# *Hack : Reclaiming the Commons*

*by*

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*A thesis*
*presented to the University of Waterloo*
*in fulfilment of the*
*thesis requirement for the degree of*
*Master of Architecture*

*Waterloo, Ontario, Canada, 2013*

## Author 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*

Architecture is an act of agency, and a technology that can be learned by anyone for their own purpose. It evolved as a system of organization and a protective shell for our fragile bodies, a vast, complex technology that enables human survival. Yet despite its universal nature, we have artificially limited our control over it, and who has access to it; we limit its potentials, its adaptive capacities, its diversity, and our continued survival. Walled-up in universities, behind certifications and dissertations, we have removed architecture from the public's mind so that few understand it and use it. The city, in its surging complexity, is ever more opaque; the systems, infrastructure, and regulations that govern its formation are hidden from view, behind doors, walls, and fences.

*Hack* seeks to make the city legible and architecture accessible, by leveraging a growing tide of hacker culture, and its subcultures – *makers* and *DIY drone enthusiasts* – and their respective technologies. Since the birth of the computer, Hackers have sought to democratize information technology held by military, government, and corporate interests. In doing so they've provided a number of methods, that enable free sharing and collaboration between individuals, distributing problem-solving practices, open-source systems, hands-on education, and free access to tools, all applicable to the challenges and opportunities facing architecture and city building today.

*Hack* bootstraps itself to these ideals with hands-on experiments and reflections on those experiments, reframing architecture as a basic skill, a technology to be used by anyone, democratizing architecture through online communities, and the Hacker culture, in order to define a new active role for the architect.

Internalizing the Hacker Ethic, and appropriate existing technologies to build new tools – devices to survey space, architecture and the city. – *Hack* traces the construction of a kite, a model car, a quadrocopter, and a remote-control airplane, each capable of gathering intimate information about the local environment.

Hack concludes by reexamining the role of the aerial view in making cities and exercising power, speculating on the potential to level the fields of perception through online co-operation and these small-scale cartographic technologies.

## Acknowledgements

I would like to thank my committee. Robert Jan van Pelt and Eric Haldenby, thank you for your enthusiasm, your support and your incredible insight into my work. My supervisor Donald McKay, thank you, for encouraging me to pursue that which I was truly more bent on addressing and guiding me on my way, thank you for your quiet encouragement, and for pulling through to the end. I would also like to thank my external reader David Dennis for bringing a refreshing and unique perspective to the work.

To the many faculty and staff that have helped me over the last few years, thank you.

I would like to thank my friends, for sharing in the highs and lows of this journey. For the late night beverages and the early morning baked goods.

To Shawn Selway, thank you for bringing me onto the Barton Tiffany project, and igniting this pursuit.

I would like to thank my editor Kimberly Schellingerhoudt.

I would like to thank my family, for everything.

The best for last, I would like to thank Lindsey Nette, I couldn't have done this without you.

## Dedication

I would like to dedicate this thesis to the memory of my Grandfather, W. George Munnik

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# ***PROLOGUE***

## *The Barton Tiffany Project :*
## *A Lesson in Urban Activism*

The Building, meanwhile, even as Architecture, is never merely a ghost. Through it remains always behind – as the concretized, unmoving, and thus closed shell of the original intention – the building is always a palpable presence.

-Wes Jones, Insturmental Form, 1998.


RHEEM

*I stood on the scarred concrete and breathed dust. I spun around with my camera in hand; it was gone. Only its pieces and parts lay strewn around me. The air was cold as the January dusk set in, the sun was setting on Rheem and I think I knew that it was over.*

*I had been visiting family. My brother and I went out for a drive and decided to swing over to the site, see the building and try to bribe the security guard to let us in. As I rounded the corner and saw construction fencing, my heart dropped. The equipment was resting at the north end, and I parked on what was the old loading area tarmac. There was no guard, no other cars driving by. Enraged, I lifted a fence bay from its base and swung it out enough to slip by. Finally, I could walk the site. I needed to break onto it and photograph what little was left: the steel and wood and scraps that laid in heaps and dumpsters across the now nearly-vacant lot.*

*The air was crisp and getting colder. In the failing light I searched for an artifact, a piece of the building that once was. I found a fuse, the canister dirty and beaten, but the shiny copper inside was bright and clean, rated for 12,000 volts.*

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**Fig 0.1 -** North End of Rheem Building, formerly Hamilton Bridge and Tool. *Photo by Author.*

A year before my brief inspired act of trespassing, I had been approached by a concerned citizen in Hamilton's north end neighborhood. As a retired millwright, Shawn Selway had seen the interiors of most of Hamilton's many factories and he was fervently active in the civic community. Shawn's official job is restoring old machinery, often for old museums, converted mill buildings, or vacated brick factories-turned-farmers-markets. Shawn contacted me out of the blue that September; he was looking for someone to do renderings, or as he called it architectural "propaganda", to battle against what he saw in his local newspaper. Shawn was concerned about the West Harbour neighborhood; also known as Barton Tiffany in North Hamilton. The Barton Tiffany District was once the burgeoning center of Hamilton's industrial past, but by 2010 it consisted of mostly abandoned industrial buildings.

Shawn was concerned about the heated Stadium debate, a shadowy rumor-filled public fiasco in which the city of Hamilton was bidding for the 2015 Pan-Am games Sport Stadium. The deal was to buy up the old industrial buildings of the west harbour, raze them, and build a 25,000 seat stadium which would be adjacent to the downtown core and near the waterfront. The bid was a gamble at best; the stadium was seen as a silver-bullet, the way to fix Hamilton's economic woes, clear a blighted area, and lift downtown businesses from the brink, all in one fell swoop.

The Stadium debate was in full swing when I became involved. Shawn, having undoubtedly discovered my website during a deep Google search, hoped I could provide an alternative image to the enormous stadium. Shawn was the vice president of the North End Neighborhood Association, and had been involved in a two year long "re-visioning study" called *Setting Sail* initiated by the City of Hamilton. The goal of the study was to develop comprehensive urban design guidelines to inform future development in the downtown, specifically the north end.

I first met Shawn in a café near the GO station in Toronto. His blue work shirt was embroidered "Selway" on the tag, his grey hair electric and his glasses held together with black electrical tape. He carried a scuffed Nokia cell phone and kept a silver mechanical pencil and a tiny coil-bound note pad in his shirt pocket. He gave me a disc of photos and a yellow melamine folder made soft by frugal reuse. It was filled with sketches, notes and newspaper clippings. He asked if I would be interested.

A small stipend later and I had done initial sketching. Researching, mapping, subsequent site visits, and I was narrowing in on a phased urban design plan still very rough and open-ended. By this time the City executed the first portion of their plan. They bought up and repossessed the industrial lands and buildings at west harbor along with a few boarded up houses. But a few months later the Stadium deal fell through, as did a separate bid for a

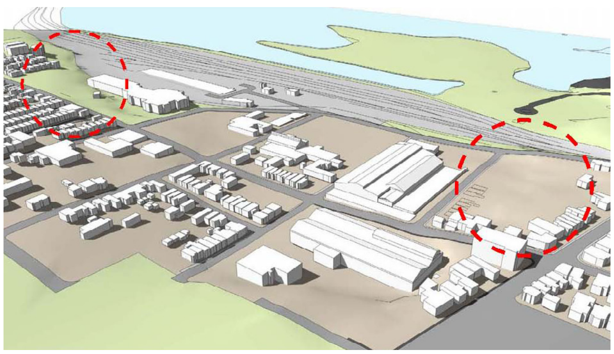
**Fig 0.2 -** Community Presentation. Shawn Selway Center, Author at left. *Photo by Cees & Annerie van Gemerden.*

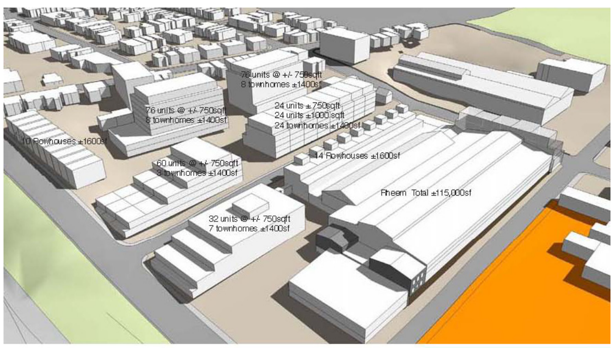
running track, and another for the PanAm Velodrome. The city was left with a multi-million dollar bill for its purchased properties and nothing to build on the newly appropriated land. In this state of uncertainty, Shawn approached the public with my drawings. We held an open house at a local art gallery and hosted about sixty people. City officials were invited but none came. Even the elected representative for the district in question did not attend. I explained the ideas and took suggestions, fielded questions and suffered some criticism for my overt optimism.

The Plan I imagined was incremental and slow. It began with assessing the potential inherent in the buildings, landscape, and adjacent properties. The first phase identified uncontaminated land with the potential to see over the old factories and to the waterfront beyond. This first phase was the foothold phase. Two modest developments would be established at either end of the site, creating anchors and building on the most desirable and salable locations first. The first phase would also include initial Phytoremediation efforts on any contaminated industrial properties.

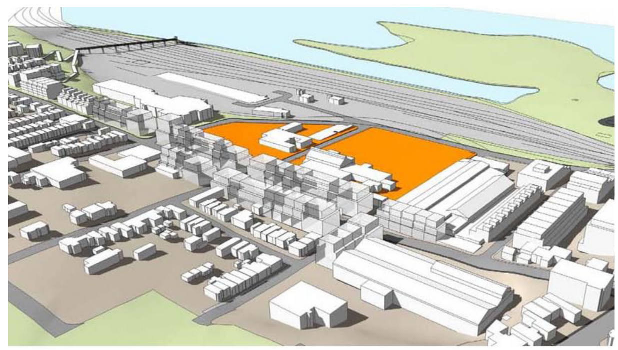
Phase two was the conversion of the Rheem factory into a mixed-use complex. The Rheem factory, formerly Hamilton Bridge and Tool Co, is a sprawling industrial complex that has been standing in one state or another for over one hundred and fifteen years and encloses over 116, 000 sqft. In its long life, the Rheem factory has grown like an organism and shed its skin more than once. Its features include original three story brick administration houses at the north wing, massive open web riveted steel joists, and original wood-timber roof decking. In phase two the complex would become an economic engine and destination at the north of the city, walking distance from the waterfront. It would have an internal north-south pedestrian street with a café and low-cost units for artisans and small businesses. The third phase proposed to increase density along Barton Street with the goal of linking the two footholds together, while extending the pedestrian-oriented feel from the James North District to the east. The final phase, imagined five to ten years after phase one, was the move toward the waterfront, extending density north. The existing CN shunting yards would be made into a park. The vital rail line leading to Hamilton's industrial district would be buried, bridged, or entrenched. The neighborhood would be established as a downtown adjacent lakeside community with a peppering of reused mixed-use industrial buildings to give it character, actively reusing existing structures.

The open house was a success, producing a wealth of suggestions from those who attended: a public pool, a film or technology school, an open air park under the lofty structure above - a record of the industrial heritage of the site. Shawn sent a record of the meeting along with the presentation to the city counselors and tried to arrange a meeting with them to discuss the community's ideas for the site. With his ear to the pavement, Shawn caught wind of a heritage site review and a structural assessment of the









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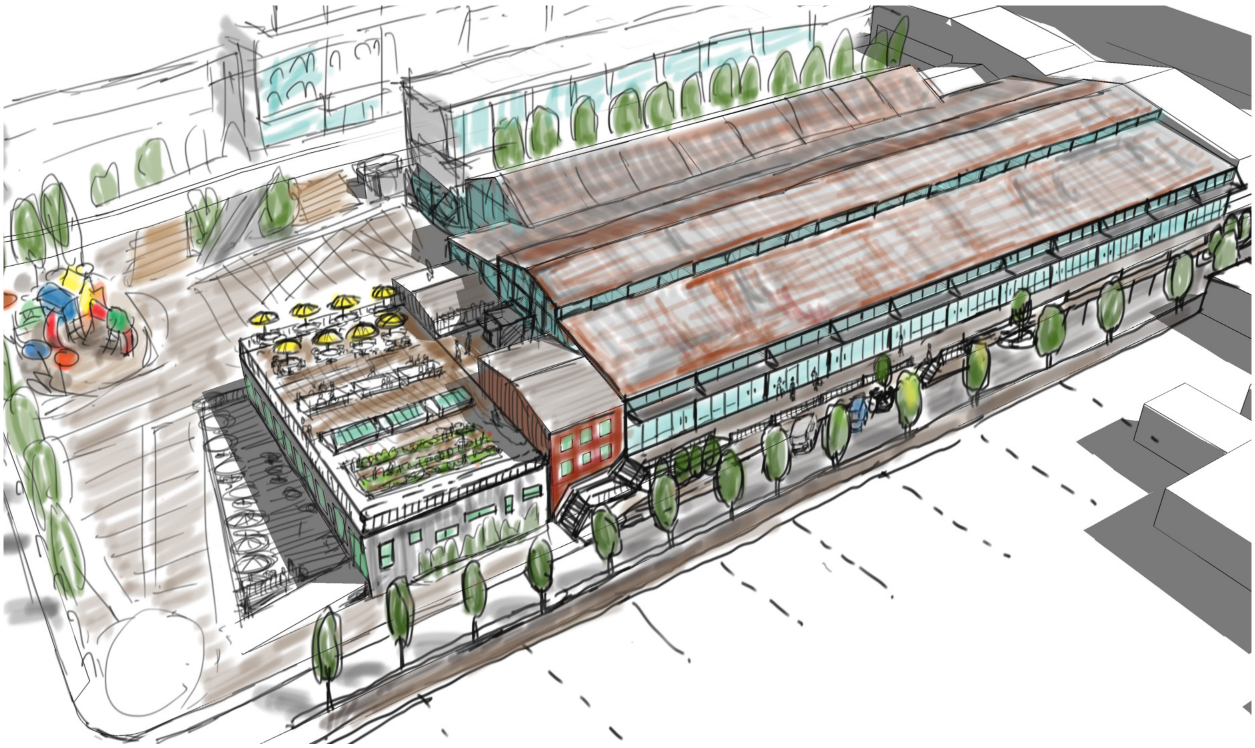

**Fig 0.7 -** Concept Drawing of the Rheem Building adaptive reuse. *Drawing by Author.*

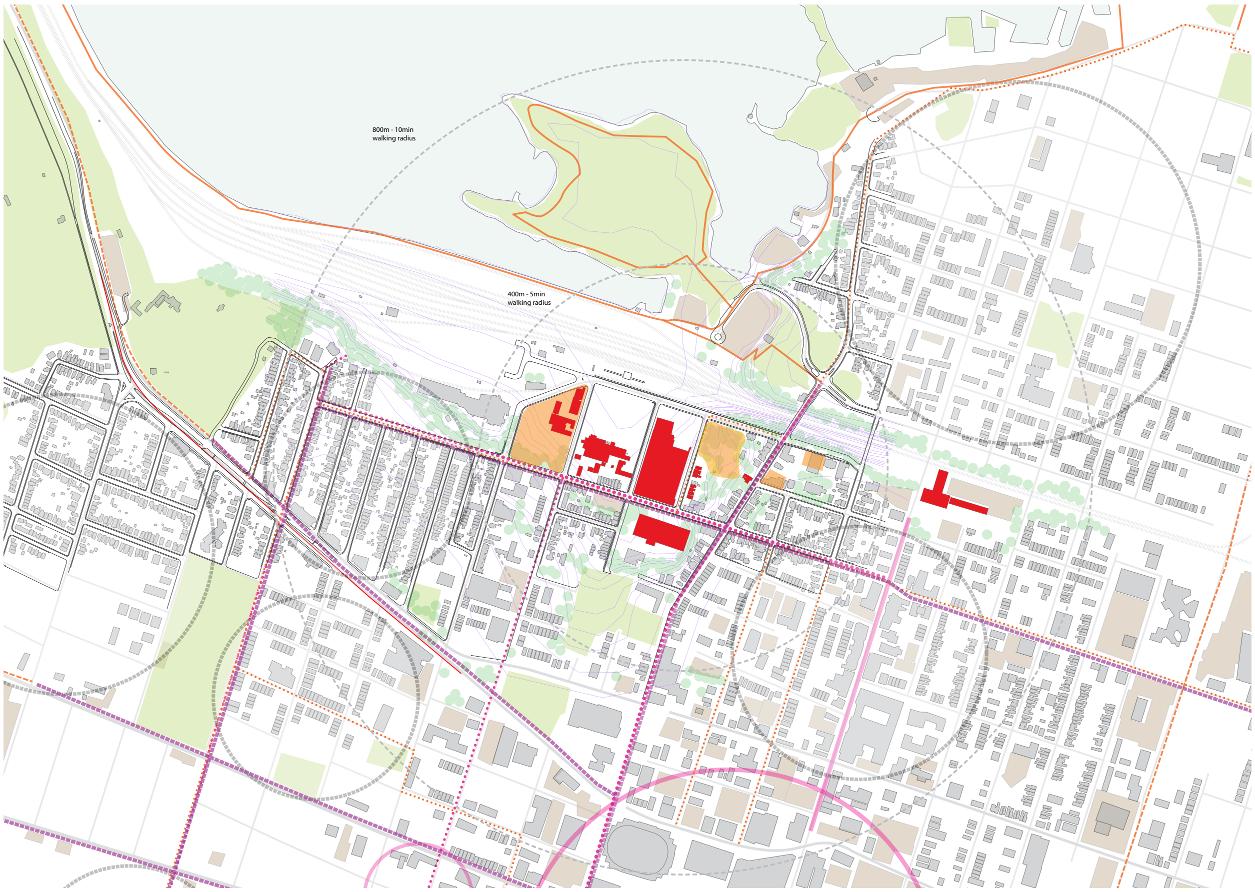


**Fig 0.8 -** Composite map of the Barton Tiffany Neighborhood showing build form, parking areas, bicycle routs, buildings of interest, green spaces, walking circles and other surrounding neighborhoods. *Drawing by Author.*

industrial buildings at Barton Tiffany. In the business of heritage restoration, he knew the firm doing the appraisal and approached them for information. Of course, client confidentiality restricted them from giving him the appraisal. The firm did, however, let him know when the review was given to the city.

Under the freedom of information act Shawn, went straight to the city and placed a request to see the review. His request was delayed. Days later, a bid for the demolition of the buildings at Barton Tiffany was issued from the city. The city had cut a deal: if a contractor agreed to do the demolition and site clean-up for free, they could have all the steel from the buildings along with whatever else they could salvage.

The City of Hamilton is a sprawling municipality, its arms stretch far to the east, west and south into the country and surrounding town centers. In recent years, it has absorbed Dundas, Ancaster, Stoney Creek, as well as farm land to the south. Tracks of suburban housing leap-frog along the old highway to Brantford. To the north, the City wraps the harbor and nearly joins with Burlington, a commuter center primarily serving Toronto. Hamilton was first nestled into the sandbar below the Niagara escarpment but grew up the side of the "mountain". It is now split into two halves: north and south. The north houses the downtown and industry below the mountain, while the south contains mostly new shopping and residential areas. To the west lies Dundas, a quaint town that once supplied hydropower to the industries at Barton Tiffany, now an idyllic setting with a bustling main street. To the east, Hamilton stretches past the heavy steel industries of Stelco and Dofasco – with their labyrinth of stainless steel piping, fiery towers, iron girders, and truck off-ramps – to Stoney Creek. Another small town absorbed by the 2001 amalgamation, Stoney Creek trickles out toward the flat wine country of Niagra-on-the-Lake, St. Catherine's and Niagara Falls beyond.

