0:00:00	0:01:48	1	1	0:07:31	-	1:05:00	1:27:39
	3	Rework	0:04:10	0:00:00	0:01:56	3	3	0:06:23	-	3:15:00	3:27:29
	4	Rework	0:00:09	0:00:00	0:03:08	1	1	0:01:07	-	1:05:00	1:09:24
	5	Rework	0:00:10	0:00:00	0:01:54	1	1	0:00:41	-	1:05:00	1:07:45
	6	Rework	0:00:10	0:00:00	0:01:37	1	1	0:00:38	-	1:05:00	1:07:25
	7	Final Check	0:00:00	0:00:00	0:02:33	0	0	0:00:00	-	-	0:02:33
		TOTAL	0:25:37	0:05:08	0:12:56	10	7	0:00:38	0:15:00	7:35:00	8:50:01
E-P-05	1	Assembly	0:02:21	0:12:03	0:00:00	3	0	0:00:00	0:15:00	-	0:29:24
	2	Final Check	0:00:45	0:00:00	0:05:41	0	0	0:00:00	-	-	0:06:26
	3	Rework	0:02:41	0:00:00	0:02:43	4	4	0:09:52	-	4:20:00	4:35:16
	4	Rework	0:01:53	0:00:00	0:00:59	3	3	0:06:11	-	3:15:00	3:24:03
	5	Rework	0:01:35	0:00:00	0:04:20	3	3	0:09:56	-	3:15:00	3:30:51
	6	Final Check	0:00:18	0:00:00	0:02:14	0	0	0:00:00	-	-	0:02:32
	7	Rework	0:01:29	0:00:00	0:02:27	1	1	0:01:57	-	1:05:00	1:10:53
	8	Rework	0:00:55	0:00:00	0:02:20	1	1	0:01:55	-	1:05:00	1:10:10
	9	Rework	0:00:55	0:00:00	0:01:58	1	1	0:00:29	-	1:05:00	1:08:22
		TOTAL	0:12:52	0:12:03	0:22:42	16	13	0:30:20	0:15:00	14:05:00	15:37:57
E-P-06	1	Assembly	0:03:40	0:30:40	0:00:00	3	0	0:00:00	0:15:00	-	0:49:20
	2	Final Check	0:00:00	0:00:00	0:02:44	0	0	0:00:00	-	-	0:02:44
		TOTAL	0:03:40	0:30:40	0:02:44	3	0	0:00:00	0:15:00	0:00:00	0:52:04
E-P-07	1	Assembly	0:18:21	0:20:38	0:00:00	3	0	0:00:00	0:15:00	-	0:53:59
	2	Rework	0:00:18	0:00:00	0:02:27	2	2	0:00:52	-	2:10:00	2:13:37
	3	Rework	0:00:38	0:00:00	0:01:45	2	2	0:00:37	-	2:10:00	2:13:00
	4	Rework	0:00:11	0:00:00	0:02:08	1	1	0:00:19	-	1:05:00	1:07:38
	5	Rework	0:00:32	0:00:00	0:02:30	1	1	0:00:48	-	1:05:00	1:08:50
	6	Final Check	0:00:00	0:00:00	0:01:36	0	0	0:00:00	-	-	0:01:36
		TOTAL	0:20:00	0:20:38	0:10:26	9	6	0:02:36	0:15:00	6:30:00	7:38:40
E-P-08	1	Assembly	0:07:20	0:10:11	0:00:00	3	0	0:00:00	0:15:00	-	0:32:31
	2	Rework	0:03:00	0:00:00	0:01:43	2	2	0:06:48	-	2:10:00	2:21:31
	3	Rework	0:00:36	0:00:00	0:02:05	2	2	0:00:26	-	2:10:00	2:13:07
	4	Rework	0:00:08	0:00:00	0:05:45	1	1	0:00:11	-	1:05:00	1:11:04
	5	Rework	0:00:16	0:00:00	0:02:00	1	1	0:00:24	-	1:05:00	1:07:40
	6	Final Check	0:00:02	0:00:00	0:01:03	0	0	0:00:00	-	-	0:01:05
		TOTAL	0:11:22	0:10:11	0:12:36	9	6	0:07:49	0:30:00	13:00:00	15:05:38
E-P-09	1	Assembly	0:03:34	0:05:07	0:00:00	3	0	0:00:00	0:15:00	-	0:23:41
	2	Rework	0:00:17	0:00:00	0:02:01	4	4	0:02:32	-	4:20:00	4:24:50
	3	Rework	0:00:55	0:00:00	0:01:25	1	1	0:00:06	-	1:05:00	1:07:26
	4	Rework	0:01:31	0:00:00	0:02:39	2	2	0:00:59	-	2:10:00	2:15:09
	5	Rework	0:04:12	0:00:00	0:01:38	5	5	0:03:46	-	5:25:00	5:34:36
	6	Rework	0:01:44	0:00:00	0:01:35	2	2	0:01:37	-	2:10:00	2:14:56
	7	Rework	0:00:13	0:00:00	0:01:54	4	4	0:00:50	-	4:20:00	4:22:57
	8	Rework	0:00:12	0:00:00	0:01:13	1	1	0:00:41	-	1:05:00	1:07:06
	9	Final Check	0:00:00	0:00:00	0:01:05	0	0	0:00:00	-	-	0:01:05
		TOTAL	0:12:38	0:05:07	0:13:30	22	19	0:10:31	0:15:00	20:35:00	21:31:46
E-P-10	1	Assembly	0:09:06	0:19:03	0:00:00	3	0	0:00:00	0:15:00	-	0:43:09
	2	Rework	0:00:23	0:00:00	0:03:20	2	2	0:00:49	-	2:10:00	2:14:32
	3	Rework	0:00:39	0:00:00	0:01:40	1	1	0:00:44	-	1:05:00	1:08:03
	4	Rework	0:00:30	0:00:00	0:01:20	2	2	0:00:36	-	2:10:00	2:12:26
	5	Rework	0:00:07	0:00:00	0:01:35	1	1	0:00:05	-	1:05:00	1:06:47
	6	Rework	0:00:03	0:00:00	0:01:02	1	1	0:00:09	-	1:05:00	1:06:14
	7	Rework	0:00:03	0:00:00	0:01:00	1	1	0:00:12	-	1:05:00	1:06:15
	8	Final Check	0:00:00	0:00:00	0:01:13	0	0	0:00:00	-	-	0:01:13
		TOTAL	0:10:51	0:19:03	0:11:10	11	8	0:02:35	0:15:00	8:40:00	9:38:39
E-P-11	1	Assembly	0:09:46	0:13:59	0:00:00	3	0	0:00:00	0:15:00	-	0:38:45
	2	Rework	0:00:23	0:00:00	0:02:41	2	2	0:00:09	-	2:10:00	2:13:13