Hamilton has been on my doorstep for a good part of my life. I was born in Hamilton and spent my first years living up the mountain. My father went where the work was and we followed. We moved like gypsies around Southern Ontario before settling in Brantford, a post-industrial town just a thirty-minute drive southwest of Hamilton. My father was a sales man, a truck driver, a construction worker, a storeowner, an electrician, and most recently – like his father – a factory worker. Before heading off to university, I worked with him in the factory through my high-school years. It has been almost ten years now, but the smell of steel and the sheen of concrete factory floors still hold a special place in my memory.

I have only been inside the Rheem building once. It was Thanksgiving, and the security guard let me in. It was colder inside than out, only the lights at the front where we stood were on, and the shadows went up into the steel girders and swallowed the original wood decking in darkness above. I stood in awe of the structure and snapped a photo, underexposed and grainy. The concrete under my feet was dusty, yellow caution lines were still visible. Reflective yellow tape surrounded open pits and other hazards, glinting in the indiscernible breeze. The guard was lonely and he talked about his kids and family dinners. He told me that Jerry Bruckheimer's film scouts were here the other day taking pictures, location-scouting for a new WWII epic. I pictured computer-generated bombers dropping their payload onto the building's roof. The bombers would have the Ace of Spades painted on one side and a pin-up-style farmer's daughter on the other. The building would be demolished in Jerry's hands too, only it would be with pyrotechnics and CG physics and complicated smoke algorithms.

When I worked on the design for Barton Tiffany, I tried to avoid creating a master plan. Sure, I had goals. I wanted to reuse the buildings and make the streets pedestrian-friendly. But I didn't want to decide what it all would look like; I didn't care about the spacing of the plants or the colour, or shape of the buildings; that would be up to someone else. I only wanted to present to the community the information and potential that I could see. I made a 3D model of the district and panned over it in digital space. I chose views that showed latent potential. I wanted to illustrate the shape of the land and how future developments could leverage its characteristics.

Shawn asked me to create evocative renderings, illustrations to battle against the propaganda being issued from the city. He saw this project as a counter-planning measure. I assumed that he wanted me to illustrate a scene rendered with plants, flowers and people drinking coffee. I wanted that too, a little. The more I worked on it, however, the more I felt that what I really wanted was to enable the community to decide what it would look like. I didn't live in the city, I had no right to it. I couldn't fight for it if I wanted to. When it came to the pretty drawings I hesitated. I told him that I couldn't conjure a design out of thin air. I had to build it up to believe that it could work.

I produced the drawings and slides for the presentation with the hope that I could encourage the neighborhood to ask for more. They could demand a better Barton Tiffany from their planning department. I wanted to teach them just a little about architecture and urbanism. I wanted to enable them to take hold of their city and change it; to participate in its shaping and have ownership over it.

(Opposite)
**Fig 0.9 -** Interior Photo of Rheem Building. *Photo by Author.*


CAUTION

I worked on Barton Tiffany in the evenings, after work, dinner and dishes. For the better part of a year, I worked. It wasn't until the open house that my diligence slipped. I should have been recharged after that meeting. The energy from the community should have powered me into productivity. The ideas should have inspired iteration after iteration. But I didn't feel that way.

It might have been because of my previous architectural experiences, where co-op positions allow you to take a project only so far before handing it off to the next person. Or maybe it was my schooling: every four months cumulated in a final project – a caffeine-riddled marathon, where I spent my waking dreams in front of my drawing board producing my next masterpiece. A cathartic exercise repeated again and again four years running, my efforts pinned to a wall, judged for twenty minutes, then scanned, archived and never looked at again. Maybe I had simply hoped the community would carry the project forward.

It might have been a lot of things, but I think the main reason I slipped was because, beyond a certain point, I was powerless. Shawn and I were stonewalled by the city and its fiscal logic repeatedly, and I felt that no matter how many drawings I did, I wasn't going to be able to affect change, not with sixty signatures and certainly not on my own. I needed the whole community, a population, to be on board.

The site was razed between November 2011 and January 2012. At of the time of this writing, more than a year later, no development has taken place on the site. The site sits a bare gravel lot, with no plans for development, three blocks of urban desert between the city to the south and the CN shunting yards and waterfront to the north.

(Opposite)
**Fig 0.10 -** Photo of Rheem Building Demolition. *Photo by Author.*

**Fig 0.11 -** Photo of Rheem Building Demolition. *Photo by Author.*


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**Fig 0.15 -** Photo of Rheem Building Demolition. *Photo by Author.*

**Fig 0.16 -** Photo of Rheem Building Demolition. *Photo by Author.*

## *UNLOCKING ARCHITECTURE*

The destruction of buildings and cities has forced the issue. Whether by open war or the rationalized acceptance of violence, destruction has commanded into being, though it never intended to, the need for a radically reconstructed architecture and city. It did this by destroying the old ways, the old times, the old city and its fabric of civilized building and of civil life. It did this also by undermining the authority of institutions responsible for protecting the life of the city. They either failed, or contributed directly to the destruction, betraying their own purposes

–Lebbeus Woods, *Radical Reconstruction*. 1997 .27

## *A Flawed System*

The City is a commons, but the privilege of this commons is not shared equally. Power corrupts[1]. Cities and governments – like corporations – have profit margins and budgets and often make decisions based on the bottom line instead of on the best course of action or the needs of the people. Cities are built and destroyed for short-term gains. For instance, the majority of condominiums and suburban houses built today are designed and executed with the cheapest available materials and only allow for short-term occupation. The designers and developers give little thought to the ongoing maintenance, future renovation, expansion and reuse of these buildings, such that the vast majority of our shiny-new-glass-buildings and our stucco-covered-cardboard-homes, will be in need of expensive and drastic repair within the next twenty to thirty years[2]. The designers, developers, investors, and city governments who profit extraordinarily from these constructions will not be held responsible, financially or otherwise, for their inevitable failure. The cost of the failure will fall on the owners, the collective, and the State. Cities are destroyed, as with Barton Tiffany, for the same reasons: to avoid penalty for a risky investment, or to make way for more profitable short-term gains. Yet there is no mechanism for accountability and still the future occupant, and the collective bear the brunt of the stigma, trauma, and financial repercussions without any of the profit.

Alexis de Tocqueville, in his 1835 *Democracy in America*, states that in a democratic society the perception of history is devoid of agency; that the "people themselves (are deprived) of the power of modifying their own condition," leaving them subject to either "inflexible providence" or "blind necessity."[3] When democratic governments don't keep their promises, they often use this perception to redistribute the blame for their shortcomings on the population. This is done by placing the blame on budget cuts, or lack of public support, or insufficient funding from higher levels of government. The managers of these institutions – who hold power granted by legislature, certifications, and licenses – outsource their failure, distributing it among the people who had little say from the start.

On top of this disparity, cities hold the most responsibility for pollution and the degradation of the environment.[4] The artificial environment created by modern city planning, like Lewis Mumford's mine, isolates its populous "topographically and mentally from the organic world"[5] it depends on. The public's ignorance enables its mindless consumption of the natural environment. Car-centered city planning, another product of the corporate influence, that leads to unhealthy living conditions, less active lifestyles, smog, greenhouse gas emissions, and environmental degradation.

It has been said that in order to make impacting long-term positive change on the state of the environment, as many people as possible must make

**Fig 1.1 -** Condominium Development Toronto. *Colour altered by Author. Original Photo by Violet Sky, Nov 1, 2011. http://violetsky-wwwblogger.blogspot.ca/2011/11/2913260663.html.*

a distributed collective effort. It is a contradiction then, to politically disable most of the population, who live in cities,[6] to make those efforts. Yet this is exactly our practice today. Throughout cities in North America, the citizen effort to convert brown fields into gardens or paint its own bike lanes is nullified, destroyed or punished.[7],[8] Instead, we entrust the management of cities, the most important arena for curbing climate change, to a morally compromised bureaucracy, rather than the collective who can have the greatest influence and who bear the brunt of the consequences. The destruction of the environment is another instance where the fallout resulting from negligence is passed onto those with or no responsibility for it, our descendants.

The trust invested in the managers of our cities to act in the best interest of their populous, has been misplaced and abused by the few who stand to benefit. Public property is no longer public. The *corporation* of the city owns it and the populous, greatly ignored, has been lulled into a state of apathy, pacified by consumerism and oppressed by outdated by-laws and regulations. The public's command over the commons of the city, which could be the most direct avenue for positive social and environmental change, has been taken.

Architecture is not innocent; since the industrial revolution it has been slowly closing itself off. Ivan Illich writes,

> Paradoxically, the simpler the tools became, the more the medical profession insisted on a monopoly of their application, the longer became the training demanded before a medicine man was initiated into the legitimate use of the simplest tool.[9]

As industrial processes speeding the construction of the City, as the architect's role fragmented into a muddied assembly of town planners, traffic engineers, and homebuilders, and as the architect's foothold on the built form and the city began to erode, we retreated. We built walls, artificial limitations and protectionist measures like licenses, accreditations and certifications. We hid in the university and became an entertainment, a spectacle, a luxury for the rich and a service to be sold. In the public's eye, architecture has ceased to be the very fabric of space surrounding us and has become an object, like museums or churches, to be purchased by wealthy corporations, and institutions.

Architects have become a cogs in the production of space, turning land into buildings, space into more salable space. We upgrade the value of a property that is ill-suited to other forms of exploitation, by way of building. There is an apparatus that supports this system, processing students and making them fit to participate in and serve the machine: to build buildings to increase value for landlords: to produce space. Industrialization combined with globalization and its capitalist logic has led to this packaging of architecture, and has produced the formulaic building practices of today; where factories build

**Fig 1.2 -** Architect Developer Debate from The Fountainhead. Warner Brothers. *Source: http://archpaper.com/news/articles.asp?id=5795.*

houses ten at a time and condos are reproduced by template. It is only when a signature building or a unique landmark is desired that we are summoned to provide spectacle and stimulation.

We are not useful. Instead, we have become entertainment. Our participation has been reduced to a point where we find ourselves with little to do and nowhere to search for work.

## *Redefining Architecture*

During the Barton Tiffany Project I developed the desire to enable a community to take control of their environment and to affect the form of their city. I failed, and since then it has become my preoccupation: How do you enable someone, a group or a population, to take hold of their own environment?

In the course of my education I have encountered a number of definitions for architecture. The most common of these is that architecture is the shaping of space, but mostly pertains to the making of the built form: buildings. The definition of the city is more elusive. I have heard varied interpretations of what a city is, how it forms and how it operates. Some of these err on the side of mysticism, and imagine architects as shamans who offer their sacrifices to appease the Spirit of the City. Others consider the city to be the result of economic forces or of hapless emergence[10]: like mold, it appears out of the air, congregates and propagates, growing into a city. I have heard analogies of the city as a virus; useful when applied to the formation of the modern city and the endless growth of the North American suburb. As convenient as these definitions are for explaining the phenomena of the city, none of them allow for human agency.

The Mythology of the city's foundation also frustrated me. I believed the city was not the mere product of chance or divine intervention, but was instead a human endeavor, an example of cooperation, symbiosis, and collective effort. An act of human will. To me, it was made from components and pieces. I saw the complex arrangement of architecture, infrastructure, buildings and open space, the sum of which became a city.

Timothy Taylor, in his book *The Artificial Ape*, defines mankind today as almost entirely artificial: a product of our innovation and technology[11]. He divides the known universe into three parts. First, the inorganic and non-living comprised of rocks, minerals, water, and the periodic elements. Second, the organic and living organisms including trees, fish, plants, animals, and bacteria. The Third part being the man-made, technologies like agriculture, language, tools, machines, clothing, and even the human body.[12] For Taylor, technology enabled us to evolve and not the other way around[13] and his definition places architecture and the city firmly in the realm of technology, along with language, writing, books, hand axes, computers, and fighter jets[14].

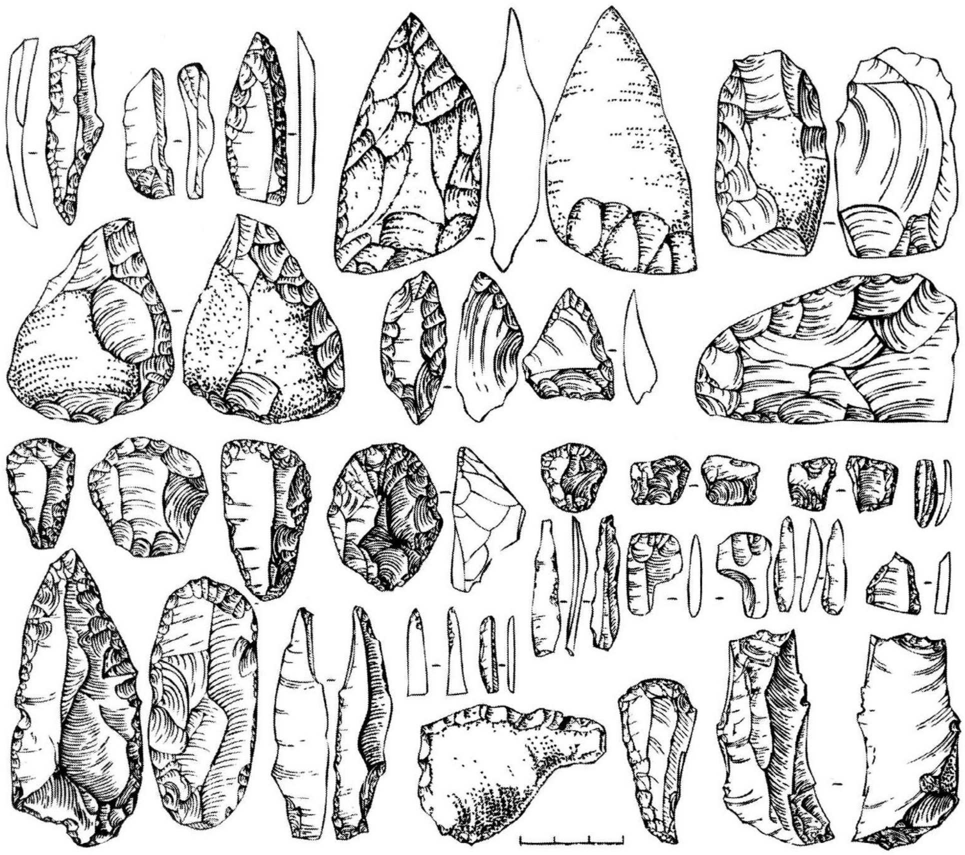

**Fig 1.3 -** The Stone Age in Ostrogozhsk area
*Source: http://donsmaps.com/lioncamp.html*

Architecture is a technology; a human construction that has enabled us to survive and settle every corner of the world. Architecture is a tool, a complex prosthetic, an exoskeleton that buffers us from the dangers and elements of the natural world. This elemental definition of architecture allows me lateral freedom in my attempts to empower others to take hold of their surroundings.

Technology can mean many things. In prehistoric time technology meant creating elementary tools and the advancement of civilizations; Stone Age, Bronze Age, etc. It can include items like a computer or car, but it can also refer to cultural constructions like education, healthcare, or currency. Technology is derived from the Greek *tekhne* meaning art or craft, and *logia* meaning oracle, word or reason.[15] These root words imply that technology is both a skill and its communication.

As a technology, architecture can be considered, both a tool for mankind, and a technique to be learned, mastered, and advanced, implying both a technical understanding – of beams, posts, windows, and gravity – and an act of creativity – form, flow, composition, and material expression. The degrees of competence and inspiration afforded by this definition enable us to imagine the potential amateur, the hack, the master, and the professional. Like the skills of reading and writing, there are those who understand and practice them at a basic level everyday and those who master them and are paid to do so. If we begin to think about architecture this way, we could make it informal and universal. The city would be realized by many people, groups and individuals, practicing that skill to create a habitat in which mankind has evolved to thrive.

In his 1973 book *Tools for Conviviality,* Ivan Illich states that basic human activities like child-rearing, homebuilding, and education, have been taken from the average person and are controlled by a growing technocratic elite[16]. During the Barton Tiffany project the technology and basic skill of city building – even when considering publicly owned property – was denied to the community and controlled by bureaucracies.

David Harvey, in his essay *The Right to the City,* stresses the need for people to exercise the skill of making their own place. This act itself engenders a commitment to the commons of the city, cooperation between individuals and groups, and a greater sense of belonging. Harvey asserts, "The freedom to make and remake our cities and ourselves is, […] one of the most precious yet most neglected, of our human rights." [17]

In order to exercise a skill or use a technology, someone first has to be made aware of its existence and its implications. Architecture, urbanism, and the act of city making, when removed from the public forum, exists as a ubiquitous yet nearly opaque technology. How can the public possibly exercise their "right to the city"[18] without first acquiring

**Fig 1.4 -** Aerial Photo over Galt, Cambridge Ontario. *Photo by Author.*

architecture as a skill? It is necessary that the public learn architecture before they can exercise this right.

Learning brings into question different models for education, or the transfer of knowledge. There is apprenticeship, where a master trains a pupil in the many intricacies of the craft, by way of example, hands-on instruction, and iteration.[19] Apprenticeship enables the direct transfer of knowledge and experience from master to student.

Another model is the classroom. Favored in modern educational systems, the industrialized method of classroom teaching uses a single instructor to provide an education simultaneously to a large number of students. The teacher instructs the class, while practice and testing ensure that students embodies the information. This model provides an insulated environment to teach and test concepts, but it lacks a meaningful exchange of information, and any diversity of education, from student to student.

Ultimately, meaningful learning is not the result of teaching, but is achieved informally by way of personal experience,[20],[21] peer-to-peer guidance, trial-and-error, and self-driven curiosity. This is only possible when there is both an incentive and accessible information. Formal education systems provide incentives with grades, discipline for poor performance, and promotion, while information takes the form of the master, the teacher, and the library. Informal education requires a need or desire learn and free access to information. Combine access to information with an opportunity to apply it in a meaningful way and informal learning is possible. When such a circumstance persists, and the task proves rewarding or necessary, iteration is possible, allowing eventually, for mastery and invention.

Considering the challenge of enabling the public to learn the skill of architecture – and the cost of a formal architectural education in today's universities – the only feasible path is to facilitate self-guided learning. Which begs the question: what circumstances, opportunities, and access to information allow for the discovery and practice of architecture by a substantial portion of the population? How does one enable a person, a group or a citizenry to educate and ultimately empower themselves in architecture and urbanism?

## *Tinkering*

Two weeks before I was to leave on my trip I decided to build the Kite Aerial Photography rig. I had seen a few different versions online; some using carbon fiber and others using plastic pop bottles, but I had aluminum laying around. I needed to make a kite, hack a digital camera to run a script, alter a couple of hobby servos, build the rig, and make a picavet suspension too keep the rig level in the air, all in two weeks. I found kite instructions online[22] and bought some nylon at a local fabric store. My partner Lindsey

When you grow up you tend to get told the world is the way it is and your life is just to live your life inside the world. Try not to bash into the walls too much. Try to have a nice family, have fun, save a little money. That's a very limited life. Life can be much broader once you discover one simple fact: Everything around you that you call life was made up by people that were no smarter than you and you can change it, you can influence it, you can build your own things that other people can use. Once you learn that, you'll never be the same again.

–Steve Jobs, *Steve Jobs: One Last Thing*, 2011.

and I spent a Saturday cutting and sewing. She knew how to sew and showed me the basics: how to allow for seams, pin the fabric, thread bobbins and needles, and how to run the machine. By the end of the day, I hade a blue three-celled parasled kite that draped the dining room table and made the room glow blue.

The Camera was Lindsey's Canon point-and-shoot; it was clunky and pink and didn't get much use. But online the camera saw a good deal of hacking action. I found the Canon Hack Development Kit wiki page, an online community dedicated to hacking Canon cameras.[23] I downloaded free software from the wiki site, which enabled me to format and install programs on SD cards. I chose the scripts that suited my camera model, unlocked the card, installed them and popped it into the camera. After a day of trial-and-error, the camera was taking pictures on its own. The intervalometer script I installed allowed me to set the delay in seconds and it would force the camera to automatically adjust its focus, exposure and aperture before taking a photo every few seconds. This new function would enable the camera to take pictures from the kite, without needing extra remotes, triggers or inputs.

Altering the hobby servo was next. Hobby servos are designed to rotate only so far before stopping. A small electric motor turns nine or ten tiny gears that translate the fast rotation of the motor into a slow high-torque movement of the arm. A potentiometer, pot for short, linked to the rotation of the arm provides a varying voltage resistance throughout the arm's rotation. A circuit board interprets the voltage resistance from the pot on one end and a pulse-width modulation, PWM, signal from the receiver on the other. Using these two readings, the chip determines in which direction to rotate and when to stop and hold the motor. I knew none of this when I opened the small black case. I removed four tiny, long screws and found a jumble of wires, a small black chip, and a cluster of gears. One of the gears had a physical stop on it, a fail-safe to keep the servo from over-rotating and damaging the pot. I removed it. The pot would also restrict the movement of the arm so I forced it past its limit. I re-assembled the servo to find it didn't work properly, rotating as soon as I plugged it in.

I searched the Internet for 'how to alter a servo for infinite rotation' and found detailed instructions on a hobby forum.[24] These covered everything from choosing a good servo to what it could be used for afterwards. I followed the steps and learned how the servo worked. I was right to remove the stop and the pot, but what I was missing was an understanding of the circuitry. I needed to trick the chip into thinking the pot hadn't moved and was in a constant neutral position. I could do this with two identical resistors located where the ends of the pot once were. The two resistors would emulate the neutral resistance reading provided by the pot. I would have to get the right resistors and would need to learn to solder, now with less than a week before our scheduled departure date.

Universal education through schooling is not feasible. It would be no more feasible if it were attempted by means of alternative institutions built on the style of present schools. Neither new attitudes of teachers toward their pupils nor the proliferation of educational hardware or software (in classroom or bedroom), nor finally the attempt to expand the pedagogue's responsibility until it engulfs his pupils' lifetimes will deliver universal education. The current search for new educational funnels must be reversed into the search for their institutional inverse: educational webs which heighten the opportunity for each one to transform each moment of his living into one of learning, sharing, and caring. We hope to contribute concepts needed by those who conduct such counterfoil research on education – and also to those who seek alternatives to other established service industries.

–Ivan Illich, *Deschooling Society*, 1971. xix.

I found resistors at the local electronics store, but I had never soldered anything. I looked up “how to solder” on YouTube and found dozens of videos of people – high-school kids and professionals – all describing how to solder; how to tin the tip of the iron, secure parts, solder them and unsolder mistakes. I followed their instruction and practiced first with some scrap wire and eventually soldered the resistors to the chip and reassembled the servo. The hack worked and the servo rotated infinitely, twitching a little to one side; I used the trims on my radio to fix it. Now when I moved the controls, the servo would respond, continually rotating until I released the controls, stopping and holding its position.

The rest of the rig and assembly went easily enough and the kite and fig flew beautifully, and we got dozens of aerial photos of the prairies to show for it. The kite and rig was my gadget, my own tool, a device whose structure and function I knew intimately. This feeling was new to me.

## New Tools for Empowerment

In his 1971 book *Reschooling Society,* Ivan Illich blamed the school system for arbitrarily limiting the potentials of individuals to defined social roles arguing the educational system only sought to perpetuate its own power. Illich argued that the institution of education also institutionalizes society by mass-producing minds, which otherwise would have been unique.

In his next book *Tools For Conviviality,* Illich called for the development of new tools:

> Give people tools that guarantee their right to work with high, independent efficiency.[25]

When I read Illich’s second chapter, “convivial reconstruction” early in my thesis, his words expressed all of the frustrations that I was feeling. My experience with the Barton Tiffany project left me questioning my capacity as an architect to generate positive change and I wanted these new tools. Sometime after, maybe during the process of soldering servos and flying kites, I began to realize that the tools he called for existed and that I used them daily. I saw these new tools and systems emerging online in forums and communities.

There is an empowering nature to the Internet, allowing anyone to conduct his or her own education, and in doing so, change the world. The nature of the Internet allows for social exchange, and the sheer volume of the online population makes this exchange diverse, and powerful. I see it as a watershed force, like the manipulation of fire or the invention of language.

Like language, the web is a communication technology. It connects people all over the world and allows for the fluid exchange of information across physical, social, and cultural barriers. The online population is extremely dense, with people existing

**Fig 1.5 -** Mass Produced Man: Screen Shot from Pink Floyd's movie *The Wall* - Alan Parker. *Source: http://www.ebertfest.com/twelve/thewall.html.*

in close proximity with to another; a recent statistic states that there is only 3.74 degrees of separation between any two of the 800 million Facebook users.[26] This density is beginning to cause the development of a variety of phenomena like the concept of an idea going 'viral". A Virus, like a common cold or the flu, moves quickly in a dense urban population, infecting thousands of people in a short time. Online ideas are able to do the same. An interesting or entertaining idea can pass from person to person at a speed never seen before.[27]

The contagious nature of ideas online provokes another phenomena: *information overload*. This is quite simply, the result of too much information. A person is bombarded with ideas, conflicting points of view, interesting articles, or pressing issues, and can be overwhelmed by the incoming information. Sometimes this overload can lead to a retreat by the individual, where avenues of communication are closed off. However most of the time the overload leads people to subconsciously control who they receive information from, limiting who they come in contact with. Many web portals, social media sites, and blog services now enable the user some level of control over their information intake. These services include the ability to choose which people and celebrities to follow, which twitter feed or blog stay up to date with. This allows users to curate thier own information streams. These self-curated sources are often composed of people with whom we agree, family and friends with similar interests and perspectives, or people we find inspiring, like scientists, artists, authors and activists.[28] This curation of information sources generates self-reinforcing online communities, where ideas are shared with other like-minded individuals within a close online population.

The Internet allows for the organic emergence of online communities. They form almost instantly as people cluster around a topic or issue without any formal organization. They emerge from diverse topics – social issues, popular cultural phenomena like music, games, movies, philosophies, schools of thought – or around a person, or a blog, a hobby or a basic skill. These communities occur over a shared interest and thrive through open social exchange and our co-operative human nature. These growing online communities signify the formation of a new tribalism, one not based on skin color, geographic location, heritage, social status, or dialect. This new tribalism is formed out of shared interest and often come without the destructive and exclusive tendencies of traditional tribalism. In fact, the anonymous and non-temporal nature of the online presence makes it possible for one person to be part of hundreds of online communities simultaneously, subscribing to news, contributing ideas, participating in discussions and influencing peers.

The open nature of this neo-tribalism allows for overlap between previously unrelated groups. This cross-pollination of experience and expertise generates new correlations and possibilities.

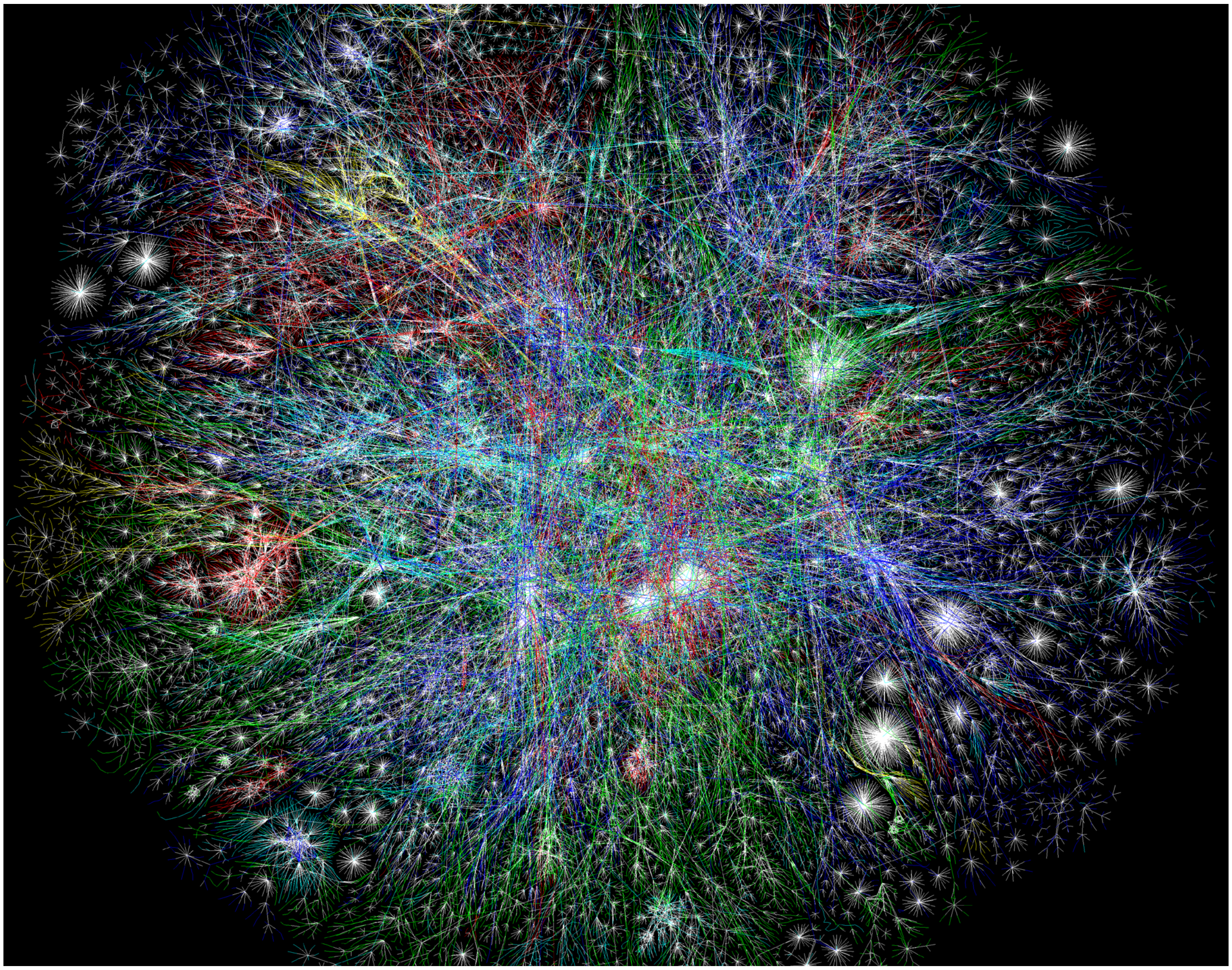

**Fig 1.6 -** Opte Project : Visualization of the Internet. *by Barrett Lyon. Source: http://www.visualcomplexity.com/vc/project_details.cfm?id=70&index=10&domain=Internet.*

Sometimes these overlaps spin off to form new hybrid communities, inventing new markets, products, technologies, and inadvertently revolutionizing a society. Take, for example, the overlap brought about by model aircraft hobbyists, hackers, programmers, photographers, GPS specialists, and smart phone enthusiasts. Their mixture has birthed the explosion the DIY Drones community, a community that now possesses more drones than the United States Military.[29] The DIY Drone community is at the forefront of low-cost-remote-unmanned-vehicles, enabling thousands of individuals to share designs and create awareness about drone politics and policy.

The Internet allows for sharing and archiving of information that can be accessed by others around the globe. The binary nature of digital information allows all of our complex communication tools to be translated into data packets. Books, writing, images, film, language, even gestures and emotion can be captured and translated into strings of code, data which is representative of our newly evolved communication constructs.[30] This data is then inscribed onto servers, harddrives, DVDs, CDs – bits of plastic and rare metals – and stored for an indefinite amount of time. These technologies are capable of storing vast amounts of information with minimal investment of energy. The data can then be transmitted to any other connected node and accessed, shared, viewed, published, or projected at anytime.

Not only can our most famous and influential cultural works be archived and distributed digitally, but the Internet enables anyone with a computer or cell phone to publish and share his or her own work and experiences. Social media aside, the web is full of people documenting their professional and amateur endeavors. Whether they document their home improvement projects, or how they make a healthy breakfast, people are sharing knowledge, experience and information. Blogs, forums, and websites of all kinds aggregate into a vast depository of openly-shared experience, stored on local computers and in huge datacenters. Search engines and web-portals allow anyone, at anytime, to find these experiences by asking a simple question, like "how to make an omelet".

The "how to" query can now be applied to almost anything and instruction will be provided, such as how to build an aerial drone, or a laser cutter, or a revolution. I have learned a number of new skills in this fashion, watching YouTube videos, reading project blogs and browsing online forums, resources freely shared by people around the world. I learned spoon carving, costume making, welding, model airplane building, programming, even basic video editing, all from free Internet sources. Each new skill creates new possibilities, new materials to work with, new programs to use, new things to make. It's harder now to buy things I could easily make myself: furniture, spatulas, children's toys, coat racks, laptop

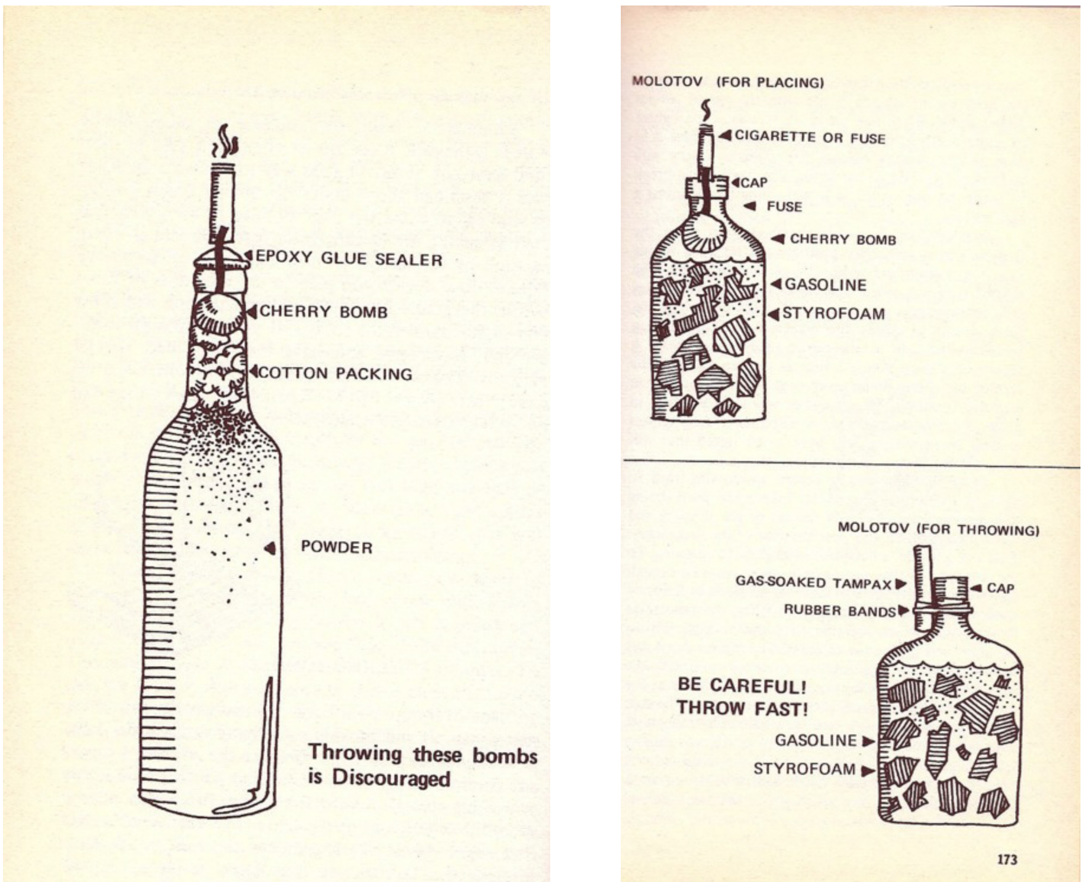


**Fig 1.7 -** Drawings of How to make a Molitov Cocktail and other DIY hand thrown fire Bombs *by Unknown, Source: http://iamanantichrist.tumblr.com/post/16838297230.*

stands, entertainment units, portable radios, model aircraft and quadrocopter frames. Before paying for it I ask myself: can I make this? In this way, I have trouble accepting things as they are. I want to fiddle and tinker with everything I own, to customize things to my liking or twist their function just to learn. Part of this perspective I owe to my education as an architect: it induces the desire to affect change, improve the world and design things for others and myself. But the ability to execute those designs on my own would not have been possible without the resources and information freely accessible online.

Instruction online often takes the form of an example: a cook shows you how to beat an egg, or an engineer demonstrates soldering a resistor. These examples come in various forms, from live action YouTube videos, to detailed written instructions accompanied by photographs. Often, the tutorial takes the form of a project that the author has undertaken and documented at each step of the way. Arrows and headings point out areas of attention or mistakes to learn from. The website *Instructables.com* is an online forum built to allow people to upload example projects or as members who freaquent the site call them "*ibles*". The *Instructables* community is made up of all kinds of people from aeronautical engineers to stay-at-home parents, each with different resources and different expertise.

Projects shared on *Instructables* are viewed and reviewed, one project often spawns a series of spin offs that refer to, but improve on the original "*ible*". Perhaps they substitute a different type of flour in a bagel recipe, or refine a gear ratio, or apply the whole principal to something completely different. Within this online community, it becomes possible to track the evolution of a project, beginning as a simple idea, a jumble of salvaged parts or lines of code, and with each iteration the idea is expanded upon, and refined until the finished prototype looks and operates at a professional level. The most recent "*ible*" then continues to be refined or applied elsewhere.

*Instructables* could be thought of as a crowd-sourced iterative product design community, a place where ideas and projects are offered up to the mob on the Internet, and tested. The Internet allows for people to learn from others' examples while at the same time, by way of sites like *Instructables*, provides fertile soil for the rapid evolution of projects, products, concepts and ideas. As a medium for the free sharing of ideas, which allows for self-guided learning and co-operation, the Internet is revolutionizing the way humans transfer knowledge and learn.

*Instructables* is one of the many online communities where users learn and share how to make things. The communities that surround *Instructables*, and other sites like it, call themselves *Makers*. In my experience with these communities, I have observed that Makers are generally people in post-industrial societies like North America and the UK, who are


**Fig 1.8 -** Whole Earth Catalog's Legacy, *Logos assembled by author. From top Right: Open source Ecology, Sparkfun Electronics, Anonymous, Linux, Make Magazine, YouTube.*

frustrated with their own inability to make things for themselves. They have come to realize that they are dependent on the apparatus of consumerism, and have little ownership over the things they both enjoy and upon which they depend. In response to these shared feelings, Makers began meeting online to share expertise and learn from others. Learning to make things and taking ownership over things you own is empowering and generates an intoxicating enthusiasm, this energy attracts more people to the movement, creating a self-reinforcing cycle of learning, doing, sharing, and teaching new-comers. This cycle has grown into the *Maker Movement.*[31] Some are calling it "the next Industrial Revolution", because the Maker, who has become both the producer and the consumer, circumvents the apparatus of production and consumption. Combined with distributed manufacturing – making your own stuff in your garage or basement – Makers are creating a new informal economy through collaboration between individuals.[32]

Makers are the latest evolution in a line of self-empowered characters that began in the post-war suburbs. The *Do It Yourself*-er emerged as a result of isolation, and a need to be in some way independent. The DIYers were encouraged and assisted by *Popular Mechanics* magazine, an educational conduit for spreading information, tips, and how-tos for maintaining lawnmowers or building a birdfeeder for the back yard.