	Step	Activity	Information Absorption	Assembling	Processing			Rework Assembly	Assembly Time	Rework Time	TOTAL
	3	Rework	0:01:17	0:00:00	0:01:40	2	2	0:00:22	-	2:10:00	2:13:19
	4	Rework	0:00:16	0:00:00	0:01:43	2	2	0:00:06	-	2:10:00	2:12:05
	5	Final Check	0:00:00	0:00:00	0:01:47	0	0	0:00:00	-	-	0:01:47
		TOTAL	0:11:42	0:13:59	0:07:51	9	6	0:00:37	0:15:00	6:30:00	7:19:09
E-P-12	1	Assembly	0:17:15	0:38:35	0:00:00	3	0	0:00:00	0:15:00	-	1:10:50
	2	Rework	0:00:16	0:00:00	0:02:40	1	1	0:03:12	-	1:05:00	1:11:08
	3	Rework	0:00:37	0:00:00	0:01:03	2	2	0:01:33	-	2:10:00	2:13:13
	4	Final Check	0:00:00	0:00:00	0:01:20	0	0	0:00:00	-	-	0:01:20
		TOTAL	0:18:08	0:38:35	0:00:00	6	3	0:04:45	15:00	15:00	36:31
E-P-13	1	Assembly	0:27:44	0:05:30	0:00:00	3	0	0:00:00	0:15:00	-	0:48:14
	2	Rework	0:05:20	0:00:00	0:06:56	4	4	0:10:39	-	4:20:00	4:42:55
	3	Rework	0:00:59	0:00:00	0:02:42	2	2	0:05:25	-	2:10:00	2:19:06
	4	Rework	0:00:22	0:00:00	0:02:55	1	1	0:00:02	-	1:05:00	1:08:19
	5	Rework	0:00:00	0:00:00	0:00:09	4	4	0:08:43	-	4:20:00	4:28:52
	6	Rework	0:00:09	0:00:00	0:01:38	1	1	0:00:01	-	1:05:00	1:06:48
	7	Rework	0:00:31	0:00:00	0:00:22	1	1	0:00:04	-	1:05:00	1:05:57
	8	Rework	0:00:00	0:00:00	0:00:28	1	1	0:00:11	-	1:05:00	1:05:39
	9	Rework	0:00:21	0:00:00	0:01:07	2	2	0:00:10	-	2:10:00	2:11:38
	10	Final Check	0:00:00	0:00:00	0:00:59	0	0	0:00:00	-	-	0:00:59
		TOTAL	0:35:26	0:05:30	0:17:16	19	16	0:25:15	0:15:00	17:20:00	18:58:27
E-P-14	1	Assembly	0:04:26	0:07:58	0:00:00	3	0	0:00:00	0:15:00	-	0:27:24
	2	Rework	0:04:25	0:00:00	0:02:42	3	3	0:10:48	-	3:15:00	3:32:55
	3	Rework	0:01:55	0:00:00	0:01:08	2	2	0:00:30	-	2:10:00	2:13:33
	4	Rework	0:00:36	0:00:00	0:01:27	2	2	0:00:30	-	2:10:00	2:12:33
	5	Rework	0:00:02	0:00:00	0:01:35	1	1	0:00:06	-	1:05:00	1:06:43
	6	Rework	0:00:03	0:00:00	0:00:11	1	1	0:00:03	-	1:05:00	1:05:17
	7	Final Check	0:00:00	0:00:00	0:00:52	0	0	0:00:00	-	-	0:00:52
		TOTAL	0:11:27	0:07:58	0:07:55	12	9	0:11:57	0:15:00	9:45:00	10:39:17
E-P-15	1	Assembly	0:14:20	0:11:30	0:00:00	3	0	0:00:00	0:15:00	-	0:40:50
	2	Rework	0:00:39	0:00:00	0:03:22	2	2	0:00:48	-	2:10:00	2:14:49
	3	Rework	0:00:31	0:00:00	0:01:12	2	2	0:00:31	-	2:10:00	2:12:14
	4	Rework	0:00:13	0:00:00	0:01:43	2	2	0:00:09	-	2:10:00	2:12:05
	5	Rework	0:00:08	0:00:00	0:01:08	2	2	0:00:10	-	2:10:00	2:11:26
	6	Final Check	0:00:00	0:00:00	0:01:27	0	0	0:00:00	-	-	0:01:27
		TOTAL	0:15:51	0:11:30	0:08:52	11	8	0:01:38	0:15:00	8:40:00	9:32:51
E-P-16	1	Assembly	0:08:03	0:07:41	0:00:00	3	0	0:00:00	0:15:00	-	0:30:44
	2	Rework	0:00:19	0:00:00	0:01:52	2	2	0:00:38	-	2:10:00	2:12:49
	3	Rework	0:00:15	0:00:00	0:01:50	1	1	0:00:04	-	1:05:00	1:07:09
	4	Final Check	0:00:00	0:00:00	0:01:01	0	0	0:00:00	-	-	0:01:01
		TOTAL	0:08:37	0:07:41	0:04:43	6	3	0:00:42	0:15:00	3:15:00	3:51:43
E-P-17	1	Assembly	0:10:27	0:27:08	0:00:00	3	0	0:00:00	0:15:00	-	0:52:35
	2	Rework	0:00:56	0:00:00	0:02:17	3	3	0:02:09	-	3:15:00	3:20:22
	3	Rework	0:00:17	0:00:00	0:02:00	1	1	0:03:07	-	1:05:00	1:10:24
	4	Rework	0:00:05	0:00:00	0:01:00	1	1	0:00:05	-	1:05:00	1:06:10
	5	Rework	0:00:10	0:00:00	0:00:13	2	2	0:00:10	-	2:10:00	2:10:33
	6	Final Check	0:00:00	0:00:00	0:01:00	0	0	0:00:00	-	-	0:01:00
		TOTAL	0:11:55	0:27:08	0:06:30	10	7	0:05:31	0:15:00	7:35:00	8:41:04
E-P-18	1	Assembly	0:18:11	0:21:35	0:00:00	3	0	0:00:00	0:15:00	-	0:54:46
	2	Final Check	0:00:00	0:00:00	0:02:05	0	0	0:00:00	-	-	0:02:05
		TOTAL	0:18:11	0:21:35	0:02:05	3	0	0:00:00	0:15:00	0:00:00	0:56:51
E-P-19	1	Assembly	0:09:44	0:25:50	0:00:00	3	0	0:00:00	0:15:00	-	0:50:34
	2	Rework	0:01:15	0:00:00	0:02:28	1	1	0:00:13	-	1:05:00	1:08:56
	3	Final Check	0:00:00	0:00:00	0:01:31	0	0	0:00:00	-	-	0:01:31
		TOTAL	0:10:59	0:25:50	0:03:59	4	1	0:00:13	0:15:00	1:05:00	2:01:01
E-P-20	1	Assembly	0:07:24	0:16:14	0:00:00	3	0	0:00:00	0:15:00	-	0:38:38
	2	Rework	0:00:24	0:00:00	0:03:07	2	2	0:00:43	-	2:10:00	2:14:14
	3	Rework	0:00:07	0:00:00	0:01:03	1	1	0:00:27	-	1:05:00	1:06:37
	4	Final Check	0:00:00	0:00:00	0:02:05	0	0	0:00:00	-	-	0:02:05
		Total	0:07:55	0:16:14	0:06:15	6	3	0:01:10	0:15:00	3:15:00	4:01:34

SUMMARY – ENGINEERS WITH PAPER								
Cycle	Information Absorption	Assembling	Processing	Rework Assembly	Assembly Time	Rework Time	TOTAL	Average
E-P-01	0:13:19	0:18:07	0:09:02	0:02:02	0:15:00	4:20:00	5:17:30	0.736
E-P-02	0:04:40	0:18:17	0:04:23	0:00:00	0:15:00	0:00:00	0:42:20	0.650
E-P-03	0:15:57	0:19:47	0:33:03	0:27:31	0:15:00	19:30:00	21:21:18	0.539

E-P-04	0:25:37	0:05:08	0:12:56	0:00:38	0:15:00	7:35:00	8:50:01	0.786
E-P-05	0:12:52	0:12:03	0:22:42	0:30:20	0:15:00	14:05:00	15:37:57	0.768
E-P-06	0:03:40	0:30:40	0:02:44	0:00:00	0:15:00	0:00:00	0:52:04	0.843
E-P-07	0:20:00	0:20:38	0:10:26	0:02:36	0:15:00	6:30:00	7:38:40	0.857
E-P-08	0:11:22	0:10:11	0:12:36	0:07:49	0:30:00	13:00:00	15:05:38	1.000
E-P-09	0:12:38	0:05:07	0:13:30	0:10:31	0:15:00	20:35:00	21:31:46	0.245
E-P-10	0:10:51	0:19:03	0:11:10	0:02:35	0:15:00	8:40:00	9:38:39	0.639
E-P-11	0:11:42	0:13:59	0:07:51	0:00:37	0:15:00	6:30:00	7:19:09	0.607
E-P-12	0:18:08	0:38:35	0:05:03	0:04:45	0:15:00	3:15:00	4:36:31	0.595
E-P-13	0:35:26	0:05:30	0:17:16	0:25:15	0:15:00	17:20:00	18:58:27	0.282
E-P-14	0:11:27	0:07:58	0:07:55	0:11:57	0:15:00	9:45:00	10:39:17	0.863
E-P-15	0:15:51	0:11:30	0:08:52	0:01:38	0:15:00	8:40:00	9:32:51	0.441
E-P-16	0:08:37	0:07:41	0:04:43	0:00:42	0:15:00	3:15:00	3:51:43	0.493
E-P-17	0:11:55	0:27:08	0:06:30	0:05:31	0:15:00	7:35:00	8:41:04	0.900
E-P-18	0:18:11	0:21:35	0:02:05	0:00:00	0:15:00	0:00:00	0:56:51	0.832
E-P-19	0:10:59	0:25:50	0:03:59	0:00:13	0:15:00	1:05:00	2:01:01	0.854
E-P-20	0:07:55	0:16:14	0:06:15	0:01:10	0:15:00	3:15:00	4:01:34	1.000

RAW DATA – FITTERS WITH APP										
	Cycle	Type	Information Absorption	Assembling	Processing	Tack Welding	Cutting Weld	Rework Assembly	Assembly Time	Rework Time	TOTAL
F-A-01	1	Assembly	0:01:32	0:00:26	0:00:19	1	0	0:00:00	0:05:00	-	0:07:17
	2	Rework	0:00:02	0:00:00	0:01:23	1	1	0:00:07	-	-	0:01:32
	3	Assembly	0:00:23	0:04:46	0:01:32	2	0	0:00:00	0:10:00	-	0:12:41
	4	Rework	0:00:35	0:01:22	0:01:23	2	2	0:00:32	-	-	0:03:52
	5	Final Check	0:00:02	0:00:00	0:01:51	0	0	0:00:00	-	-	0:01:53
		TOTAL	0:02:34	0:02:34	0:06:28	6	3	0:00:39	0:15:00	-	0:27:15
F-A-02	1	Assembly	0:03:46	0:03:59	0:00:13	1	0	0:00:00	0:05:00	-	0:12:58
	2	Assembly	0:04:36	0:03:49	0:01:46	1	0	0:00:00	0:05:00	-	0:15:11
	3	Rework	0:00:02	0:00:00	0:01:28	1	1	0:00:07	-	-	0:01:37
	4	Assembly	0:00:29	0:01:14	0:03:37	1	0	0:00:00	0:05:00	-	0:10:20
	5	Final Check	0:00:01	0:00:00	0:02:33	0	0	0:00:00	-	-	0:02:34
		TOTAL	0:08:54	0:09:02	0:09:37	4	1	0:00:07	0:15:00	-	0:42:40
F-A-03	1	Assembly	0:01:15	0:02:42	0:00:25	1	0	0:00:00	0:05:00	-	0:09:22
	2	Both	0:03:21	0:03:49	0:01:32	2	1	0:00:14	0:05:00	-	0:13:56
	3	Rework	0:00:42	0:00:00	0:02:08	1	1	0:01:14	-	-	0:04:04
	4	Assembly	0:00:57	0:01:13	0:02:06	1	0	0:00:00	0:05:00	-	0:09:16
	5	Rework	0:00:05	0:00:00	0:02:15	1	1	0:00:45	-	-	0:03:05
	6	Final Check	0:00:00	0:00:00	0:01:35	0	0	0:00:00	-	-	0:01:35
		TOTAL	0:06:20	0:07:44	0:10:01	6	3	0:02:13	0:15:00	-	0:41:18
F-A-04	1	Assembly	0:12:38	0:03:40	0:00:26	2	0	0:00:00	0:10:00	-	0:26:44
	2	Final Check	0:00:16	0:00:00	0:01:57	0	0	0:00:00	-	-	0:02:13
	3	Assembly	0:02:53	0:00:09	0:01:09	1	0	0:00:00	0:05:00	-	0:09:11
	4	Rework	0:00:11	0:00:00	0:01:38	1	1	0:00:24	-	-	0:02:13
	5	Final Check	0:00:02	0:00:00	0:01:34	0	0	0:00:00	-	-	0:01:36
		TOTAL	0:16:00	0:03:49	0:06:44	4	1	0:00:24	0:15:00	-	0:41:57
F-A-05	1	Assembly	0:04:44	0:09:51	0:00:00	3	0	0:00:00	0:15:00	-	0:29:35
	2	Rework	0:00:31	0:00:00	0:02:58	2	2	0:02:24	-	-	0:05:53
	3	Rework	0:01:19	0:00:00	0:02:04	2	2	0:02:49	-	-	0:06:12
	4	Rework	0:01:08	0:00:00	0:01:05	1	1	0:00:06	-	-	0:02:19
		TOTAL	0:07:42	0:09:51	0:06:07	8	5	0:05:19	0:15:00	-	0:43:59
F-A-06	1	Assembly	0:01:45	0:02:10	0:00:24	1	0	0:00:00	0:05:00	-	0:09:19
	2	Rework	0:00:24	0:00:00	0:00:55	1	1	0:00:31	-	-	0:01:50
	3	Assembly	0:02:34	0:03:03	0:01:33	2	0	0:00:00	0:10:00	-	0:17:10
	4	Rework	0:00:11	0:00:00	0:01:25	1	1	0:00:24	-	-	0:02:00
	5	Rework	0:00:10	0:00:00	0:03:16	1	1	0:00:09	-	-	0:03:35
	6	Final Check	0:00:00	0:00:00	0:01:30	0	0	0:00:00	-	-	0:01:30
		TOTAL	0:05:04	0:05:13	0:09:03	6	3	0:01:04	0:15:00	-	0:35:24
F-A-07	1	Assembly	0:05:19	0:05:28	0:00:22	2	0	0:00:00	0:10:00	-	0:21:09
	2	Assembly	0:04:02	0:03:45	0:01:32	1	0	0:00:00	0:05:00	-	0:14:19
	3	Rework	0:00:15	0:00:00	0:05:57	1	1	0:01:16	-	-	0:07:28
	4	Rework	0:00:04	0:00:00	0:01:10	2	2	0:00:21	-	-	0:01:35
	5	Final Check	0:00:01	0:00:00	0:00:48	0	0	0:00:00	-	-	0:00:49
		TOTAL	0:09:41	0:09:13	0:09:49	6	3	0:01:37	0:15:00	-	0:45:20
F-A-08	1	Assembly	0:00:17	0:00:24	0:00:00	1	0	0:00:00	0:05:00	-	0:05:41
	2	Assembly	0:00:27	0:00:10	0:01:10	1	0	0:00:00	0:05:00	-	0:06:47
	3	Rework	0:00:05	0:00:00	0:01:34	1	1	0:00:04	-	-	0:01:43
	4	Rework	0:00:16	0:00:00	0:02:21	2	2	0:01:00	-	-	0:03:37