The next character in this loose lineage emerges in the heat of the counter-cultural revolution of the late 1960's. The *Back-to-Landers,* aka the *New-Communalists,* revolted against post-war corporate America and the isolation of suburban life – retreating into the wilds of the rural American landscape.[33] The Back-to-Landers sought to empower themselves through small-scale technologies and new forms of co-operative hierarchies, free from the control of 'the system'. Stuart Brand, who founded and published *The Whole Earth Catalog,* assisted in their endeavors. Like *Popular Mechanics*, *The Whole Earth Catalog* also served as a conduit to spread ideas and educate the Back-to-landers. The catalog developed with the goal of providing access to information – access to tools – to anyone who desired them[34]. A low cost subscription featured mostly user-generated reviews of products, books, and methods. Like *Instructables,* the catalog sought both to connect people and empower them to make things and educate themselves. It encouraged them to find independence and autonomy; freedom from the corporate dependency emerging in that post war era, freedom from big industry, big government, big business, organized education, organized religion, and the regimentation of the American Family.[35] Stuart Brand believed that a grassroots power could be obtained through self-education and self-organization.[36]

Ivan Illich was writing *Reschooling Society* and *Tools for Conviviality* during the height of the *The Whole Earth Catalog* and the Back-to-Land

I think that hackers- dedicated, innovative, irreverent computer programmers- are the most interesting and effective body of intellectuals since the framers of the U.S. Constitution.. No other group that I know of has set out to liberate a technology and succeeded... the quietest of all the '60s sub-subcultures has emerged at the most innovative and powerful.

-Stuart Brand, quoted from Levy, *Hackers,* 1994. 431.

movement. Unlike the new communalists, who retreated from society, Illich's books called for engagement – a re-invention of society and its tools and systems at large. His call didn't go unheard. In the halls of Berkley, another character heard his call and saw its potential realization in the nascent stages of the computer revolution and a military communication project that would later become the Internet.[37]

Hackers, are next the in the lineage. Early Hackers, the likes of Lee Felsenstein of the Home Brew Computer Club, sought to democratize the computer in order to build the system that Illich had called for – peer networks and learning webs.[38],[39],[40] Like the Back-to-Landers' geodesic domes, Hackers appropriated a military technology to facilitate empowerment, collaboration, and self-guided education. Hackers, in building the Internet, built the new tools that Ivan Illich had called for 40 years ago – tools we now enjoy and are just beginning to explore and understand.[41]

## *The Hacker Ethic*

Stuart Brand, founder of *The Whole Earth Catalog*, organized the first Hacker convention in Northern California, and applauded Hackers as a new power. It's important to pause here to define 'Hackers' as something other than what has come before and after. I believe the Hacker persona is one that architects could benefit from embodying. In the previous section of this essay, I traced the lineage of Makers, through the likes of the DIYer, to the Back-to-Lander, and the Hacker. But I need to make a clarification: each of these characters represents a different stage of dealing with a system – society at large – that is broken. The DIYers are internal to the system; a part of it, and largely oblivious to it. Their self-taught competence is a way of coping with isolation while struggling to maintain some measure of control over their own lives. The Back-to-Landers left the system; sought freedom by being apart from it, outside of it, in their communes. Makers are the goal; they are what comes after a system is unlocked and democratized. They are self-governing, self-empowering, and self-reinforcing. Hackers, however, are an integral step in this chain of evolution. First, Hackers built the infrastructure – the Internet – that allows for free sharing and self-education, which facilitates the Maker movement. But perhaps more importantly, and unlike the others in the lineage, Hackers *engage* the system. Regardless of artificial laws, rules or barriers, Hackers, by their nature, confront the system.

The Hacker culture has spilled out into society at large, enabling the rise of ubiquitous computing, the Internet, and the information revolution movements that are actively renovating every facet of society. Their culture is changing the face of countless industries, democratizing technologies and enabling self-directed education. During our time the Hacker culture has become a full-blown social movement, with many tribes, sects, and subcultures. The energy from this movement is palpable as its numbers grow, and its ideals continue to spill out into the world. It can be leveraged to democratize the technology of architecture, and re-democratize the shaping of cities.

Today's Hacker cultures are built on the foundations of the Hacker Ethic originally developed in the Train Model Railway Club and the halls of MIT's Artificial Intelligence Lab.[42] The Ethic invokes a few simple principles: sharing, openness, decentralization, free access to information, and world improvement.[43] Steven Levy, in chapter two of his 1984 book *Hackers: Heroes of the Computer Revolution*, explains the Hacker Ethic in detail.

Sharing has been converted to the more ubiquitous hackerism: "all information should be free".[44] Similar to tools, information needs to be accessible for the Hacker to able to learn from it, fix it and improve it. Hackers knew from experience, dealing with the onerous magnetic tape reels and punch cards or early computing and programming, that the free and easy exchange of information led, overall, to greater creativity and better systems.[45] Like Stuart Brand's and Ivan Illich's *tools*, *information* refers to all forms of systems the desire to free information is a call for greater transparency of those systems, not for the sole purpose of accountability, but instead, for the ideal of improvement.

Openness is deeply rooted in the Hacker Ethic. It is the core belief that *Hackers should only be judged on their actions and their ability to hack*, not on criteria such as age, sex, race, social position or certification.[46] The Hacker culture is a *do-ocracy* wherein your renown, participation and influence is based only on your actions and abilities, on the things you do. Ironically, this has less to do with equality and more to do with a person's potential ability to improve and advance a program or system.[47]

Decentralization, a product of sharing and openness, where projects are created by a distributed effort, became not only a method for hacking and programming – giving rise to the principals behind the open source movement, but also refers to the *systemic distrust of authority* that the early Hacker culture came to embrace. Authority, as they learned with the Department of Defense and MIT's administration, always seeks to control information. Hackers believed that bureaucracies of all kinds were flawed systems, focused only on self-perpetuation.[48]

*Access to computers should be universal*. This concept has been expanded to include anything that can teach you about how the world works: such as tools, ideas and systems. [49]It parallels *Whole Earth Catalog*'s mantra, *access to tools,* in order to allow for hands-on learning. Levy wrote that the Hackers' ability to take things apart enabled them to learn about those things, to fix and improve them.[50] The ability to dismantle, reconstruct and repurpose systems became the principal means for learning in the Hacker world.

Throughout Levy's book *Hackers* he refers to the logic and operation of the computer, the innate nature of the machine, as the primary inspiration in the development of the Hacker culture. The simple act of working with computer technology and the medium of programming code, having control over its functions and exploring its applications for both serious and pleasurable endeavors, was empowering in itself.[51] Architecture, the creation and manipulation of space, the evolved technology of city making, has its own empowering and liberating logic and can, like the computer, drive the establishment of its own open culture and inherently empower its users.

Hackers emerged because a group of inspired individuals had access to a tool, the computer, which empowered them so much they were driven to share it with the hope that it might also empower others. Access is the first step in enabling empowerment. In the book *Tactical Urbanism,* Mike Lydon wrote:

> Citizens are typically invited to engage in a process that is fundamentally broken: rather than being asked to contribute to incremental change at the neighborhood or block level, residents are asked to react to proposals that are conceived for interests disconnected from their own, and at a scale for which they have little control.[52]

Lydon then call for and outline a number of ways that citizens and neighborhoods can engage in the shaping of their own cities at a smaller, more intimate, scale. This participation, they write, empowers the citizens by building trust, cooperation and local action networks.[53] The initiatives cataloged in *Tactical Urbanism* serve as an example for the initial steps of empowerment. Like a child learning to create through guided crafts, people are able to participate in the shaping of their environments, using these successful examples for community engagement.

In order to learn about a system or a program, a Hacker will often probe it and tinker with it, often intentionally breaking and reconstructing it. Levy writes:

> Hackers believe that essential lessons can be learned about the systems – about the world – from taking things apart, seeing how they work, and using this knowledge to create new and even more interesting things. They resent any person, physical barrier, or law that tries to keep them from doing this.[54]

The city is a complex system and, unlike a computer program that can be copied, archived and "backed-up", it is a living technology, where changes, tweaks, and breaks happen in real time and can have immediate effects and consequences. Due to its organic nature, the city, however, is able to adapt and can continue to function, even in the presence of a disturbance. When a street is closed, traffic is divided along surrounding avenues. The resilience of cities enables immediate feedback on the success or failure of an alteration. When encouraged at the neighborhood scale communities could be empowered to learn how their neighborhood operates, in order to control it for themselves.

There is also another essential lesson hidden in the Hacker mindset of deconstruction and reconstruction: the act of mimicry. Children learn by mimicking their parents and others around them. By deconstructing an object, program or building step-by-step, you can learn, in reverse, how it was assembled. You begin with a functioning assembly of parts, and as you remove its cover and loosen some bolts, the whole returns to its components, and you begin to understand what connects to what. In this way, an example can be read, its logic exposed, as the hacker learns how it was made, and how it might be remade. Fundamental to this process is the art of taking something apart so that you are able to learn about it and reuse it, rather than destroying it.

Eric S. Raymond, in *Cathedral and the Bazaar,* provides the Hacker proverb;

> A good programmer knows when to write, a great programmer knows when to rewrite and reuse.[55]

Too often, new buildings require the destruction of old structures or the demolition of large areas to provide a clean slate. But a great architect channeling the Hacker ethic would see potential for the reuse of existing structures, and creatively adapt the armatures in place to suit a new function. If this process of reuse happens often enough, an old structure could change organically with the needs of its users and avoid demolition altogether. The destruction of old buildings is a throwaway mentality applied to the largest of human constructions, and represents a phenomenal waste of resources, making buildings the largest and most damaging consumer product.

If as a society we could cultivate an eye for reuse, like a Hacker or Maker, seeing inherent potential in obsolete technologies or discarded materials, we could avoid this waste and develop a skill, and a language for disassembly, reuse, and rearrangement. We could we alter the perception of architecture – objectified, static, and sacred – into the more plastic medium that more accurately describes it, made up of components, and materials that anyone can learn to manipulate.

Sometimes, as Raymond admitted, you have to write something new. When Hackers and programmers make something new, they often do it in a way that will allow others to understand its logic, learn from it, and be able to reuse, rearrange, and reinvent it. A common practice in programming code, new or hacked, is to leave comments, a kind of *metadata*, greyed beside the function, that explain its operation, its logic and the thinking behind it. They allow another Hacker or programmer, later, to understand the operation and implications of a line of code.

One way we can be responsible for our decisions, and considerate of future users, is to allow future generations to understand our reasoning for doing, making or changing something in a particular way. The implications of this practice are manifold. Understanding why a decision was made allows a user to question whether that logic continues to be valid, and if it is still necessary or applicable. This transparency allows future decisions to be made with confidence, without worrying about unforeseen repercussions. Embedding this reasoning into our cities and buildings is now becoming possible through the digitization of spacial information: geographic information systems building information modeling software, ubiquitous computing and emerging technologies like augmented reality, and cloud computing. The intersection of these technologies, along with an agreeable digital file format, could create what might be called *Building-Meta-Data*, radically altering the way cities evolve.

This legacy of information left behind for future users is another way we could demystify architecture. A client in a previous renovation project, lets call her Molly,[56] would constantly ask why were doing things in particular ways – why we placed windows where we did, or laid out furniture in a room, or how we designed stairs, landings and handrails. Like a child who loves the question 'why' and wont stop asking it. Molly paid for a house but received an education, and so did we. About half way through the project a funny thing began to happen. Molly began to make incredible suggestions based on how her family operated, pushing our design further and customizing the house more and more to her own liking. The project improved greatly, not only due to the client's curiosity and suggestions, but also by making us consciously aware of why we were making decisions that we usually made by rote, instinct or personal preference. By being aware of why we made these moves we were able to question them and decide their merit and applicability.

As a direct result of her questioning, Molly achieved a greater understanding of the logic of the home, hopefully, making it easier for her to maintain and improve it in the future. I believe that this kind of understanding leads to a greater sense of ownership, and in turn increases an owner's commitment to it and his or her sense of belonging in it.

I would like to see architects embrace the Hacker Ethic and the open exchange it entails. The first step would be to jettison any sense of entitlement and ownership over architecture, granted by certifications and fancy words, in order to engage the public locally and intimately, on terms and at a scale that is meaningful to them, it could then be possible to enable the public to learn about architecture and value it – and us.

In every Hacker community there are specialists, people who offer profound insights into problems, projects, and skills. Sometimes they are the masters

**Fig 1.9 -** Screen Capture from *Watch Dogs* trailer E3 2012.
*Ubisoft, source: http://www.youtube.com/watch?v=1U8KsQPIrY0.*

of welding or soldering, or those who know and understand hardware and circuit boards, or those who can program in a dozen languages. Often this leadership is embodied in one person. A leader and a guide in the world of gadgetry, machines and computers, the leader spends more time showing, demonstrating and teaching than he does doing these tasks himself. The leader is the enabler. Sometimes he has been formally educated in a school or taught by someone else, but more often he has no prerequisite certification other than experience, practice, and prowess.

The role of the architect in an open-source city, a democratized architectural world, is that of the enabler, the teacher, the leader of the built environment, passing on the skill of architecture to the public and community. In doing so architects would again earn respect and renown, not from arbitrary certifications, but instead from skills, actions, insights, prowess, abilities to hack the city, manipulate the material nature of the built environment, for need, enjoyment, and betterment.

The goal of the Hacker Ethic with its consideration for future users, it openness, and subversive demeanor, is to build an empowered society and allow others to learn from and improve upon what you have done. It's about educating others and passing on your knowledge directly, through the things you have made. This disposition may have evolved out of early computer programming practice, or maybe from the turbulent circumstances of the computer revolution. The rapid pace of improvement and reinvention caused early Hackers to assume their work would face imminent change and constant reinterpretation as they themselves drove the technology forward. Imbedding information in their work allowed the construction of a shared consciousness, where the transference of knowledge and discovery, like an ant leaving pheromones for other ants to follow, could be fluid, simultaneous with the acts of learning, creation, and recreation.[57] In constructing this medium, this tool, this collective language, they also constructed a culture, an ethic, an agreed upon logic of terms, that has allowed them to improve and democratize a technology. These new tools for collaboration and communication evolved with a technological code for the transfer of human knowledge and experience. The cooperative culture that emerged from this evolution, Hackers, can now be applied to other aspects of the human endeavor, in this case the democratization of architecture and the city. In order to evolve architects must channel the Hacker Ethic, embody the Hacker, and embrace the open exchange it enables. Only then can architects join the effort remake the world.

(Endnotes)

1 Sophocles, *Antigone*, lines 295-303, 442 B.C.E.

2 CBC news Toronto, *Throw-Away Buildings – Toronto's Glass Condos*. 2011.

3 Tocqueville, *Democracy in America*, 70.

4 Waste from construction, renovation and demolition represents one third of solid waste sent to landfills in Canada. Source: Public works and Government Services Canada. *The Environmentally Responsible Construction and Renovation Handbook,* 201201-03.

5 Illich, *Tools for Convivialiyy*,29.

6 United Nations, *Urbanization.2011.*

7 Gordon, *LA's South Central Farm Shut Down and Bulldozed*. 2006.

8 Doolittle, *Bike Activists going Guerrilla*.2007.

9 Illich, *Tools for Conviviality*.1.

10 Johnson, *Emergence.* 113.

11 Taylor, The Artificial Ape, 7.

12 Inib, 5.

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18 Ibid.

19 Sennet, *The Craftsman.* 55.

20 Illich, *Deschooling Society*. 13.

21 Wilson, Frank. *The Hand,* 13.

22 Rudolph, Double Parasled.

23 CHDK-Wiki, CHDK in Brief Wiki.

24 Seatle Robotics Society, *Hacking a Servo*.

25 Illich, *Tools for Conviviality,*10

26 BBC news, *Facebook users average 3.74 degrees of separation*.

27 Gladwell, Tipping Point, 7.

28 Kramer, *Astrophysist Neil deGrasse Tyson Joins Twitteratti with 1 million followers*.

29 Anderson, *Wired* "Here Come the Drones". 110.

30 Dyar, *Interview with Mckenzie Mason Motion Capture Actress*.

31 Anderson, *Makers: The New Industrial Revolution*.

32 Ibid.

33 Turner, *From Counter Culture to Cyber Culture*, 4.

34 *The Whole Earth Catalog.* 1.

35 Roznak, *The Making of a Counter Culture*, 6.

36 Turner*, From Counter Culture to Cyber Culture*. 75.

37 Levy, *Hackers: Heroes of the Computer Revolution*, 181.

38 Ibid,182.

39 Crosby, An Interview with Lee Felsenstien.

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42 Levy, *Hackers: Heroes of the Computer Revolution*, 35.

43 Ibid, 49.

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45 Ibid, 40.

46 Ibid, 43.

47 Ibid, 43.

48 Ibid, 41.

49 Ibid, 40.

50 Ibid, 40.

51 Ibid, 46.

52 Lydon et al. *Tactical Urbanism*, 1.

53 Ibid.

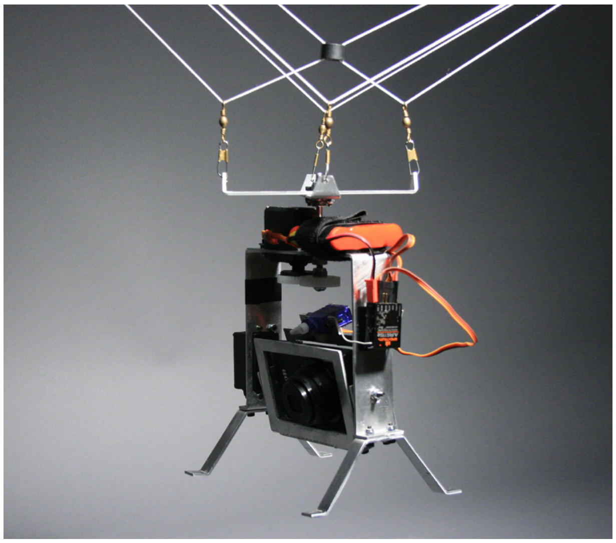
54 Levy, *Hackers: Heroes of the Computer Revolution*, 40.

55 Raymond, *The Cathedral and the Bazaar*, 4.

56 Molly's name has been changed for confidentiality.

57 Johnson, *Emergence.* 75.

## *TRIAL AND ERROR*



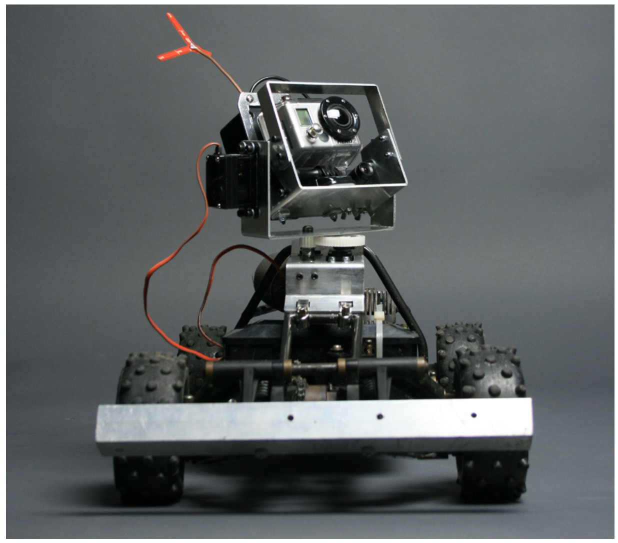


**Fig 2.1 -** The Kite Rig. *Photo by Author.*
**Fig 2.2 -** The Car. *Photo by Author.*

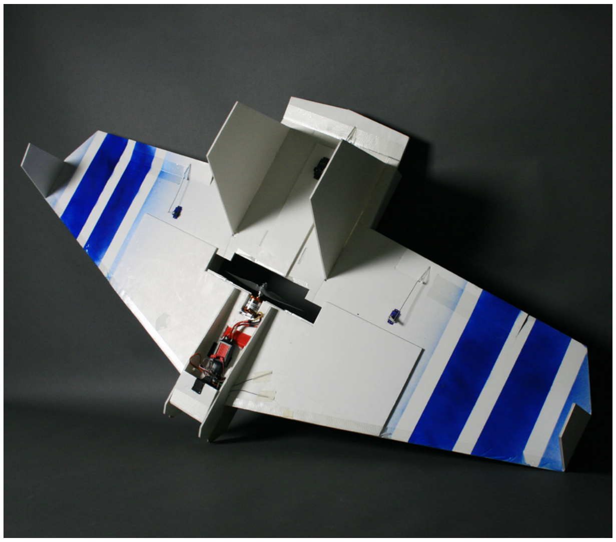
 

**Fig 2.3 -** The Quadrocopter. *Photo by Author.*
**Fig 2.4 -** The Plane. *Photo by Author.*

The following is a record of how I have addressed the issues expressed in Unlocking Architecture. It catalogs my effort to build four devices: a kite, a car, a quadrocopter, and a plane.

Each enables self-directed learning – through reconnaissance – about the urban landscape. In cataloguing my work, its successes and failures, I hope to provide a realistic account of the challenges involved when making one's own tools for urban reconnaissance. I also hope to express the act of self-education through trial and error, online resources, and participation in online communities.

I conceived these devices as instruments for finding latent potentials. By creating low-cost devices, and testing them against my own incompetence and lack of prior knowledge, I could identify usable techniques and technologies that might allow anyone to search for, find, and capitalize on potentials latent in their community. This includes the ability to gather information about a neighborhood. At this intimate scale, I imagined this exploration would allow for the rediscovery of familiar landscapes from new perspectives. For example, my team and I could have used these devices during the Barton Tiffany project to acquire valuable information about the state of the properties in question.

These devices extend one's perception of space by granting the ability to see over fences, beyond walls, over rooftops and across landscapes. They provide a low cost means to generate cartographic information at a neighborhood scale.

The Kite and Rig was the first device I made. In winds between 20-40km/h, it affords a bird's eye perspective from a sustained aerial position. Legally, the kite is exempt from regulations by government authorities because it weighs less than 2.27 kg(5lbs).[1] Technically, I can fly it from anywhere that is considered public property as long as I exercise due caution, common sense, and avoid violating anyone's personal privacy in a way that could be considered "highly offensive".[2] In Canada, the kite is a harmless and unregulated technology.

The Car is an antique remote-control dune buggy, I appropriated to provide a ground level perspective of a selected site. It can be dropped over fences and piloted remotely via a video transmitter. The Car, like the Kite, can be deployed on public property, again as long as due caution is exercised. Unlike the kite, as soon as the Car is on private property it can be considered as trespassing and should not be deployed where no-trespassing signs exist. Trespass occurs *on the land*.[3] Canadian law states that trespassing occurs when an uninvited occupant enters onto a premise, or frustrates the owner's ability to use their land for their own means of production and enjoyment. I'm sure this definition could be stretched to apply to other things, depending on who is doing the arguing. That said, I cannot recommend it for this purpose, and any deployment of this tactic for acquiring ground-based information on private property is at the operator's risk.

The Quadrocopter is a four-rotor remote-control helicopter. I built it by following the instructions provided by various online sources. The Quad allows for agility and control at a range of heights, in close confines, and during times of low or medium wind speeds – under 20km/h. Unlike the Car, the Quad doesn't trespass because it doesn't come in contact with the ground – *on the premises* – and therefore can be piloted from public property over private property. The Quad is free to fly over any land that the operator chooses, as long as due caution and common sense is exercised. This means keeping a horizontal distance of 100m between the craft and a crowd, and following a few other guidelines. This freedom is afforded because Transport Canada, under the Canadian Aviation Regulations, (CARs) considers it a "*Model Aircraft".* A Model Aircraft is defined as a remotely piloted aircraft, weighing under 35kg that is mechanically propelled and piloted for recreation.[4] Model Aircraft are exempt from any regulations under the CARs. However, the moment the Quad, or any other Model Aircraft, is used for anything other than recreation, it becomes a Unmanned Air Vehicle UAV.[5] As a UAV, the Quad comes under strict regulation and requires formal permissions called SFOCs – Special Flight Operation Certificates – for every flight. Transit Canada alone can issue these permissions, which take up to 30 days to process. It is for these reasons that I recommend thoroughly enjoying yourself – to a point of recreation and relaxation – while participating in this form of urban reconnaissance. Or, alternatively, make grassroots aerial cartography a recreational hobby, as I have.

The Plane is built from off-the-shelf parts and readily available craft and construction materials. It enables long-range low-altitude reconnaissance of large areas at speed, and is deployable in low-to-medium wind conditions – possibly high winds in the hands of a skilled pilot. The Plane is subject to the same rules and definitions as the quad, as a Model Aircraft when flown for recreation, or a UAV when used for commercial purposes.

(Endnotes)

1 "This chapter applies to the marking and lighting of any moored balloon[…] and of any kite weighing more than 2.27 kg (5 lbs.)" From: Transport Canada, *Exemption 605.20b, 2010*

2 Morman, *Personal privacy: Explaining the new right to sue. 2011*

3 The Canadian Tresspass to property act defines "premises" as: lands and structures, or either of them, and includes, water. Air isn't mentioned- From: Gov. Canada, *Tresspass to Property Act,* 2000

4 Transit Canada, *Canadian Aviation Regulations: Model Aircraft.* 2012

5 Transit Canada, *Staff Instruction No.623-001: sect 4.2.2-4. 2011*

**Fig 2.1.1 -** Lake Borgne-LA. *Aerial imaging aquired by Grassroots mapper Erin Sharkey Image (cc) GonzoEarth on Flickr. http://www.flickr.com/photos/gonzoearth/4930715043/in/photostream.*

## *The Kite*


After the 2011 British Petroleum oil spill in the Gulf of Mexico, a group of MIT students traveled to the gulf to help with the clean up. The group used satellite photographs to track the spill but was frustrated by the speed, consistency, and quality of the imagery. Jeffrey Warren of MIT's media lab developed a work-around, a way to acquire immediate low-cost aerial photographs and make maps of sensitive areas affected by the spill. Warren's low-cost DIY system used a small kite, a pop bottle, and some string, to send a consumer-grade Canon camera – hacked to run a intervalometer script – hundreds of meters into the air. The resultant images, low altitude and at a high-resolution, were stitched together on a laptop, printed and distributed to the cleanup teams. These maps provided near real-time tracking of the spill along the coast.

After the spill, Warren and his friends documented their efforts and published their low-cost system online. They created GrassrootsMapping.org, a wiki page that has grown into a distributed effort to promote and provide low cost aerial mapping tools to anyone who wants them.

**Fig 2.1.2 -** Camera Payload *Photo by Chris Eichler. GonzoEarth on Flickr. http://www.flickr.com/photos/gonzoearth/4765059238/in/photostream.*

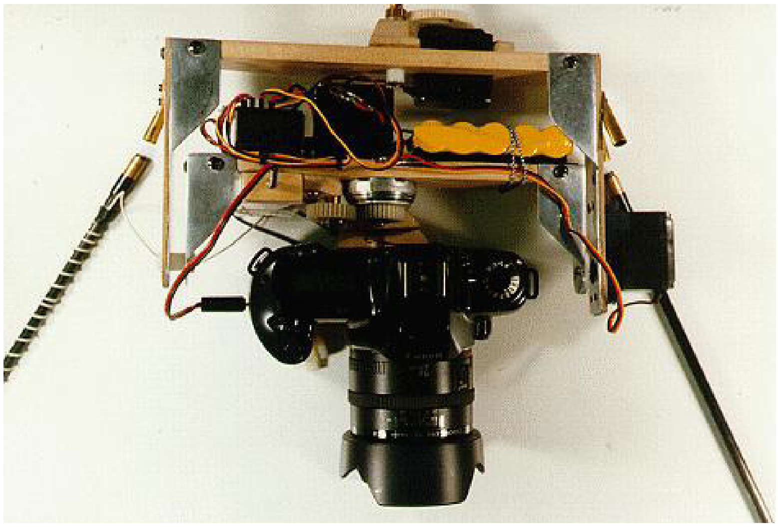


**Fig 2.1.3 -** KAP rig precedent. *Photo by Charlse C. Benton. KAP Rig No. 2 Source: http://arch.ced.berkeley.edu/kap/images/2rig1.jpg.*

**Fig 2.1.4 -** KAP rig precedent. *Photo by Brooxes Kite Aerial Photography. Source: http://brooxes.com/newsite/HOME.html.*

During the summer of 2011, I was planning a road trip to the prairies with my partner, Lindsey Nette, who was researching human settlement patterns in western Canada and the perception of emptiness in the North American grasslands. With the promise of a flat horizon, I imagined I would get to spend plenty of time looking up at the sky. I was already planning to bring a kite with us when I stumbled on the Grassroots mapping website, and decided this kite would have to carry a camera.

In all honesty, I didn't have enough faith in the pop-bottle, string and packing tape version proposed by the Warren and his buddies to entrust our camera to it, hundreds of feet up in the air. Instead, I searched for other examples of Kite Aerial Photography, KAP, and found all kinds of precedents. Some were highly entailed and expensive, while others were dirt cheap and used silly putty and disposable cameras. As a designer, I funneled these variations through the materials I had on-hand and what I thought I could make in a short period of time. Pushing and pulling the design as it evolved in my head, and my sketchbook, I set out to make a KAP rig.

I planned to use Lindsey's Canon Camera (because the scripts from the GrassrootsMapping.org site didn't work on my old Panasonic) and would therefore required a rig made from sturdy materials and a kite strong enough to lift it. I wanted to be able to control the pan and tilt mechanisms remotely from the ground while the script handled the shutter. I would mimic a formal remote controlled KAP rig like Charles C. Benton's - only without his remote shutter and digital SLR. Benton, a professor of architecture at Berkeley, is a KAP advocate and enthusiast; he has a comprehensive website featuring equipment lists, kite choices, online suppliers and a full history of the hobby featuring the likes of Nadar in France and George R. Lawrence over San Francisco. The Grassroots Mapping website and Benton's KAP site provided me with all the inspiration and information. I needed to make my own tool for acquiring low-cost aerial photographs.

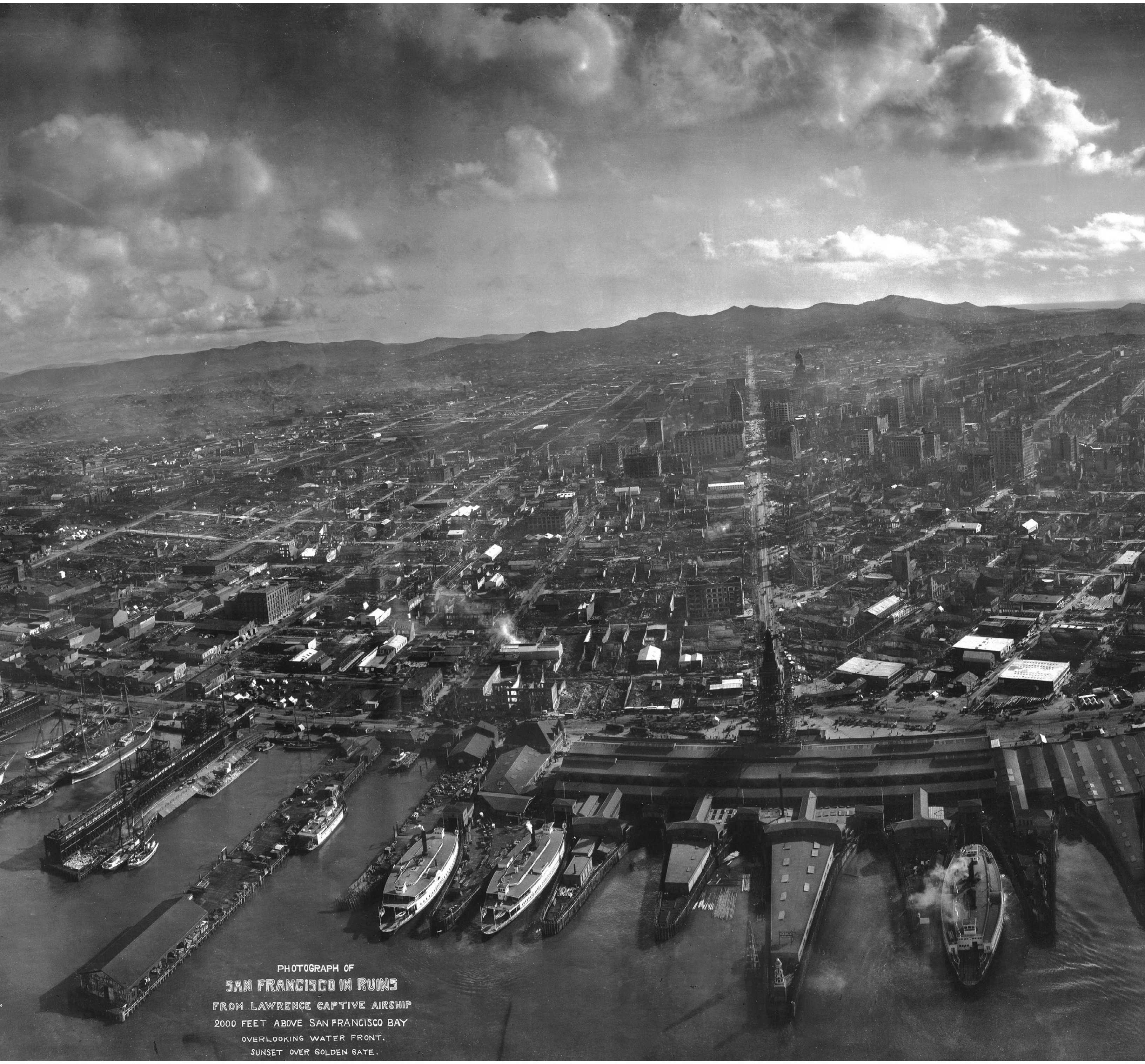



**Fig 2.1.5 -** San Francisco in Ruins. *Photo by George R. Laurence 1906.*
*Source : http://en.wikipedia.org/wiki/File:San_Francisco_in_ruin_edit2.jpg*