ID	#	Operation									
	5	Assembly	0:00:41	0:00:10	0:01:54	1	0	0:00:00	0:05:00	-	0:07:45
	6	Rework	0:00:02	0:00:00	0:01:53	1	1	0:00:33	-	-	0:02:28
	7	Final Check	0:00:02	0:00:00	0:01:43	0	0	0:00:00	-	-	0:01:45
		TOTAL	0:01:50	0:00:44	0:10:35	7	4	0:01:37	0:15:00	-	0:29:46
F-A-09	1	Assembly	0:00:46	0:01:32	0:00:00	3	0	0:00:00	0:15:00	-	0:17:18
	2	Rework	0:00:19	0:00:00	0:02:19	1	1	0:00:19	-	-	0:02:57
	3	Rework	0:00:36	0:00:00	0:03:17	1	1	0:00:16	-	-	0:04:09
	4	Final Check	0:00:00	0:00:00	0:03:13	0	0	0:00:00	-	-	0:03:13
		TOTAL	0:01:41	0:01:32	0:08:49	5	2	0:00:35	0:15:00	-	0:27:37
F-A-10	1	Assembly	0:06:45	0:01:14	0:00:10	2	0	0:00:00	0:10:00	-	0:18:09
	2	Rework	0:00:59	0:00:00	0:01:24	1	1	0:00:58	-	-	0:03:21
	3	Final Check	0:01:06	0:00:00	0:02:08	0	0	0:00:00	-	-	0:03:14
	4	Assembly	0:02:03	0:03:01	0:00:22	1	0	0:00:00	0:05:00	-	0:10:26
		TOTAL	0:10:53	0:04:15	0:04:04	4	1	0:00:58	0:15:00	-	0:35:10
F-A-11	1	Assembly	0:02:12	0:02:09	0:00:10	1	0	0:00:00	0:05:00	-	0:09:31
	2	Rework	0:00:40	0:00:00	0:02:15	1	1	0:00:35	-	-	0:03:30
	3	Assembly	0:02:55	0:03:05	0:01:58	1	0	0:00:00	0:05:00	-	0:12:58
	4	Assembly	0:01:54	0:02:30	0:00:55	1	0	0:00:00	0:05:00	-	0:10:19
	5	Final Check	0:00:10	0:00:00	0:02:50	0	0	0:00:00	-	-	0:03:00
		TOTAL	0:07:51	0:07:44	0:08:08	4	1	0:00:35	0:15:00	-	0:39:18
F-A-12	1	Assembly	0:02:10	0:05:57	0:00:06	2	0	0:00:00	0:10:00	-	0:18:13
	2	Assembly	0:01:45	0:03:36	0:01:33	1	0	0:00:00	0:05:00	-	0:11:54
	3	Final Check	0:00:02	0:00:00	0:02:31	0	0	0:00:00	-	-	0:02:33
		TOTAL	0:03:57	0:09:33	0:04:10	3	0	0:00:00	0:15:00	-	0:32:40
F-A-13	1	Assembly	0:00:14	0:00:09	0:00:35	1	0	0:00:00	0:05:00	-	0:05:58
	2	Assembly	0:00:46	0:00:11	0:01:37	1	0	0:00:00	0:05:00	-	0:07:34
	3	Assembly	0:00:26	0:00:46	0:02:02	1	0	0:00:00	0:05:00	-	0:08:14
	4	Rework	0:00:08	0:00:00	0:02:41	1	1	0:00:10	-	-	0:02:59
	5	Final Check	0:00:02	0:00:00	0:01:39	0	0	0:00:00	-	-	0:01:41
		TOTAL	0:01:36	0:01:06	0:08:34	4	1	0:00:10	0:15:00	-	0:26:26
F-A-14	1	Assembly	0:06:49	0:04:18	0:00:26	3	0	0:00:00	0:15:00	-	0:26:33
	2	Rework	0:00:06	0:00:00	0:01:25	1	1	0:00:04	-	-	0:01:35
	3	Final Check	0:00:22	0:00:00	0:01:07	0	0	0:00:00	-	-	0:01:29
	4	Rework	0:00:19	0:00:00	0:01:16	1	1	0:00:01	-	-	0:01:36
	5	Rework	0:00:16	0:00:00	0:01:25	1	1	0:00:23	-	-	0:02:04
	6	Rework	0:00:46	0:00:00	0:02:16	1	1	0:00:20	-	-	0:03:22
	7	Final Check	0:00:05	0:00:00	0:01:15	0	0	0:00:00	-	-	0:01:20
		TOTAL	0:08:43	0:04:18	0:09:10	7	4	0:00:48	0:15:00	-	0:37:59
F-A-15	1	Assembly	0:00:00	0:00:06	0:00:10	1	0	0:00:00	0:05:00	-	0:05:16
	2	Both	0:02:16	0:00:40	0:01:42	3	1	0:01:01	0:10:00	-	0:15:39
	3	Final Check	0:00:04	0:00:00	0:02:14	0	0	0:00:00	-	-	0:02:18
		TOTAL	0:02:20	0:00:46	0:04:06	4	1	0:01:01	0:15:00	-	0:23:13
F-A-16	1	Assembly	0:00:50	0:00:18	0:00:22	2	0	0:00:00	0:10:00	-	0:11:30
	2	Rework	0:00:09	0:00:00	0:01:31	2	2	0:00:21	-	-	0:02:01
	3	Assembly	0:00:30	0:00:33	0:01:17	1	0	0:00:00	0:05:00	-	0:07:20
	4	Rework	0:00:09	0:00:00	0:01:07	1	1	0:00:11	-	-	0:01:27
	5	Final Check	0:00:02	0:00:00	0:00:49	0	0	0:00:00	-	-	0:00:51
		TOTAL	0:01:40	0:00:51	0:05:06	6	3	0:00:32	0:15:00	-	0:23:09
F-A-17	1	Assembly	0:01:37	0:01:08	0:00:00	3	0	0:00:00	0:15:00	-	0:17:45
	2	Final Check	0:00:01	0:00:00	0:01:36	0	0	0:00:00	-	-	0:01:37
		TOTAL	0:01:38	0:01:08	0:01:36	3	0	0:00:00	0:15:00	-	0:19:22
F-A-18	1	Assembly	0:00:58	0:00:31	0:00:00	3	0	0:00:00	0:15:00	-	0:16:29
	2	Rework	0:00:26	0:00:00	0:01:13	2	2	0:00:11	-	-	0:01:50
	3	Rework	0:01:10	0:01:03	0:01:16	2	2	0:01:25	-	-	0:04:54
	4	Final Check	0:00:06	0:00:00	0:01:09	0	0	0:00:00	-	-	0:01:15
		TOTAL	0:02:40	0:01:34	0:03:38	7	4	0:01:36	0:15:00	-	0:24:28

SUMMARY – FITTERS WITH APP							
Cycle	Information Absorption	Assembling	Processing	Rework Assembly	Assembly Time	Rework Time	TOTAL	Average
F-A-01	0:02:34	0:02:34	0:06:28	0:00:39	0:15:00	-	0:27:15	0.579
F-A-02	0:08:54	0:09:02	0:09:37	0:00:07	0:15:00	-	0:42:40	0.400
F-A-03	0:06:20	0:07:44	0:10:01	0:02:13	0:15:00	-	0:41:18	0.604
F-A-04	0:16:00	0:03:49	0:06:44	0:00:24	0:15:00	-	0:41:57	0.525
F-A-05	0:07:42	0:09:51	0:06:07	0:05:19	0:15:00	-	0:43:59	0.652
F-A-06	0:05:04	0:05:13	0:09:03	0:01:04	0:15:00	-	0:35:24	0.770
F-A-07	0:09:41	0:09:13	0:09:49	0:01:37	0:15:00	-	0:45:20	0.546