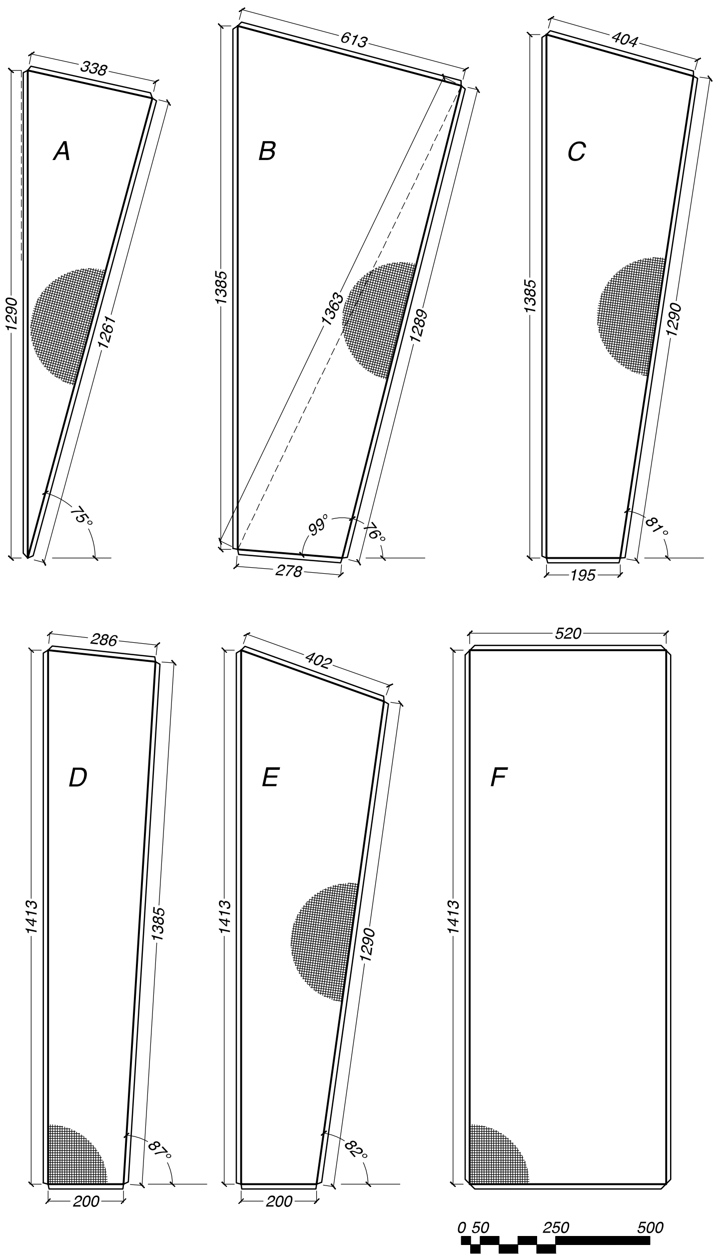



**Fig 2.1.6 -** Double Parasled Kite plans. *Redrawn by author*
*Source: http://www.kites.org/tmr/parasled_engl.htm.*

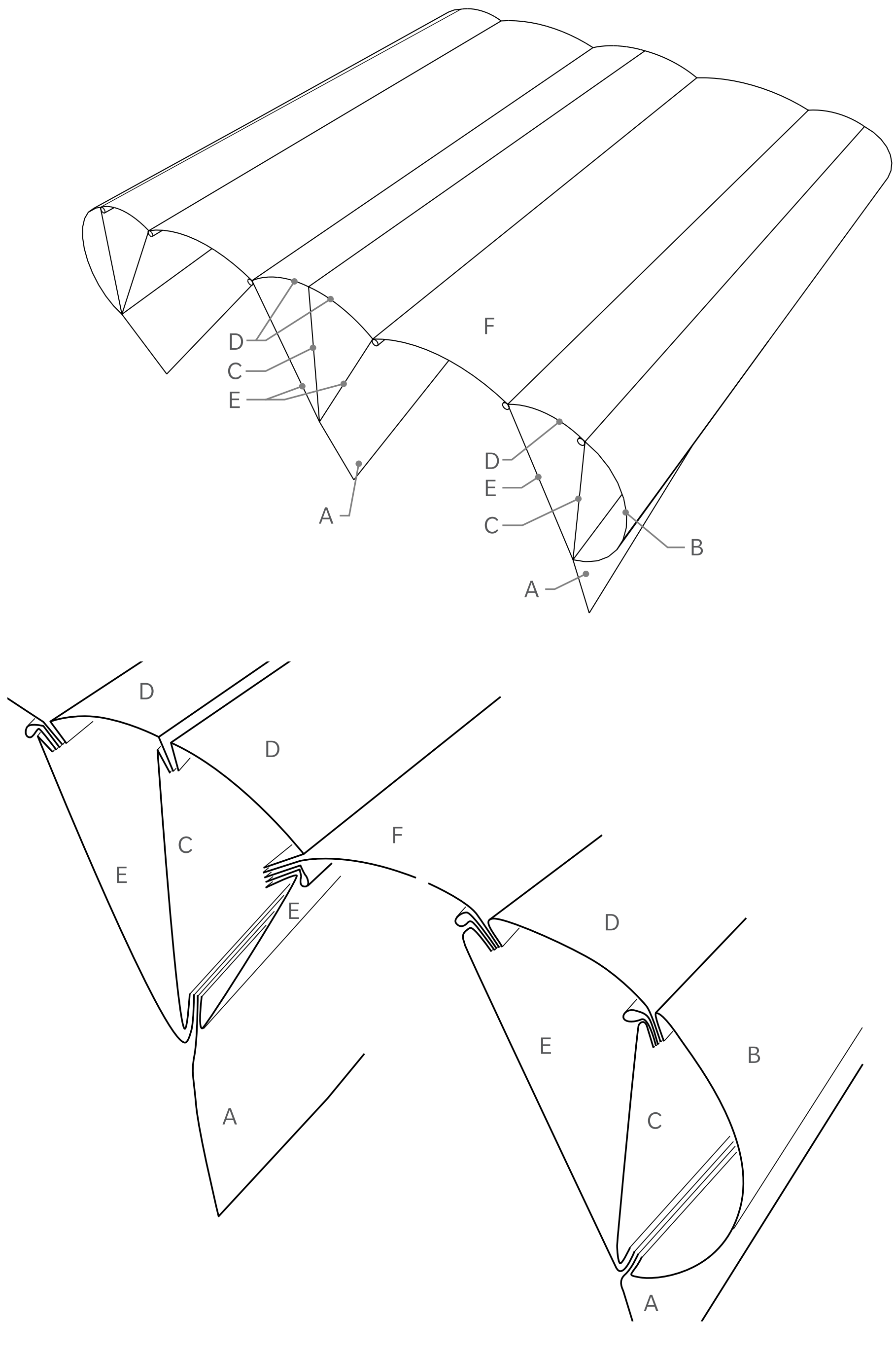



**Fig 2.1.7 -** Kite Assembly Diagram. *Drawing by Author.*

**Fig 2.1.8 -** Lindsey Nette measuring and marking the kite pattern onto  nylon kite fabric. *Photo by Author.*

**Fig 2.1.9 -** Authour learning to sew while constructing the Kite. *Photo by Lindsey Nette*

**Fig 2.1.10 -** First Kite Flight in Saskatchewan. *Photo by Lindsey Nette*

**Fig 2.1.11 -** Author with Kite hiking in Grasslands National Park, Saskatchewan. *Photo by Lindsey Nette.*

**Fig 2.1.12 -** Author Flying Kite and Rig in Grasslands National Park, Saskatchewan. *Photo by Lindsey Nette.*

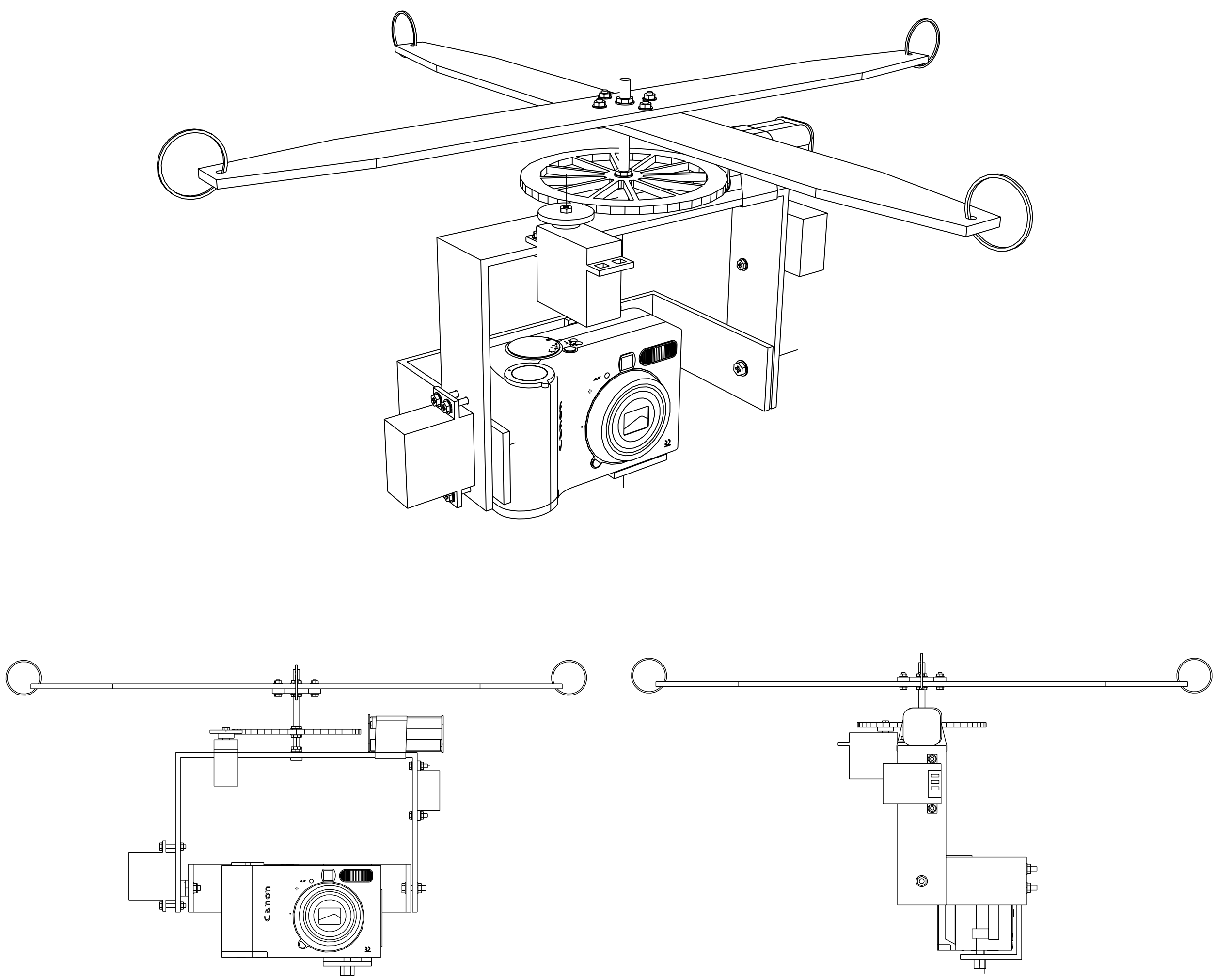



**Fig 2.1.13 -** Kite Rig-01 Design. *Drawing by Author.*

Parts List:
1- Canon Camera Loaded With CDHK Script

For Rig and Suspension:
Aluminum scraps.
4 - AA batteries
1 - Battery holder
1 - 2 Channel receiver
1 - 2 Channel transmitter
2 - Standard servos
4 - Key rings
4 - Fishing swivels
16 - Small bolts
16 - Small nuts
22 - Small lock washers
1 - Set of salvaged printer gears
1 - Camera mount screw
1 - 4" Bolt
6 - Large lock washers
4 - Nuts
1 - Wing nut

For Rig Blocks:
2 - 4" Pieces of aluminum
4 - Small bolts
4 - Lock washers
12 - Nuts
2 - Sets of plastic winding parts.

To attach the camera rig to a single kite line is a question of tension and friction. An adaptation of an adaptation, the original version of the design was made by Brooks Leffler, and then Charlse C. Benton adapted the geometry to this form. His version of these hang-ups uses aluminum and balsa wood but I adapted his design to use aluminum and bits of left over acrylic from after making the gears for the first Kite Rig.

**Fig 2.1.14 -** Kite Line Clips. *Photo by Author.*

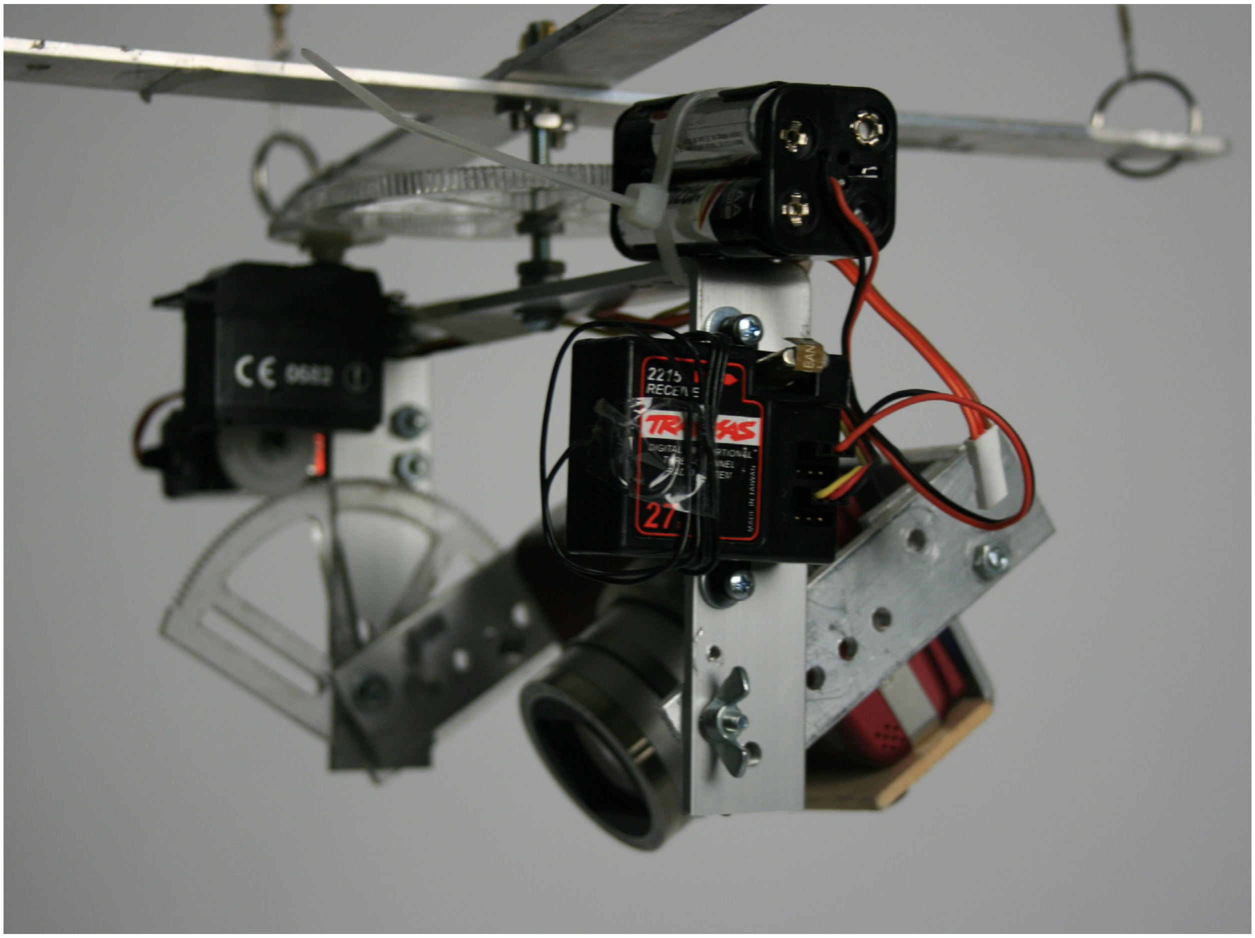



**Fig 2.1.15 -** Completed Kite Rig-01. *Photo by Author.*

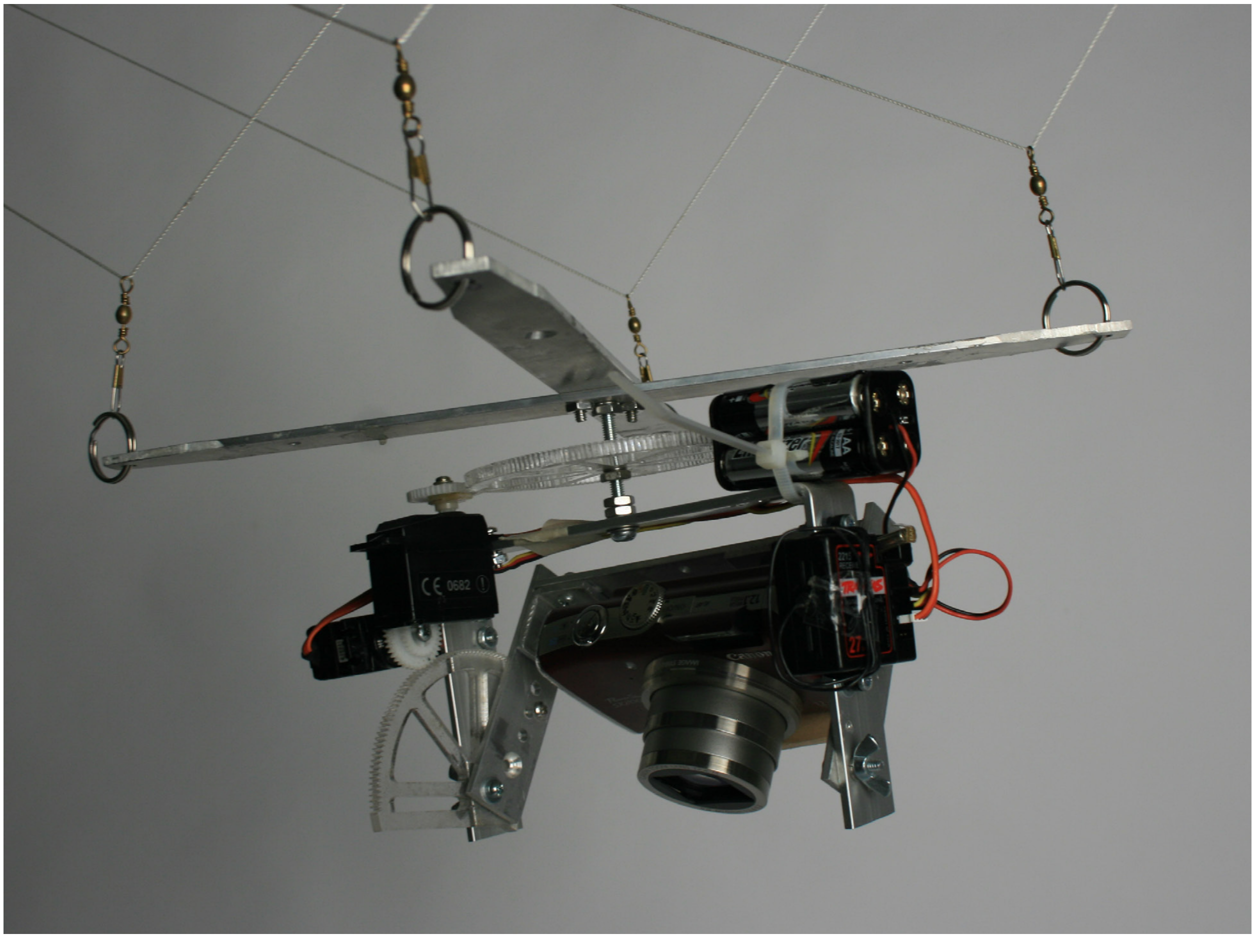


**Fig 2.1.16 -** Completed Kite Rig-01. *Photo by Author*

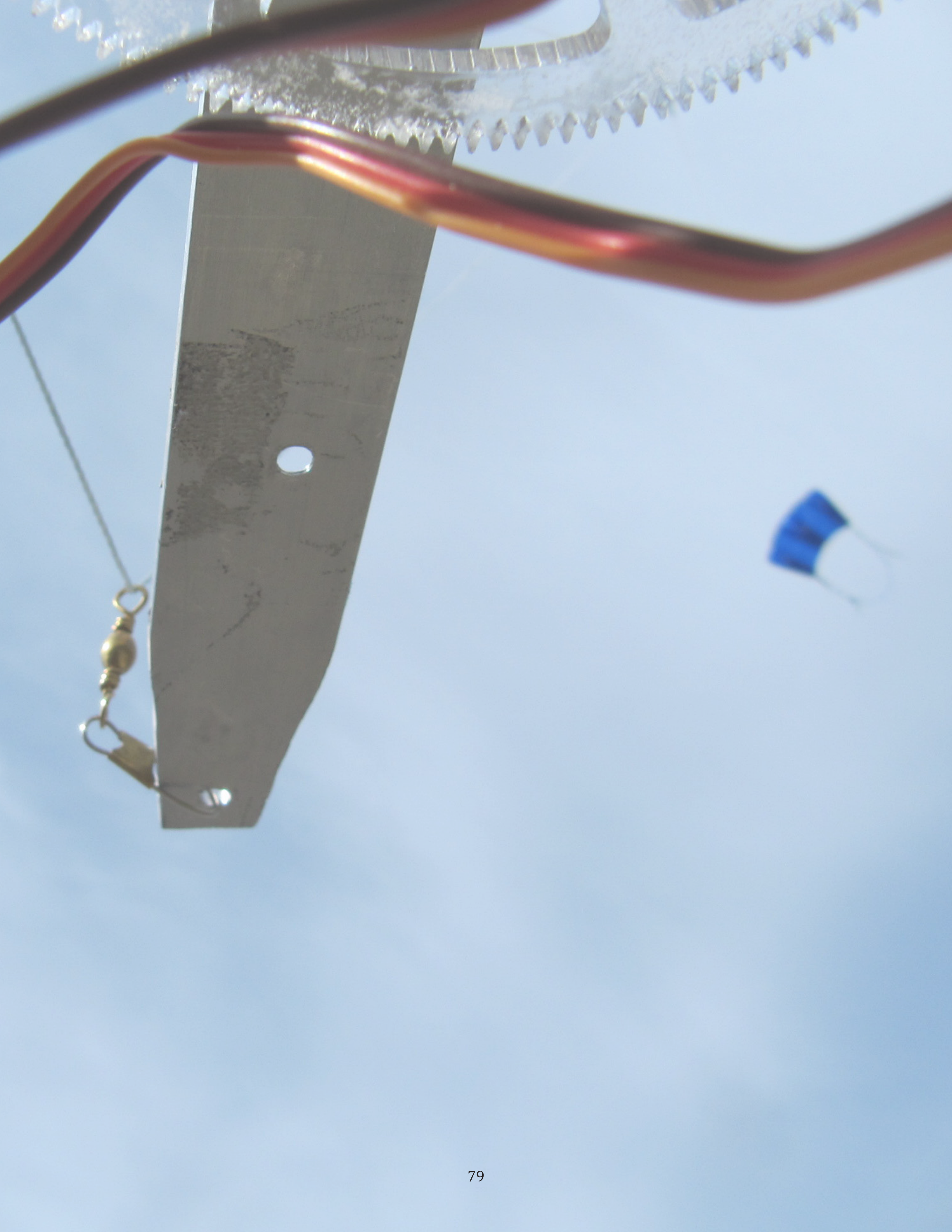
The KAPR-01, after a total of seven flights, fell over three hundred feet to the ground below. It was a particularly windy day and the kite was pulling strong and lifting well. I entrusted the transmitter to eager undergraduate students, the controls were simple and the camera was automatically taking pictures, so I was sure we would get some good results.

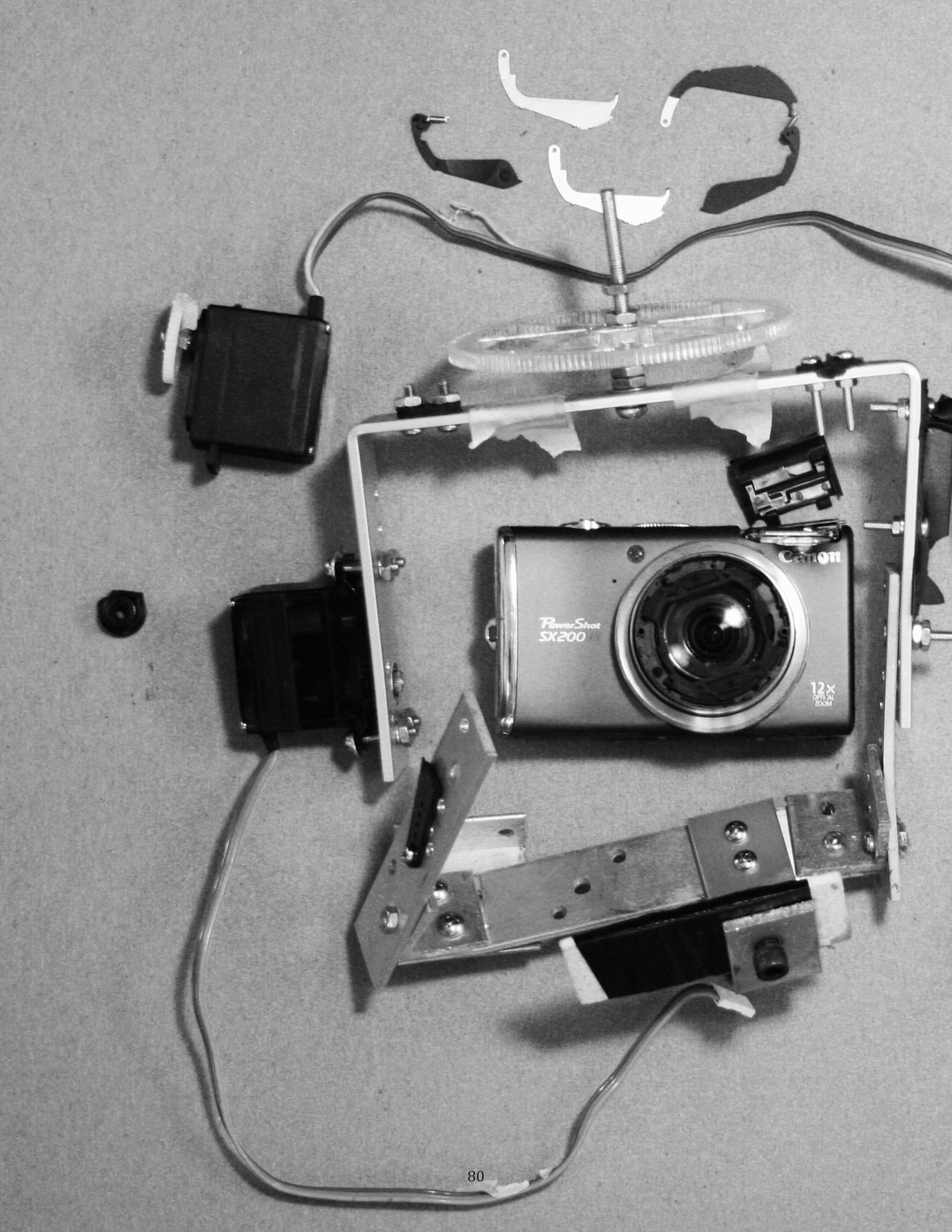
We had the kite line out fully, all five hundred feet of it, which put the rig in the three hundred foot range. I flew it for about fifteen minutes before beginning to bring it down. To avoid tiring myself out I reeled only when the gusts died down. It was a slow process, but kite flying is relatively relaxing. As we were standing watching the kite fight my efforts, the rig let go from the suspension. The camera plummeted for what seemed like forever and landed half a field away. Even at that distance, I could see bits and pieces of the rig bounce and spring in different directions as it hit the frozen ground below.

The camera was irreparably maimed, the lense forced into the housing. The rig was bent and many of the bolts that once held it together had sheared. It was destroyed.

I am convinced that the failure of the rig occurred at the lock-washer and wing nut assembly, which connects the rig to the suspension. I assume that the momentum caused by the wind gusts, in combination with the rotation of the rig loosened the wing nut. The moment a heavy gust caused the snugness of the nut to be broken; the rotation mechanism would no longer work, and instead would rotate only the bolt. Factor in the force of gravity, and it's possible to imagine the nut loosening, slowly unthreading for the length of the bolt until finally letting go.

(Opposite)
**Fig 2.1.17 -** One of the last photos from The Kite Rig-01. *Photo by Author.*




Canon
PowerShot
SX200
12×
OPTICAL
ZOOM


DURACELL
ALKALINE BATTERY
1.5V
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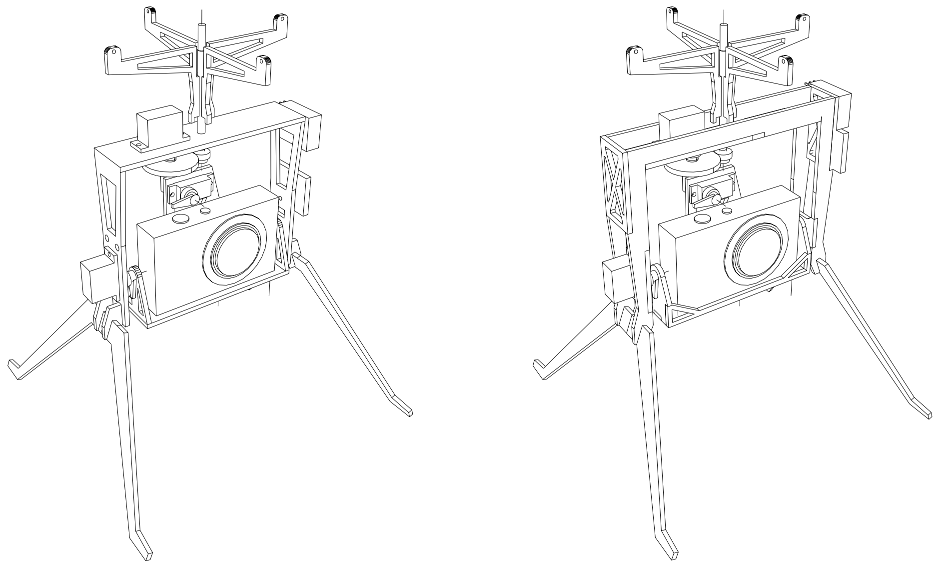
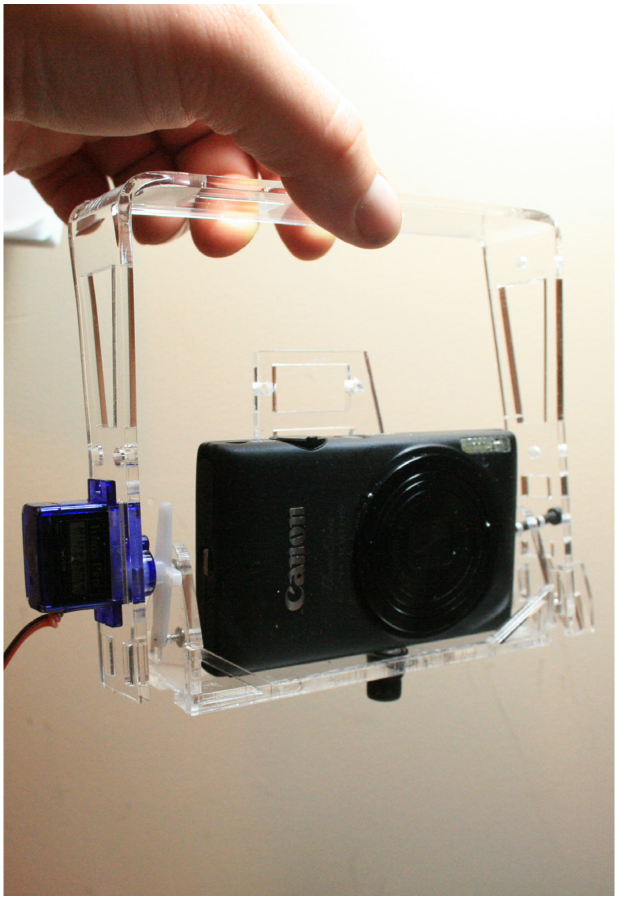
CANON ZOOM



I made the Kite Rig-02.1 and -02.2 in parallel. Both are constructed with laser-cut 3 mm acrylic components. The -02.1 was designed to be heat bent, using a bench vise, a heat gun and thick work gloves. The result holds its shape but the acrylic becomes brittle and is easily shattered. The -02.2 is assembled using super glue and nesting components and, though stronger than the -02.1, the final product was still too brittle and suffered cracking and breaking during its assembly. After these two models I eliminated Acrylic as a suitable construction material for KAP rigs.

(Previous Page)
**Fig 2.1.18 -** The recovered parts from Kite Rig-01 fall. *Photo by Author.*
(Above)
**Fig 2.1.19 -** Kite Rig-02.1 3D Model. *Drawing by Author.*
**Fig 2.1.20 -** Kite Rig-02.2 3D Model. *Drawing by Author.*



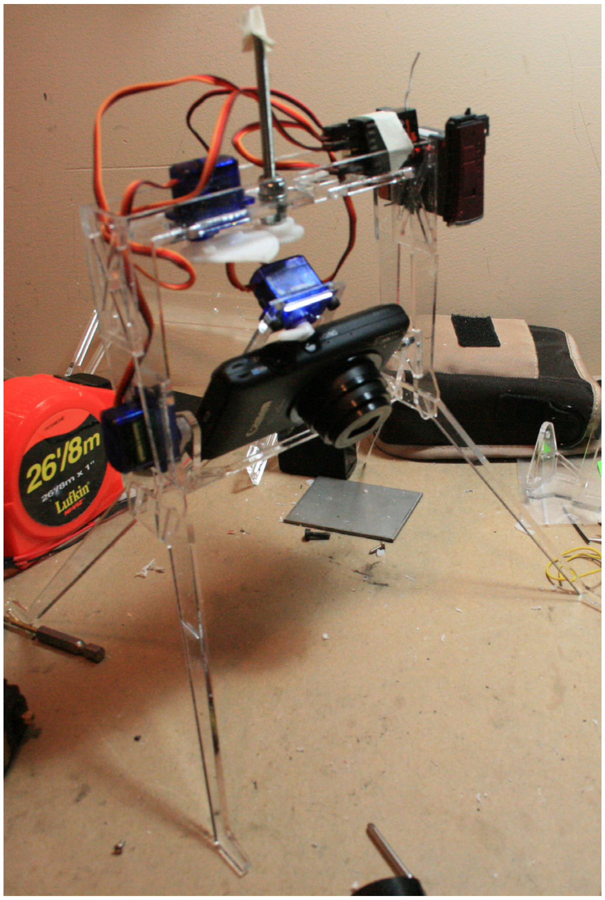




**Fig 2.1.21 -** Kite Rig-02.1 progress tilt Mechanism. *Photo by Author*
**Fig 2.1.22 -** Kite Rig-02.2 Assembled. *Photo by Author*

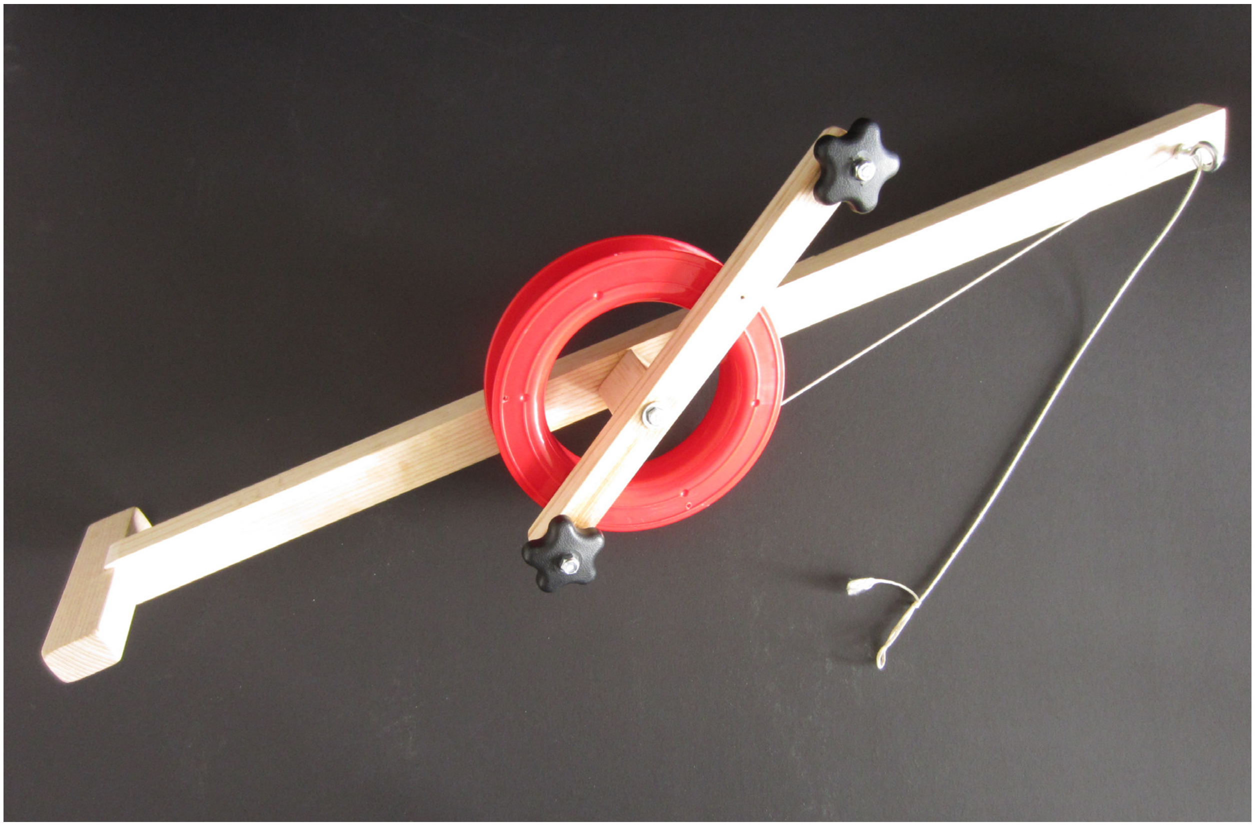


**Fig 2.1.23 -** Kite Reel. *Photo by Author.*

After the KAP-01 fell, I still had to reel the Kite down in high winds using just the red spool. By the time I had pulled in all five hundred feet of line, I could barely lift my arms, let alone close my hands. Even if I did see the rig loosening, I wouldn't have been able to reel it in fast enough.

The Kite Reel shown here, is made from white ash, and uses lawn mower height adjustment knobs for handles, and an eye-bolt to guide the line. This reel allows for more leverage and easier winding. It holds a thousand feet of two hundred-pound Kite line and can be anchored to the ground.

Parts List

1 - 6”x17” Sheet Of 3003 aluminum
1 - Canon ELPH 300HS with CDHK script
1 - 5 Channel transmitter (Spektrum 5xe)
1 - 6 Channel receiver (Spektrum AR6115E)
1 -Standard hobby servo (Tower Pro M995)
1- Standard hobby servo modified for continuous rotation (Tower Pro M995)
2 - 2.2k Resistors (for servo modification)
1 - 9g Mini servo (TowerPro SG90)
1 - 4.8v Rechargeable battery pack (Futaba NR-4J 600mAh NiCad)
1 - Set of salvaged printer gears
18 - 3-.50x10 metric hex socket head bolts
18 - 3-.50 Locknut nylon insert zinc plated metric nuts
8 washers
1 - Velcro Strap
2 - 30x30 mm Velcro mith adhesive
4 - Fishing swivels
2 - Kite blocks
Electrical Tape

Aluminum Process Instructions:

1. Print part templates.
2. Cut out paper templates.
3. Spray glue to 6” x 17” sheet of 2mm thick 3001 aluminum.
4. Rough cut parts using stomp shear.
5. Refine cuts with hand shear.
6. Drill all holes.
7. File burs caused by drilling.
8. Where interior openings are needed drill large holes at each corner of opening.
9. Use hand nibbler to remove material in interior openings.
10. Hand file all edges and corners, squaring interior openings.
11. Bend parts with hand break
12. Soak in soapy water for 15 min to remove spray mount.
13. Use plastic scraper to remove paper from aluminum parts.
14. Let dry.
15. Assemble kite rig (see figure 2.1.26)

The Final Rig is made from Mild 2mm thick 3003 Aluminum. The Aluminum is ductile enough for me to bend it easily by hand, and soft enough for me to cut with the shop’s stomp shear and hand notcher. Once bent, the aluminum frame is strong and holds its shape well. With some effort I used a handheld nibbler to chomp through the aluminium and make precise interior openings. I then used a hand file to remove burrs and finish the openings.