F-A-08	0:01:50	0:00:44	0:10:35	0:01:37	0:15:00	-	0:29:46	0.854
F-A-09	0:01:41	0:01:32	0:08:49	0:00:35	0:15:00	-	0:27:37	0.900
F-A-10	0:10:53	0:04:15	0:04:04	0:00:58	0:15:00	-	0:35:10	0.543
F-A-11	0:07:51	0:07:44	0:08:08	0:00:35	0:15:00	-	0:39:18	0.471
F-A-12	0:03:57	0:09:33	0:04:10	0:00:00	0:15:00	-	0:32:40	0.539
F-A-13	0:01:36	0:01:06	0:08:34	0:00:10	0:15:00	-	0:26:26	0.904
F-A-14	0:08:43	0:04:18	0:09:10	0:00:48	0:15:00	-	0:37:59	0.379
F-A-15	0:02:20	0:00:46	0:04:06	0:01:01	0:15:00	-	0:23:13	0.614
F-A-16	0:01:40	0:00:51	0:05:06	0:00:32	0:15:00	-	0:23:09	0.807
F-A-17	0:01:38	0:01:08	0:01:36	0:00:00	0:15:00	-	0:19:22	1.000
F-A-18	0:02:40	0:01:34	0:03:38	0:01:36	0:15:00	-	0:24:28	0.463

			RAW DATA – FITTERS WITH PAPER							
	Cycle	Type	Information Absorption	Assembling	Processing	Tack Welding	Cutting Weld	Rework Assembly	Assembly Time	Rework Time	TOTAL
F-P-01	1	Assembly	0:09:18	0:05:13	0:00:00	3	0	0:00:00	0:15:00	-	0:29:31
	2	Rework	0:05:36	0:00:00	0:00:00	3	3	0:01:09	-	3:15:00	3:21:45
		TOTAL	0:14:54	0:05:13	0:00:00	6	3	0:01:09	0:15:00	3:15:00	3:51:16
F-P-02	1	Assembly	0:05:53	0:17:01	00:00	3	0	0:00:00	0:15:00	-	0:37:54
	2	Final Check	0:00:00	0:00:00	03:31	0	0	0:00:00	-	-	0:03:31
		TOTAL	0:05:53	0:17:01	0:03:31	3	0	0:00:00	0:15:00	0:00:00	0:41:25
F-P-03	1	Assembly	0:02:25	0:03:50	0:00:00	1	0	0:00:00	0:05:00	-	11:15
	2	Both	0:02:38	0:00:13	0:01:57	3	1	0:01:24	0:10:00	1:05:00	1:21:12
	3	Rework	0:09:38	0:00:00	0:04:11	3	3	0:02:59	-	3:15:00	3:31:48
		TOTAL	0:14:41	0:04:03	0:06:08	7	4	0:04:23	0:15:00	4:20:00	5:04:15

			SUMMARY – FITTERS WITH PAPER							
Cycle	Information Absorption	Assembling	Processing	Tack Welding	Cutting Weld	Rework Assembly	Assembly Time	Rework Time	TOTAL	Spatial
F-P-01	0:14:54	0:05:13	0:00:00	0:00:00	0:00:00	0:01:09	0:15:00	3:15:00	3:51:16	0.586
F-P-02	0:05:53	0:17:01	0:03:31	0:00:00	0:00:00	0:00:00	0:15:00	0:00:00	0:41:25	0.802
F-P-03	0:14:41	0:04:03	0:06:08	0:00:00	0:00:00	0:04:23	0:15:00	4:20:00	5:04:15	0.704

Appendix I

Rework Analysis Data

	Cycle	Information Absorption	Assembling	Processing	Cutting Weld	Rework Assembly	Rework Time	TOTAL
RAW DATA – ENGINEERS WITH APP
E-A-01	3	0:01:42	0:00:34	0:03:17	1	0:00:19	1:05:00	1:15:52
	4	0:00:33	0:00:00	0:03:36	1	0:00:17	1:05:00	1:09:26
	5	0:00:14	0:00:00	0:02:30	1	0:00:45	1:05:00	1:08:29
	7	0:00:10	0:00:00	0:02:11	1	0:00:07	1:05:00	1:07:28
	Total	0:02:39	0:00:34	0:11:34	4	0:01:28	4:20:00	4:41:15
E-A-02	2	0:00:11	0:00:00	0:05:32	1	0:00:31	1:05:00	1:11:14
	Total	0:00:11	0:00:00	0:05:32	1	0:00:31	1:05:00	1:11:14
E-A-03	2	0:00:18	0:00:00	0:02:47	1	0:00:00	1:05:00	1:08:05
	4	0:01:19	0:00:41	0:02:50	0	0:00:00	-	0:04:50
	5	0:01:43	0:00:00	0:02:35	0	0:00:00	0:00:00	0:04:18
	6	0:01:06	0:00:00	0:03:11	1	0:00:00	1:05:00	1:09:17
	8	0:01:40	0:00:00	0:01:55	1	0:00:00	1:05:00	1:08:35
	9	0:00:26	0:00:00	0:01:32	1	0:00:00	1:05:00	1:06:58
	10	0:01:02	0:00:00	0:03:01	1	0:00:00	1:05:00	1:09:03
	11	0:00:05	0:00:00	0:00:00	1	0:00:00	1:05:00	1:05:05
	12	0:01:56	0:00:23	0:01:15	0	0:00:00	-	0:03:33
	13	0:00:14	0:00:00	0:01:28	2	0:00:00	2:10:00	2:11:42
	Total	0:09:49	0:01:04	0:20:34	8	0:00:00	8:40:00	9:11:27
E-A-04	3	0:00:24	0:00:00	0:03:32	1	0:00:21	1:05:00	1:09:17
	4	0:00:44	0:00:00	0:02:19	2	0:00:53	2:10:00	2:13:56
	5	0:01:18	0:00:00	0:03:15	1	0:00:19	1:05:00	1:09:52
	6	0:00:05	0:00:00	0:02:45	1	0:00:08	1:05:00	1:07:58
	7	0:00:48	0:00:00	0:01:30	1	0:00:08	1:05:00	1:07:26
	8	0:00:21	0:00:00	0:02:10	1	0:00:07	1:05:00	1:07:38
	9	0:01:30	0:00:00	0:01:57	1	0:00:15	1:05:00	1:08:42
	10	0:00:36	0:00:00	0:01:35	1	0:00:08	1:05:00	1:07:19
	12	0:00:13	0:00:00	0:02:05	1	0:00:06	1:05:00	1:07:24
	13	0:00:36	0:00:00	0:03:45	1	0:00:06	1:05:00	1:09:27
	Total	0:06:35	0:00:00	0:24:53	11	0:02:31	11:55:00	12:28:59
E-A-05	2	0:01:05	0:00:00	0:02:39	1	0:00:33	1:05:00	1:09:17
	3	0:01:00	0:00:00	0:03:10	2	0:00:46	2:10:00	2:14:56
	4	0:00:45	0:00:00	0:02:22	2	0:00:48	2:10:00	2:13:55
	5	0:00:04	0:00:00	0:03:46	1	0:00:22	1:05:00	1:09:12
	6	0:00:07	0:00:00	0:01:38	1	0:00:26	1:05:00	1:07:11
	7	0:00:41	0:00:00	0:02:32	2	0:00:12	2:10:00	2:13:25
	8	0:00:25	0:00:00	0:04:07	2	0:00:23	2:10:00	2:14:55
	9	0:00:15	0:00:00	0:01:53	2	0:00:11	2:10:00	2:12:19
	10	0:00:49	0:00:00	0:02:14	1	0:00:23	1:05:00	1:08:26
	11	0:00:18	0:00:00	0:01:41	2	0:00:12	2:10:00	2:12:11
	12	0:00:19	0:00:00	0:01:18	1	0:00:04	1:05:00	1:06:41
	13	0:00:21	0:00:00	0:01:17	2	0:00:30	2:10:00	2:12:08
	14	0:00:35	0:00:00	0:01:18	1	0:00:09	1:05:00	1:07:02
	15	0:00:25	0:00:00	0:01:04	1	0:00:16	1:05:00	1:06:45
	16	0:00:17	0:00:00	0:01:27	1	0:00:10	1:05:00	1:06:54
	17	0:00:16	0:00:00	0:02:56	1	0:00:21	1:05:00	1:08:33
	18	0:00:01	0:00:00	0:01:10	1	0:00:04	1:05:00	1:06:15
	19	0:01:22	0:00:00	0:01:57	1	0:00:09	1:05:00	1:08:28
	20	0:00:24	0:00:00	0:01:50	2	0:00:23	2:10:00	2:12:37
	21	0:00:10	0:00:00	0:02:24	1	0:00:10	1:05:00	1:07:44
	22	0:00:26	0:00:00	0:02:21	1	0:00:10	1:05:00	1:07:57
	Total	0:10:05	0:00:00	0:45:04	29	0:06:42	7:25:00	8:26:51
E-A-06	4	0:03:05	0:00:00	0:03:39	1	0:00:30	1:05:00	1:12:14
	5	0:01:32	0:00:00	0:02:42	1	0:00:21	1:05:00	1:09:35
	7	0:00:51	0:00:00	0:02:42	1	0:00:14	1:05:00	1:08:47
	8	0:02:20	0:00:00	0:01:45	1	0:00:20	1:05:00	1:09:25
	Total	0:07:48	0:00:00	0:10:48	4	0:01:25	4:20:00	4:40:01
E-A-07	2	0:01:30	0:00:50	0.003438	1	0:00:57	1:05:00	1:18:14
	3	0:00:19	0:00:00	0:03:19	1	0:00:15	1:05:00	1:08:53
	4	0:00:05	0:00:00	0:02:15	1	0:00:06	1:05:00	1:07:26
	5	0:00:10	0:00:00	0:02:12	1	0:00:17	1:05:00	1:07:39
	7	0:00:24	0:00:00	0:01:40	1	0:00:16	1:05:00	1:07:20

	Total	0:02:28	0:00:50	0:14:23	5	0:01:51	5:25:00	5:49:32
E-A-08	3	0:01:09	0:00:00	0:02:48	2	0:00:20	2:10:00	2:14:17
	5	0:01:20	0:00:00	0:02:14	1	0:01:40	1:05:00	1:10:14
	6	0:01:31	0:00:00	0:01:30	2	0:02:15	2:10:00	2:15:16
	8	0:00:55	0:00:00	0:01:40	1	0:00:12	1:05:00	1:07:47
	Total	0:04:55	0:00:00	0:08:12	6	0:04:27	6:30:00	6:47:34
E-A-09	3	0:00:48	0:00:00	0:03:40	2	0:00:18	2:10:00	2:14:46
	4	0:01:39	0:00:00	0:01:45	1	0:00:16	1:05:00	1:08:40
	5	0:01:21	0:00:00	0:04:08	2	0:00:39	2:10:00	2:16:08
	6	0:01:26	0:00:00	0:01:42	2	0:00:21	2:10:00	2:13:29
	7	0:00:40	0:00:00	0:01:02	2	0:00:15	2:10:00	2:11:57
	8	0:02:01	0:00:00	0:02:32	2	0:00:52	2:10:00	2:15:25
	9	0:02:58	0:00:00	0:02:24	2	0:00:15	2:10:00	2:15:37
	10	0:01:01	0:00:00	0:01:55	1	0:00:34	1:05:00	1:08:30
	11	0:00:27	0:00:00	0:01:30	1	0:00:03	1:05:00	1:07:00
	12	0:00:52	0:00:00	0:01:35	1	0:00:02	1:05:00	1:07:29
	Total	0:13:13	0:00:00	0:22:13	16	0:03:35	17:20:00	17:59:01
E-A-10	2	0:00:23	0:00:00	0:02:29	1	0:01:01	1:05:00	1:08:53
	3	0:01:07	0:00:00	0:03:42	2	0:00:45	2:10:00	2:15:34
	4	0:00:16	0:00:00	0:04:44	1	0:00:23	1:05:00	1:10:23
	5	0:00:25	0:00:00	0:03:52	1	0:02:23	1:05:00	1:11:40
	6	0:01:12	0:00:00	0:03:15	1	0:00:18	1:05:00	1:09:45
	7	0:01:06	0:00:00	0:03:19	1	0:02:51	1:05:00	1:12:16
	8	0:00:18	0:00:00	0:04:09	1	0:02:20	1:05:00	1:11:47
	9	0:00:22	0:00:00	0:02:30	1	0:00:42	1:05:00	1:08:34
	11	0:00:31	0:00:00	0:02:14	1	0:00:35	1:05:00	1:08:20
	12	0:00:36	0:00:00	0:02:13	2	0:00:55	2:10:00	2:13:44
	13	0:00:46	0:00:00	0:01:51	1	0:00:13	1:05:00	1:07:50
	14	0:00:26	0:00:00	0:06:06	1	0:00:14	1:05:00	1:11:46
	Total	0:07:28	0:00:00	0:40:24	14	0:12:40	15:10:00	16:10:32
E-A-11	3	0:00:25	0:00:00	0:02:40	1	0:00:20	1:05:00	1:08:25
	Total	0:00:25	0:00:00	0:02:40	1	0:00:20	1:05:00	1:08:25
E-A-12	2	0:02:32	0:06:01	0:02:38	2	0:03:36	2:10:00	2:24:47
	3	0:00:32	0:00:00	0:02:24	2	0:00:30	2:10:00	2:13:26
	4	0:00:18	0:00:00	0:01:04	1	0:00:37	1:05:00	1:06:59
	5	0:00:57	0:00:00	0:02:35	2	0:00:58	2:10:00	2:14:30
	6	0:00:11	0:00:00	0:01:23	1	0:00:21	1:05:00	1:06:55
	Total	0:04:30	0:06:01	0:10:04	8	0:06:02	8:40:00	9:06:37
E-A-13	2	0:04:45	0:00:00	0:02:17	4	0:04:39	4:20:00	4:31:41
	3	0:03:17	0:00:00	0:01:30	3	0:04:50	3:15:00	3:24:37
	4	0:00:16	0:00:00	0:02:22	1	0:03:24	1:05:00	1:11:02
	Total	0:08:02	0:00:00	0:03:47	7	0:09:29	7:35:00	7:56:18
E-A-14	2	0:00:18	0:00:00	0:02:13	1	0:00:12	1:05:00	1:07:43
	3	0:00:49	0:00:00	0:02:01	1	0:00:11	1:05:00	1:08:01
	4	0:00:09	0:00:00	0:01:46	1	0:00:04	1:05:00	1:06:59
	5	0:00:17	0:00:00	0:01:22	1	0:00:09	1:05:00	1:06:48
	6	0:00:53	0:00:00	0:01:40	1	0:00:29	1:05:00	1:08:02
	7	0:01:10	0:00:00	0:03:35	1	0:00:23	1:05:00	1:10:08
	8	0:00:26	0:00:00	0:06:21	1	0:00:04	1:05:00	1:11:51
	9	0:00:13	0:00:00	0:05:33	1	0:00:08	1:05:00	1:10:54
	10	0:00:29	0:00:00	0:03:45	2	0:00:18	2:10:00	2:14:32
	Total	0:04:44	0:00:00	0:28:16	10	0:01:58	10:50:00	11:24:58
E-A-15	2	0:00:26	0:00:00	0:02:17	1	0:00:14	1:05:00	1:07:57
	3	0:00:22	0:00:00	0:01:36	1	0:00:07	1:05:00	1:07:05
	5	0:01:05	0:00:00	0:04:52	1	0:00:34	1:05:00	1:11:31
	7	0:00:09	0:00:00	0:02:15	1	0:00:50	1:05:00	1:08:14
	Total	0:02:02	0:00:00	0:11:00	4	0:01:45	4:20:00	4:34:47
E-A-16	2	0:01:40	0:00:00	0:02:14	1	0:01:59	1:05:00	1:10:53
	3	0:00:28	0:00:00	0:01:01	1	0:00:32	1:05:00	1:07:01
	5	0:01:26	0:00:00	0:03:01	1	0:01:19	1:05:00	1:10:46
	7	0:00:07	0:00:00	0:02:50	1	0:00:06	1:05:00	1:08:03
	9	0:00:08	0:00:00	0:02:27	1	0:00:13	1:05:00	1:07:48
	10	0:00:16	0:00:00	0:02:31	1	0:00:07	1:05:00	1:07:54
	Total	0:04:05	0:00:00	0:14:04	6	0:04:16	6:30:00	6:52:25
E-A-17	2	0:00:12	0:00:00	0:01:27	1	0:00:11	1:05:00	1:06:50
	3	0:00:03	0:00:00	0:00:47	1	0:00:07	1:05:00	1:05:57
	Total	0:00:15	0:00:00	0:02:14	2	0:00:18	2:10:00	2:12:47
E-A-18	2	0:02:24	0:09:14	0:01:35	1	0:03:13	1:05:00	1:26:26
	3	0:00:22	0:00:00	0:04:36	1	0:04:26	1:05:00	1:14:24

	Total	0:02:46	0:09:14	0:06:11	2	0:07:39	2:10:00	2:40:50
E-A-19	2	0:02:20	0:00:00	0:01:19	2	0:03:22	2:10:00	2:17:01
	3	0:00:40	0:00:00	0:02:53	1	0:00:17	1:05:00	1:08:50
	Total	0:03:00	0:00:00	0:04:12	3	0:03:39	3:15:00	3:25:51
E-A-20	2	0:00:43	0:00:00	0:01:16	1	0:02:57	1:05:00	1:09:56
	5	0:00:19	0:00:00	0:01:32	1	0:00:14	1:05:00	1:07:05
	6	0:00:22	0:00:00	0:01:38	1	0:00:15	1:05:00	1:07:15
	8	0:00:02	0:00:00	0:01:03	1	0:00:03	1:05:00	1:06:08
	9	0:00:00	0:00:00	0:01:30	1	0:00:04	1:05:00	1:06:34
	Total	0:01:26	0:00:00	0:06:59	5	0:03:33	5:25:00	5:36:58

SUMMARY – ENGINEERS WITH APP							
Cycle	Information Absorption	Processing	Cutting Weld	Rework Assembly	Rework Time	TOTAL	Spatial
E-A-01	0:02:39	0:11:34	4	0:01:28	4:20:00	4:41:15	0.639
E-A-02	0:00:11	0:05:32	1	0:00:31	1:05:00	1:11:14	0.716
E-A-03	0:09:49	0:20:34	8	0:00:00	8:40:00	9:11:27	0.138
E-A-04	0:06:35	0:24:53	11	0:02:31	11:55:00	12:28:59	0.682
E-A-05	0:10:05	0:45:04	29	0:06:42	7:25:00	8:26:51	0.541
E-A-06	0:07:48	0:10:48	4	0:01:25	4:20:00	4:40:01	0.938
E-A-07	0:02:28	0:14:23	5	0:01:51	5:25:00	5:49:32	0.648
E-A-08	0:04:55	0:08:12	6	0:04:27	6:30:00	6:47:34	0.543
E-A-09	0:13:13	0:22:13	16	0:03:35	17:20:00	17:59:01	0.580
E-A-10	0:07:28	0:40:24	14	0:12:40	15:10:00	16:10:32	0.679
E-A-11	0:00:25	0:02:40	1	0:00:20	1:05:00	1:08:25	0.625
E-A-12	0:04:30	0:10:04	8	0:06:02	8:40:00	9:06:37	0.480
E-A-13	0:08:02	0:03:47	7	0:09:29	7:35:00	7:56:18	0.795
E-A-14	0:04:44	0:28:16	10	0:01:58	10:50:00	11:24:58	0.891
E-A-15	0:02:02	0:11:00	4	0:01:45	4:20:00	4:34:47	0.539
E-A-16	0:04:05	0:14:04	6	0:04:16	6:30:00	6:52:25	0.441
E-A-17	0:00:15	0:02:14	2	0:00:18	2:10:00	2:12:47	0.663
E-A-18	0:02:46	0:06:11	2	0:07:39	2:10:00	2:40:50	0.857
E-A-19	0:03:00	0:04:12	3	0:03:39	3:15:00	3:25:51	0.879
E-A-20	0:01:26	0:06:59	5	0:03:33	5:25:00	5:36:58	0.843

RAW DATA – ENGINEERS WITH PAPER							
	Cycle	Information Absorption	Processing	Cutting Weld	Rework Assembly	Rework Time	TOTAL
E-P-01	2	0:00:54	0:02:00	2	0:00:47	2:10:00	2:13:41
	3	0:00:08	0:02:16	1	0:00:27	1:05:00	1:07:51
	4	0:00:00	0:02:01	1	0:00:48	1:05:00	1:07:49
	Total	0:01:02	0:06:17	4	0:02:02	4:20:00	4:29:21
E-P-03	2	0:01:04	0:02:14	3	0:08:31	3:15:00	3:26:49
	3	0:00:19	0:03:45	2	0:01:32	2:10:00	2:15:36
	4	0:00:34	0:02:13	0	0:02:28	0:00:00	0:05:15
	5	0:00:07	0:02:57	2	0:01:41	2:10:00	2:14:45
	6	0:00:25	0:01:39	1	0:01:57	1:05:00	1:09:01
	7	0:00:06	0:01:30	1	0:02:34	1:05:00	1:09:10
	8	0:00:12	0:00:45	1	0:01:59	1:05:00	1:07:56
	9	0:00:17	0:00:43	1	0:01:17	1:05:00	1:07:17
	10	0:00:18	0:01:48	1	0:02:58	1:05:00	1:10:04
	11	0:00:13	0:02:22	1	0:00:50	1:05:00	1:08:25
	12	0:00:11	0:01:21	1	0:00:36	1:05:00	1:07:08
	14	0:00:04	0:01:36	1	0:00:08	1:05:00	1:06:48
	15	0:00:10	0:01:25	1	0:00:14	1:05:00	1:06:49
	16	0:00:28	0:01:36	1	0:00:07	1:05:00	1:07:11
	17	0:00:34	0:04:11	1	0:00:39	1:05:00	1:10:24
	Total	0:05:02	0:30:05	18	0:27:31	19:30:00	20:32:38
E-P-04	2	0:13:20	0:01:48	1	0:07:31	1:05:00	1:27:39
	3	0:04:10	0:01:56	3	0:06:23	3:15:00	3:27:29
	4	0:00:09	0:03:08	1	0:01:07	1:05:00	1:09:24
	5	0:00:10	0:01:54	1	0:00:41	1:05:00	1:07:45
	6	0:00:10	0:01:37	1	0:00:38	1:05:00	1:07:25
	Total	0:17:59	0:10:23	7	0:16:20	7:35:00	8:19:42
E-P-05	3	0:02:41	0:02:43	4	0:09:52	4:20:00	4:35:16
	4	0:01:53	0:00:59	3	0:06:11	3:15:00	3:24:03
	5	0:01:35	0:04:20	3	0:09:56	3:15:00	3:30:51
	7	0:01:29	0:02:27	1	0:01:57	1:05:00	1:10:53
	8	0:00:55	0:02:20	1	0:01:55	1:05:00	1:10:10

	9	0:00:55	0:01:58	1	0:00:29	1:05:00	1:08:22
	Total	0:09:28	0:14:47	13	0:30:20	14:05:00	14:59:35
E-P-07	2	0:00:18	0:02:27	2	0:00:52	2:10:00	2:13:37
	3	0:00:38	0:01:45	2	0:00:37	2:10:00	2:13:00
	4	0:00:11	0:02:08	1	0:00:19	1:05:00	1:07:38
	5	0:00:32	0:02:30	1	0:00:48	1:05:00	1:08:50
	Total	0:01:39	0:08:50	6	0:02:36	6:30:00	6:43:05
E-P-08	2	0:03:00	0:01:43	2	0:06:48	2:10:00	2:21:31
	3	0:00:36	0:02:05	2	0:00:26	2:10:00	2:13:07
	4	0:00:08	0:05:45	1	0:00:11	1:05:00	1:11:04
	5	0:00:16	0:02:00	1	0:00:24	1:05:00	1:07:40
	Total	0:04:00	0:11:33	6	0:07:49	6:30:00	6:53:22
E-P-09	2	0:00:17	0:02:01	4	0:02:32	4:20:00	4:24:50
	3	0:00:55	0:01:25	1	0:00:06	1:05:00	1:07:26
	4	0:01:31	0:02:39	2	0:00:59	2:10:00	2:15:09
	5	0:04:12	0:01:38	5	0:03:46	5:25:00	5:34:36
	6	0:01:44	0:01:35	2	0:01:37	2:10:00	2:14:56
	7	0:00:13	0:01:54	4	0:00:50	4:20:00	4:22:57
	8	0:00:12	0:01:13	1	0:00:41	1:05:00	1:07:06
	Total	0:09:04	0:12:25	19	0:10:31	20:35:00	21:07:00
E-P-10	2	0:00:23	0:03:20	2	0:00:49	2:10:00	2:14:32
	3	0:00:39	0:01:40	1	0:00:44	1:05:00	1:08:03
	4	0:00:30	0:01:20	2	0:00:36	2:10:00	2:12:26
	5	0:00:07	0:01:35	1	0:00:05	1:05:00	1:06:47
	6	0:00:03	0:01:02	1	0:00:09	1:05:00	1:06:14
	7	0:00:03	0:01:00	1	0:00:12	1:05:00	1:06:15
	Total	0:01:45	0:09:57	8	0:02:35	8:40:00	8:54:17
E-P-11	2	0:00:23	0:02:41	2	0:00:09	2:10:00	2:13:13
	3	0:01:17	0:01:40	2	0:00:22	2:10:00	2:13:19
	4	0:00:16	0:01:43	2	0:00:06	2:10:00	2:12:05
	Total	0:01:56	0:06:04	6	0:00:37	6:30:00	6:38:37
E-P-12	2	0:00:16	0:02:40	1	0:03:12	1:05:00	1:11:08
	3	0:00:37	0:01:03	2	0:01:33	2:10:00	2:13:13
	Total	0:00:53	0:03:43	3	0:04:45	3:15:00	3:24:21
E-P-13	2	0:05:20	0:06:56	4	0:10:39	4:20:00	4:42:55
	3	0:00:59	0:02:42	2	0:05:25	2:10:00	2:19:06
	4	0:00:22	0:02:55	1	0:00:02	1:05:00	1:08:19
	5	0:00:00	0:00:09	4	0:08:43	4:20:00	4:28:52
	6	0:00:09	0:01:38	1	0:00:01	1:05:00	1:06:48
	7	0:00:31	0:00:22	1	0:00:04	1:05:00	1:05:57
	8	0:00:00	0:00:28	1	0:00:11	1:05:00	1:05:39
	9	0:00:21	0:01:07	2	0:00:10	2:10:00	2:11:38
	Total	0:07:42	0:16:17	16	0:25:15	17:20:00	18:09:14
E-P-14	2	0:04:25	0:02:42	3	0:10:48	3:15:00	3:32:55
	3	0:01:55	0:01:08	2	0:00:30	2:10:00	2:13:33
	4	0:00:36	0:01:27	2	0:00:30	2:10:00	2:12:33
	5	0:00:02	0:01:35	1	0:00:06	1:05:00	1:06:43
	6	0:00:03	0:00:11	1	0:00:03	1:05:00	1:05:17
	Total	0:07:01	0:07:03	9	0:11:57	9:45:00	10:11:01
E-P-15	2	0:00:39	0:03:22	2	0:00:48	2:10:00	2:14:49
	3	0:00:31	0:01:12	2	0:00:31	2:10:00	2:12:14
	4	0:00:13	0:01:43	2	0:00:09	2:10:00	2:12:05
	5	0:00:08	0:01:08	2	0:00:10	2:10:00	2:11:26
	Total	0:01:31	0:07:25	8	0:01:38	8:40:00	8:50:34
E-P-16	2	0:00:19	0:01:52	2	0:00:38	2:10:00	2:12:49
	3	0:00:15	0:01:50	1	0:00:04	1:05:00	1:07:09
	Total	0:00:34	0:03:42	3	0:00:42	3:15:00	3:19:58
E-P-17	2	0:00:56	0:02:17	3	0:02:09	3:15:00	3:20:22
	3	0:00:17	0:02:00	1	0:03:07	1:05:00	1:10:24
	4	0:00:05	0:01:00	1	0:00:05	1:05:00	1:06:10
	5	0:00:10	0:00:13	2	0:00:10	2:10:00	2:10:33
	Total	0:01:28	0:05:30	7	0:05:31	7:35:00	7:47:29
E-P-19	2	0:01:15	0:02:28	1	0:00:13	1:05:00	1:08:56
	Total	0:01:15	0:02:28	1	0:00:13	1:05:00	1:08:56
E-P-20	2	0:00:24	0:03:07	2	0:00:43	2:10:00	2:14:14
	3	0:00:07	0:01:03	1	0:00:27	1:05:00	1:06:37
	Total	0:00:31	0:04:10	3	0:01:10	3:15:00	3:20:51

SUMMARY – ENGINEERS WITH PAPER							
Cycle	Information Absorption	Processing	Cutting Weld	Rework Assembly	Rework Time	TOTAL	Spatial
E-P-01	0:01:02	0:06:17	4	0:02:02	4:20:00	4:29:21	0.736
E-P-03	0:05:02	0:30:05	18	0:27:31	19:30:00	20:32:38	0.539
E-P-04	0:17:59	0:10:23	7	0:16:20	7:35:00	8:19:42	0.786
E-P-05	0:09:28	0:14:47	13	0:30:20	14:05:00	14:59:35	0.768
E-P-07	0:01:39	0:08:50	6	0:02:36	6:30:00	6:43:05	0.857
E-P-08	0:04:00	0:11:33	6	0:07:49	6:30:00	6:53:22	1.000
E-P-09	0:09:04	0:12:25	19	0:10:31	20:35:00	21:07:00	0.245
E-P-10	0:01:45	0:09:57	8	0:02:35	8:40:00	8:54:17	0.639
E-P-11	0:01:56	0:06:04	6	0:00:37	6:30:00	6:38:37	0.607
E-P-12	0:00:53	0:03:43	3	0:04:45	3:15:00	3:24:21	0.595
E-P-13	0:07:42	0:16:17	16	0:25:15	17:20:00	18:09:14	0.282
E-P-14	0:07:01	0:07:03	9	0:11:57	9:45:00	10:11:01	0.863
E-P-15	0:01:31	0:07:25	8	0:01:38	8:40:00	8:50:34	0.441
E-P-16	0:00:34	0:03:42	3	0:00:42	3:15:00	3:19:58	0.493
E-P-17	0:01:28	0:05:30	7	0:05:31	7:35:00	7:47:29	0.900
E-P-19	0:01:15	0:02:28	1	0:00:13	1:05:00	1:08:56	0.854
E-P-20	0:00:31	0:04:10	3	0:01:10	3:15:00	3:20:51	1.000

RAW DATA – FITTERS WITH APP							
	Type	Information Absorption	Processing	Cutting Weld	Rework Assembly	Rework Time	TOTAL
F-A-01	2	0:00:02	0:01:23	1	0:00:07	1:05:00	1:06:32
	4	0:00:35	0:01:23	2	0:00:32	2:10:00	2:13:52
	TOTAL	0:00:37	0:02:46	3	0:00:39	3:15:00	3:20:24
F-A-02	3	0:00:02	0:01:28	1	0:00:07	1:05:00	1:06:37
	TOTAL	0:00:02	0:01:28	1	0:00:07	1:05:00	1:06:37
F-A-03	2	0:03:21	0:01:32	1	0:00:14	1:05:00	1:18:56
	3	0:00:42	0:02:08	1	0:01:14	1:05:00	1:09:04
	5	0:00:05	0:02:15	1	0:00:45	1:05:00	1:08:05
	TOTAL	0:04:08	0:05:55	3	0:02:13	3:15:00	3:36:05
F-A-04	4	0:00:11	0:01:38	1	0:00:24	1:05:00	1:07:13
	TOTAL	0:00:11	0:01:38	1	0:00:24	1:05:00	1:07:13
F-A-05	2	0:00:31	0:02:58	2	0:02:24	2:10:00	2:15:53
	3	0:01:19	0:02:04	2	0:02:49	2:10:00	2:16:12
	4	0:01:08	0:01:05	1	0:00:06	1:05:00	1:07:19
	TOTAL	0:02:58	0:06:07	5	0:05:19	5:25:00	5:39:24
F-A-06	2	0:00:24	0:00:55	1	0:00:31	1:05:00	1:06:50
	4	0:00:11	0:01:25	1	0:00:24	1:05:00	1:07:00
	5	0:00:10	0:03:16	1	0:00:09	1:05:00	1:08:35
	TOTAL	0:00:45	0:05:36	3	0:01:04	3:15:00	3:22:25
F-A-07	3	0:00:15	0:05:57	1	0:01:16	1:05:00	1:12:28
	4	0:00:04	0:01:10	2	0:00:21	2:10:00	2:11:35
	TOTAL	0:00:19	0:07:07	3	0:01:37	3:15:00	3:24:03
F-A-08	3	0:00:05	0:01:34	1	0:00:04	1:05:00	1:06:43
	4	0:00:16	0:02:21	2	0:02:00	2:10:00	2:13:37
	6	0:00:02	0:01:53	1	0:00:33	1:05:00	1:07:28
	TOTAL	0:00:23	0:05:48	4	0:01:37	4:20:00	4:27:48
F-A-09	2	0:00:19	0:02:19	1	0:00:19	1:05:00	1:07:57
	3	0:00:36	0:03:17	1	0:00:16	1:05:00	1:09:09
	TOTAL	0:00:55	0:05:36	2	0:00:35	2:10:00	2:17:06
F-A-10	2	0:00:59	0:01:24	1	0:00:58	1:05:00	1:08:21
	TOTAL	0:00:59	0:01:24	1	0:00:58	1:05:00	1:08:21
F-A-11	2	0:00:40	0:02:15	1	0:00:35	1:05:00	1:08:30
	TOTAL	0:00:40	0:02:15	1	0:00:35	1:05:00	1:08:30
F-A-13	4	0:00:08	0:02:41	1	0:00:10	1:05:00	1:07:59
	TOTAL	0:00:08	0:02:41	1	0:00:10	1:05:00	1:07:59
F-A-14	2	0:00:06	0:01:25	1	0:00:04	1:05:00	1:06:35
	4	0:00:19	0:01:16	1	0:00:01	1:05:00	1:06:36
	5	0:00:16	0:01:25	1	0:00:23	1:05:00	1:07:04
	6	0:00:46	0:02:16	1	0:00:20	1:05:00	1:08:22
	TOTAL	0:01:27	0:06:22	4	0:00:48	4:20:00	4:28:37
F-A-15	2	0:02:16	0:01:42	1	0:01:01	1:05:00	1:20:39
	TOTAL	0:02:16	0:01:42	1	0:01:01	1:05:00	1:20:39
F-A-16	2	0:00:09	0:01:31	2	0:00:21	2:10:00	2:12:01
	4	0:00:09	0:01:07	1	0:00:11	1:05:00	1:06:27
	TOTAL	0:00:18	0:02:38	3	0:00:32	3:15:00	3:18:28

F-A-18	2	0:00:26	0:01:13	2	0:00:11	2:10:00	2:11:50
	3	0:01:10	0:01:16	2	0:01:25	2:10:00	2:14:54
	TOTAL	0:01:36	0:02:29	4	0:01:36	4:20:00	4:26:44

SUMMARY – FITTERS WITH APP							
	Information Absorption	Processing	Cutting Weld	Rework Assembly	Rework Time	TOTAL	Spatial
F-A-01	0:00:37	0:02:46	3	0:00:39	3:15:00	3:20:24	0.579
F-A-02	0:00:02	0:01:28	1	0:00:07	1:05:00	1:06:37	0.400
F-A-03	0:04:08	0:05:55	3	0:02:13	3:15:00	3:36:05	0.604
F-A-04	0:00:11	0:01:38	1	0:00:24	1:05:00	1:07:13	0.525
F-A-05	0:02:58	0:06:07	5	0:05:19	5:25:00	5:39:24	0.652
F-A-06	0:00:45	0:05:36	3	0:01:04	3:15:00	3:22:25	0.770
F-A-07	0:00:19	0:07:07	3	0:01:37	3:15:00	3:24:03	0.546
F-A-08	0:00:23	0:05:48	4	0:01:37	4:20:00	4:27:48	0.854
F-A-09	0:00:55	0:05:36	2	0:00:35	2:10:00	2:17:06	0.900
F-A-10	0:00:59	0:01:24	1	0:00:58	1:05:00	1:08:21	0.543
F-A-11	0:00:40	0:02:15	1	0:00:35	1:05:00	1:08:30	0.471
F-A-13	0:00:08	0:02:41	1	0:00:10	1:05:00	1:07:59	0.904
F-A-14	0:01:27	0:06:22	4	0:00:48	4:20:00	4:28:37	0.379
F-A-15	0:02:16	0:01:42	1	0:01:01	1:05:00	1:20:39	0.614
F-A-16	0:00:18	0:02:38	3	0:00:32	3:15:00	3:18:28	0.807
F-A-18	0:01:36	0:02:29	4	0:01:36	4:20:00	4:26:44	0.463

RAW DATA – FITTERS WITH PAPER							
	Cycle	Information Absorption	Processing	Cutting Weld	Rework Assembly	Rework Time	TOTAL
F-P-01	2	0:05:36	0:00:00	3	01:09	3:15:00	3:21:45
	TOTAL	0:05:36	0:00:00	3	01:09	3:15:00	3:21:45
F-P-03	2	0:02:38	0:01:57	1	01:24	1:05:00	1:21:12
	3	0:09:38	0:04:11	3	02:59	3:15:00	3:31:48
	TOTAL	0:12:16	0:06:08	4	04:23	4:20:00	4:53:00

SUMMARY – FITTERS WITH PAPER							
Cycle	Information Absorption	Processing	Cutting Weld	Rework Assembly	Rework Time	TOTAL	Spatial
F-P-01	0:05:36	0:00:00	3	0:01:09	3:15:00	3:21:45	0.586
F-P-03	0:12:16	0:06:08	4	0:04:23	4:20:00	4:53:00	0.704

Appendix J

Technical Background Survey Raw Data

	Background				Use of Technology			Use of Technology at Work			Personal Use of Technology	
ID	Tech Interest Score	Age	Profession	Gender	Personal Computer	Tablet	Smart-phone	Work Use Level of Interest	Biggest Apprehension About Using Technology at Work	Would Make More Comfortable Using Technology at Work	Personal Use Level of Interest	Reason for Interest
E-A-01	4	42	Engineer	M	Daily	Once every few months	Daily	Very interested	Change to routine	Ability to provide feedback during development phase	Very interested	Makes life easier
E-A-02	-1	56	Engineer	M	Daily	Few times per week	Daily	Neutral	Time required for training	Ability to provide feedback during development phase

Transparency during implementation

Sufficient training | Somewhat disinterested | Makes life easier |
| E-A-03 | 4 | 20 | Engineering Student | M | Daily | Few times per week | Daily | Very interested | Less time for direct work | Ability to provide feedback during development phase

Simplification of annoying tasks

Transparency during implementation | Very interested | Makes life easier |
| E-A-04 | 0 | 28 | Phd Student | F | Daily | Never | Daily | Very disinterested | Time required for training

Additional tasks to be done

Change to routine | Simplification of annoying tasks

Sufficient training | Very interested | Makes life easier |
| E-A-05 | 4 | 30 | Phd Student | M | Daily | Once every few months | Daily | Very interested | Time required for training
Additional tasks to be done | Simplification of annoying tasks | Very interested | Makes life easier |
| E-A-06 | 3 | 22 | Engineering Student | M | Daily | Daily | Daily | Very interested | Time required for training

Additional tasks to be done | Sufficient training

Simplification of annoying tasks

More independence due to technology | Somewhat interested | Makes life easier |
| E-A-07 | 4 | 18 | Engineering Student | M | Daily | Once every few months | Daily | Very interested | Additional tasks to be done | Optional use | Very interested | Makes life easier |
| E-A-08 | 2 | 18 | Engineering Student | M | Daily | Once a week | Daily | Somewhat interested | Additional tasks to be done
Change to routine | Simplification of annoying tasks
Sufficient training | Somewhat interested | Makes life easier |
| E-A-09 | 3 | 25 | Engineering Student | F | Daily | Never | Daily | Very interested | Time required for training | Simplification of annoying tasks | Somewhat interested | Makes life easier |
| E-A-10 | 4 | 27 | Engineering Student | M | Daily | Daily | Daily | Very interested | Additional tasks to be done | More independence due to technology

Simplification of annoying tasks | Very interested | Makes life easier |
| E-A-11 | 1 | 26 | Engineering Student | F | Daily | Few times per week | Daily | Very interested | Time required for training | Ability to provide feedback during development phase

Sufficient training | Somewhat disinterested | Makes life easier |
| E-A-12 | -4 | 25 | Engineering Student | F | Daily | Never | Daily | Very disinterested | Time required for training | Ability to provide feedback during development phase

More independence due to technology

Simplification of annoying tasks | Very disinterested | Makes life easier |
| E-A-13 | 4 | 26 | Student | F | Daily | Never | Daily | Very interested | | Sufficient training | Very interested | Is entertaining |

ID		Age	Role	Gender								
E-A-14	1	24	Student	F	Daily	Once every few months	Once every few months	Somewhat interested	Additional tasks to be done	Sufficient training Ability to provide feedback during development phase Simplification of annoying tasks Transparency during implementation	Neutral	Makes life easier
E-A-15	4	25	Civ Eng	M	Daily	Few times per week	Daily	Very interested	Change to routine	Ability to provide feedback during development phase	Very interested	Makes life easier
E-A-16	2	20	Student	F	Daily	Never	Daily	Somewhat interested	Time required for training	Sufficient training Simplification of annoying tasks	Somewhat interested	Makes life easier
E-A-17	4	24	Engineer	F	Daily	Daily	Daily	Very interested	Change to routine	Simplification of annoying tasks	Very interested	Makes life easier
E-A-18	4	24	EIT	M	Daily	Once a week	Daily	Very interested	Less time for direct work	Simplification of annoying tasks	Very interested	Makes life easier
E-A-19	4	31	Student	M	Daily	Once a week	Daily	Very interested	Less time for direct work	Sufficient training	Very interested	Makes life easier
E-A-20	4	44	Prof	M	Daily	Daily	Daily	Very interested	Change to routine	Simplification of annoying tasks Optional use	Very interested	Makes life easier
E-P-01	4	24	Eng Student	M	Daily	Never	Daily	Very interested	Change to routine	Ability to provide feedback during development phase	Very interested	Makes life easier
E-P-02	4	24	Engineer	M	Daily	Daily	Daily	Very interested	Additional tasks to be done	simplification of annoying tasks	Very interested	Is entertaining
E-P-03	4	24	Engineer	M	Daily	Once a week	Daily	Very interested	Time required for training	Simplification of annoying tasks	Very interested	Is entertaining
E-P-04	4	23	ECE Student	M	Daily	Never	Daily	Very interested	Potential for job loss	Transparency during implementation Simplification of annoying tasks	Very interested	Makes life easier
E-P-05	4	22	Engineering Student	M	Daily	Never	Daily	Very interested	Time required for training	Simplification of annoying tasks	Very interested	Makes life easier
E-P-06	4	24	Civ Eng	M	Daily	Once a week	Daily	Very interested	Distrust of management	Simplification of annoying tasks More independence due to technology Ability to provide feedback during development phase	Very interested	Both
E-P-07	-4	21	Student	M	Daily	Never	Daily	Very disinterested	Change to routine	Simplification of annoying tasks	Very disinterested	Makes life easier
E-P-08	2	25	MASc Student	F	Daily	Daily	Daily	Somewhat interested	Time required for training	Simplification of annoying tasks	Somewhat interested	Is entertaining
E-P-09	4	26	Eng Student	F	Daily	Few times per week	Daily	Very interested	Time required for training	Sufficient training	Very interested	Makes life easier
E-P-10	4	23	Student	F	Daily	Once a month	Daily	Very interested	Time required for training	Sufficient training	Very interested	Makes life easier
E-P-11	2	26	Student	M	Daily	Never	Daily	Somewhat interested	Change to routine	Simplification of annoying tasks	Somewhat interested	Makes life easier
E-P-12	2	25	Grad Student	M	Daily	Once every few months	Daily	Somewhat interested	Time required for training Less time for direct work	Sufficient training More independence due to technology Optional use	Somewhat interested	Makes life easier
E-P-13	2	26	Student	M	Daily	Never	Daily	Somewhat interested	Less time for direct work	Sufficient training	Somewhat interested	Makes life easier
E-P-14	3	23	Student	F	Daily	Once every few months	Daily	Very interested	Time required for training	Sufficient training Simplification of annoying tasks	Somewhat interested	Makes life easier
E-P-15	4	28	PhD	M	Daily	Once a month	Daily	Very interested	Additional tasks to be done	Transparency during implementation Simplification of annoying tasks	Very interested	Makes life easier

										Optional use		
E-P-16	3	23	Student	F	Daily	Never	Daily	Very interested	Time required for training	Transparency during implementation	Somewhat interested	Makes life easier
E-P-17	2	30	Student	M	Daily	Once a week	Daily	Somewhat interested	Time required for training	Simplification of annoying tasks	Somewhat interested	Makes life easier
E-P-18	0	32	Student	M	Daily	Once a week	Daily	Very disinterested	Time required for training	Sufficient training	Very interested	Makes life easier
E-P-19	0	24	Student	F	Daily	Never	Daily	Neutral	Time required for training	Simplification of annoying tasks	Neutral	Makes life easier
E-P-20	-4	23	Student	M	Daily	Once a month	Daily	Very disinterested	Change to routine	Simplification of annoying tasks	Very disinterested	Makes life easier
F-A-01	2	19	Fabricator	M	Few times per week	Never	Daily	Somewhat interested	Distrust of management	Optional use	Somewhat interested	Makes life easier
F-A-02	2	28	Steamfitter	M	Once a week	Daily	Daily	Somewhat interested	Additional tasks to be done Less time for direct work	Sufficient training Transparency during implementation Ability to provide feedback during development phase	Somewhat interested	Makes life easier
F-A-03	4	22	Steamfitter	M	Once a week	Once every few months	Daily	Very interested	Additional tasks to be done	Simplification of annoying tasks	Somewhat interested	Makes life easier
F-A-04	6	22	Welder	M	Daily	Never	Daily	Very interested	Potential for job loss Change to routine	Sufficient training	Very interested	Makes life easier
F-A-05	6	44	Pipefitter	M	Daily	Daily	Daily	Very interested	Change to routine	Sufficient training	Very interested	
F-A-06	6	29	Steamfitter	M	Never	Never	Daily	Very interested	Additional tasks to be done Time required for training Distrust of management	Sufficient training Simplification of annoying tasks More independence due to technology	Very interested	Makes life easier
F-A-07	1	49	Steamfitter	M	Few times per week	Never	Daily	Somewhat interested	Additional tasks to be done	Ability to provide feedback during development phase	Neutral	Makes life easier
F-A-08	1	34	Foreman	M	Once every few months	Never	Daily	Somewhat interested	Additional tasks to be done	Sufficient training	Neutral	Makes life easier
F-A-09	-2	44	Fitter	M	Once a month	Daily	Daily	Somewhat disinterested	Less time for direct work	Ability to provide feedback during development phase	Somewhat disinterested	Makes life easier
F-A-10	2	54	Steamfitter	M	Once every few months	Never	Daily	Somewhat interested	Time required for training Less time for direct work	More independence due to technology Simplification of annoying tasks Optional use	Somewhat interested	Both
F-A-11	4	26	Steamfitter	M	Few times per week	Never	Daily	Very interested	Additional tasks to be done	Sufficient training	Somewhat interested	Makes life easier
F-A-12	4	34	Steamfitter	M	Few times per week	Once a month	Daily	Very interested	Change to routine	More independence due to technology	Somewhat interested	Makes life easier
F-A-13	2	35	Welder	M	Never	Never	Daily	Somewhat interested	Less time for direct work	Sufficient training	Somewhat interested	Makes life easier
F-A-14	0	38	Fitter	M	Daily	Once a week	Daily	Very disinterested		Sufficient training Transparency during implementation Optional use	Very interested	Makes life easier
F-A-15	0	29	Steamfitter	M	Few times per week	Few times per week	Daily	Neutral	Change to routine Additional tasks to be done	Optional use Simplification of annoying tasks	Neutral	Both
F-A-16	4	22	Metal Fabricator	M	Once a month	Once every few months	Daily	Very interested	Potential for job loss	Simplification of annoying tasks	Somewhat interested	Is entertaining
F-A-17	4	19	Metal Fabricator	M	Once every few months	Once every few months	Daily	Somewhat interested	Potential for job loss	Sufficient training	Very interested	Is entertaining

F-A-18	2	21	Welder	M	Few times per week	Never	Daily	Somewhat disinterested	Time required for training	Sufficient training	Very interested	Makes life easier
F-P-01	4	48	Steamfitter	M	Daily	Few times per week	Daily	Somewhat interested		Simplification of annoying tasks	Very interested	Makes life easier
F-P-02	-4	39	Pipefitter	M	Once every few months	Never	Daily	Somewhat disinterested	Change to routine Less time for direct work	Sufficient training Optional use	Very disinterested	Both
F-P-03	4	54	Steamfitter	M	Daily	Once every few months	Daily	Somewhat interested	Additional tasks to be done Less time for direct work	Sufficient training	Very interested	Makes life easier