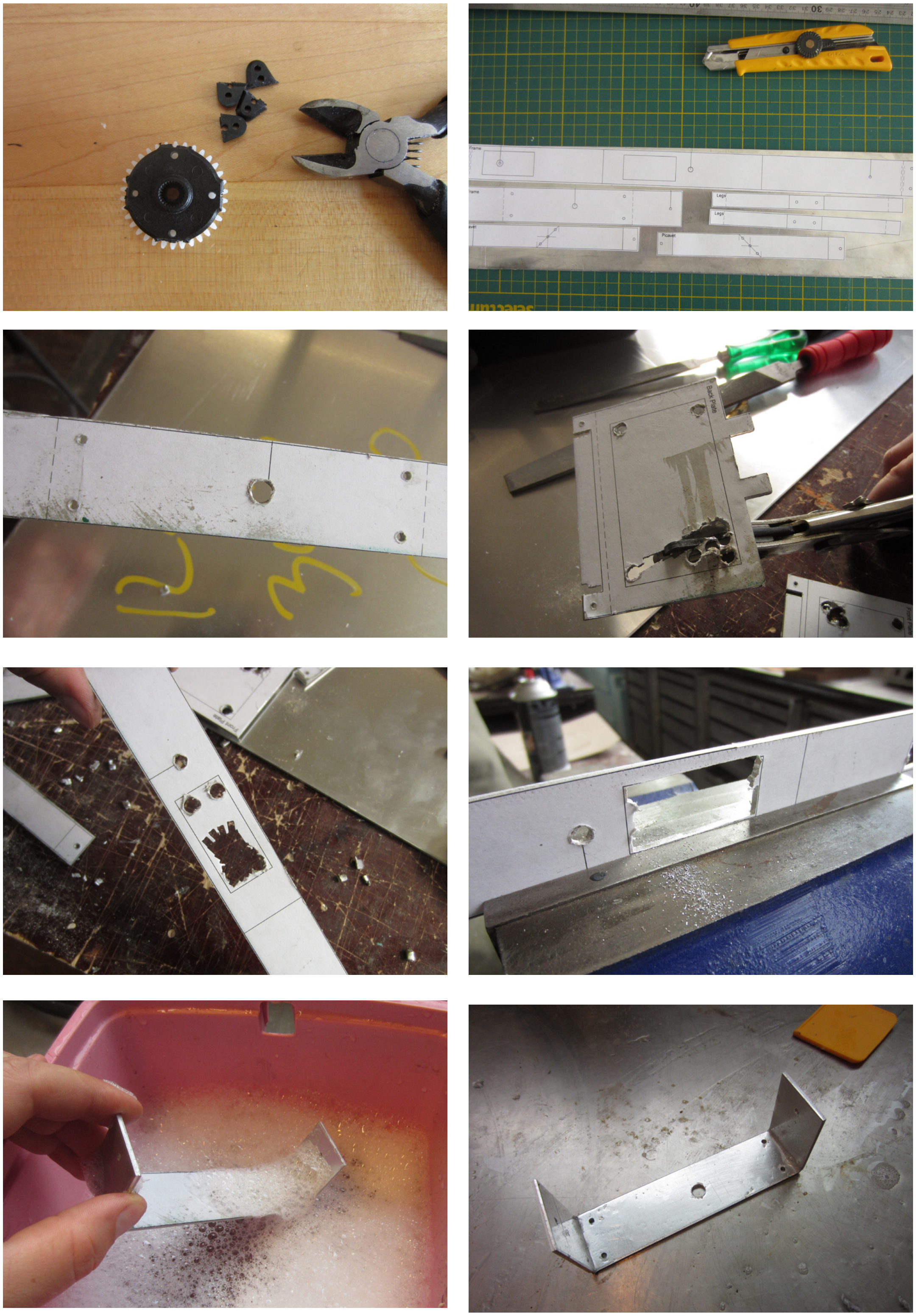


**Fig 2.1.24 -** Kite Rig-03 construction progress. *Photos by Author*

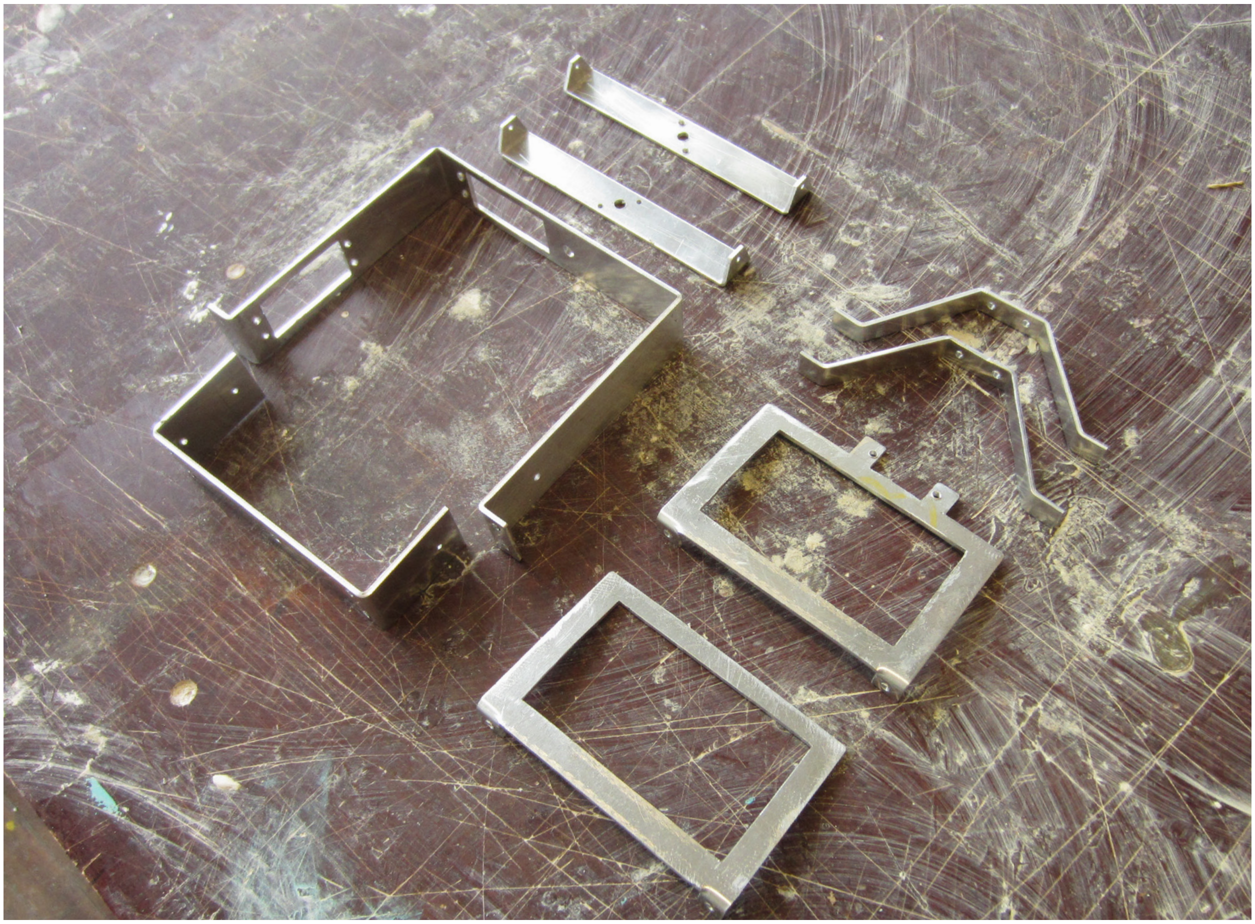


**Fig 2.1.25 -** Finished Rig Parts. *Photo by Author.*

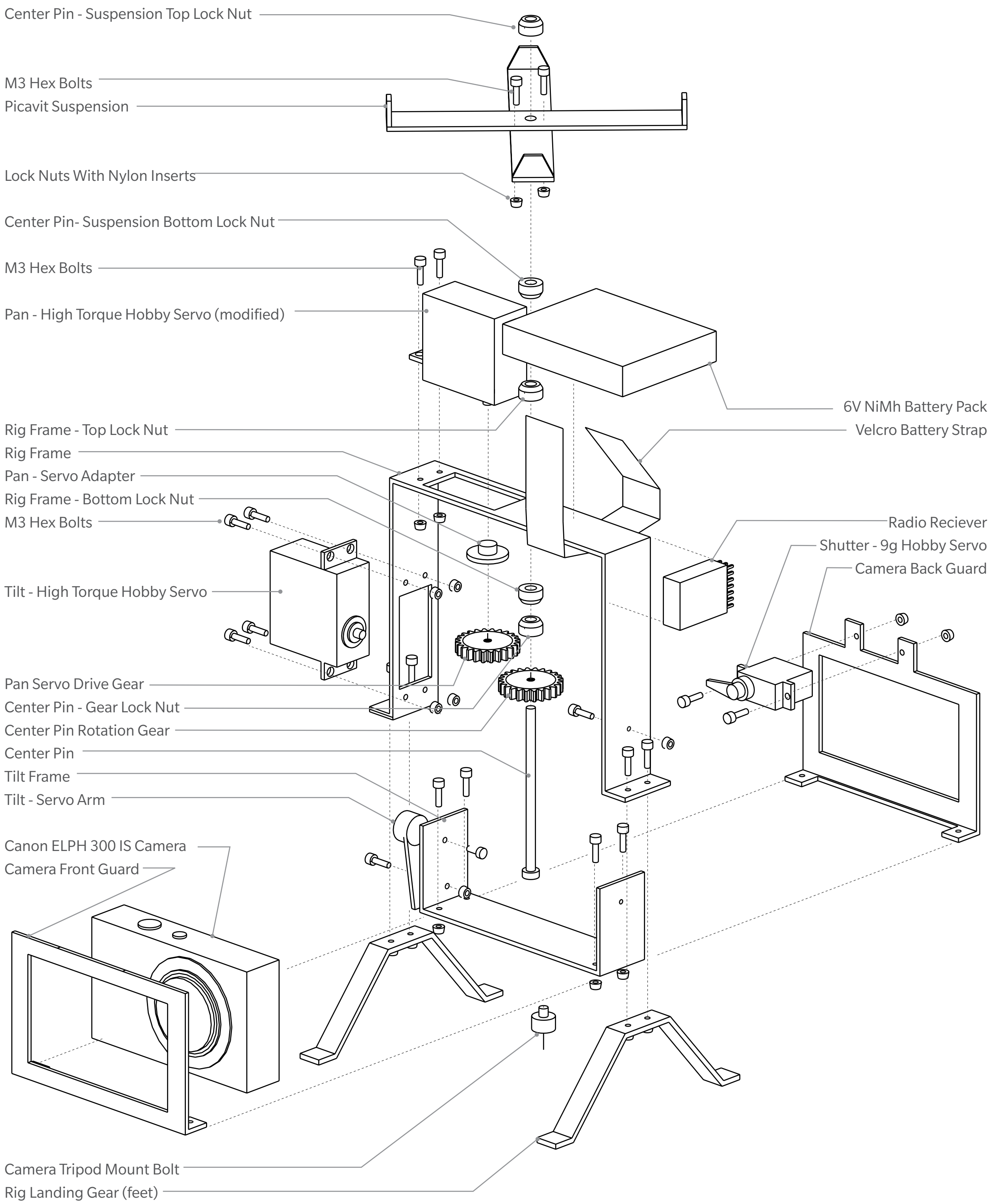



**Fig 2.1.26 -** Kite Rig-03 Exploded Axonimetric. *Drawing by Author.*

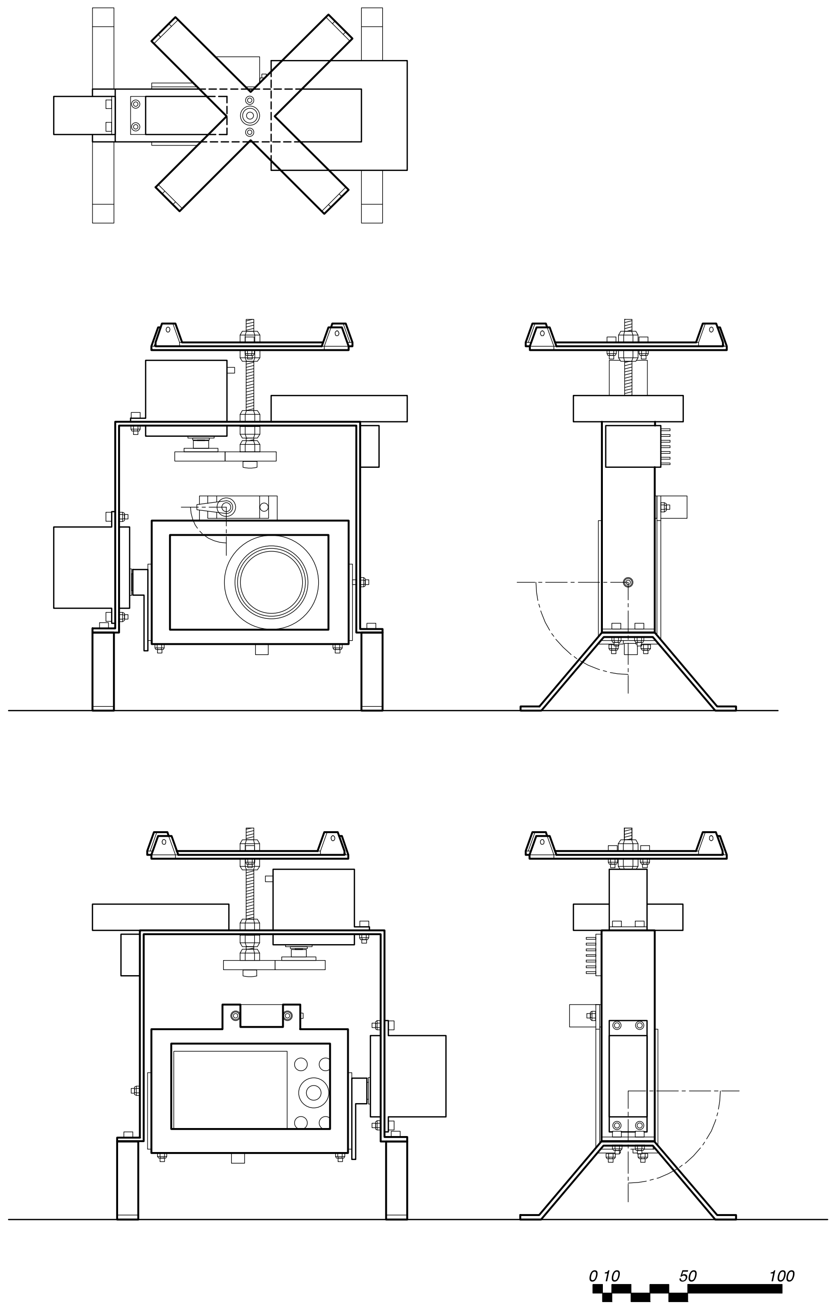
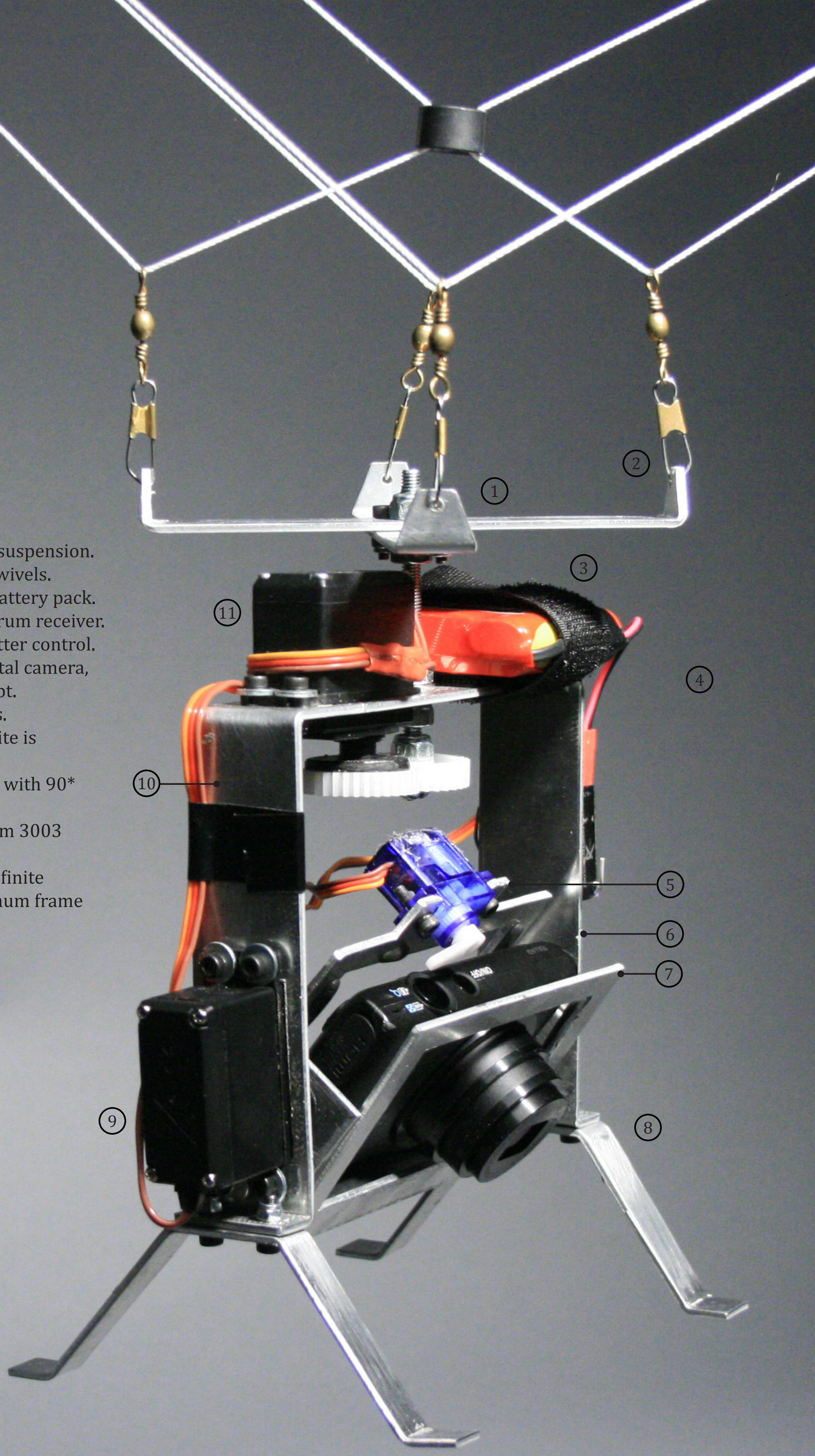



**Fig 2.1.28 -** Kite Rig-03 Orthographics. *Drawing by Author.*

(Opposite)

**Fig 2.1.27 -** Completed Kite Rig-03. *Photo by Author.*

1. Non-removable picavet suspension.
2. Directly linked fishing swivels.
3. Rechargeable receiver battery pack.
4. 2.4GHz 6-channel spektrum receiver.
5. 9g servo for remote shutter control.
6. Canon 300HS ELPH digital camera, Hacked With CDHK script.
7. Front and back bumpers.
8. Feet support rig while kite is launched.
9. Tilt Servo set into frame with 90* range of motion.
10. Rigid frame made of 2mm 3003 aluminum.
11. Pan servo (hacked for infinite rotation) set into aluminum frame limits gear slippage.



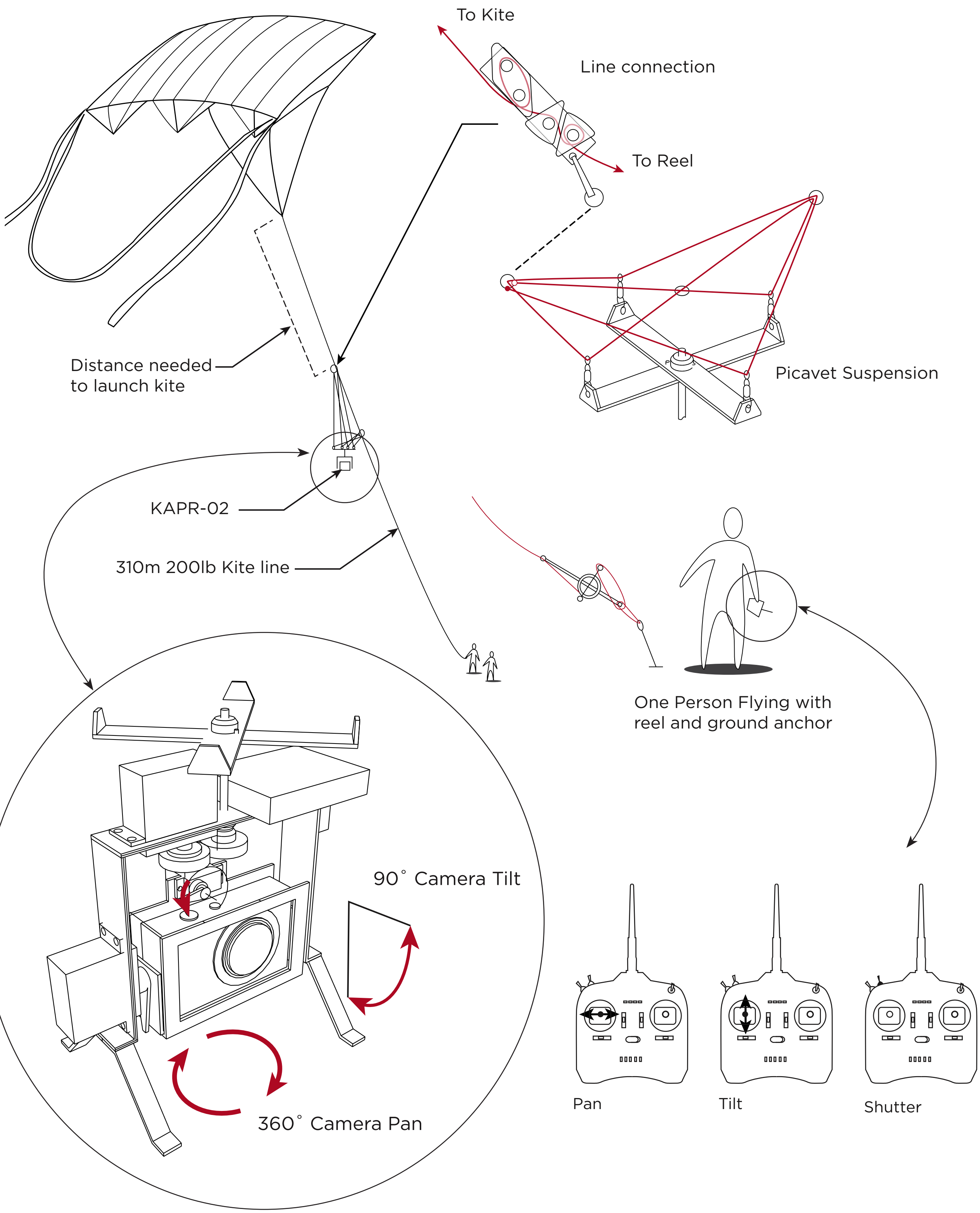



**Fig 2.1.29 -** Kite Rig-03 Operation Diagrams. *Drawing by Author.*

On a pleasant summer day with ideal wind conditions, Kite Aerial Photography is the most relaxing and enjoyable form of DIY aerial reconnaissance. It is slow-paced, quiet, accessible and so unassuming that security guards, park wardens and passers-by think nothing of it. A friendly form of aerial mapping, it is the simplest, easiest, and least expensive platform I have made. A KAP rig can be either a dead simple device, or a highly entailed piece of photography equipment, making KAP appeal to all levels of skill and expertise. The KAPR can acquire photos from a very high altitude and, in docile conditions, can remain stable in one location above the earth's surface, loitering for any length of time, while taking in a truly panoramic perspective. The KAPR-03 is my go-to option, the device that I am most comfortable using. I often wait for favorable kite flying conditions solely because it's my favorite device to use.

The KAPR isn't without its shortcomings though; it can only be used when conditions are near perfect: with wind speeds between 25-40km/h and preferably without rain. It is temperamental in high winds and can be a challenge to launch alone. It is also poorly suited to urban areas and favors wide-open landscapes, where power-lines are non-existent and winds constant. To fully capitalize on this form of mapping, a weather balloon could be used in lieu of a kite. A heavy-lifting helium-filled latex balloon would allow the camera rig to be deployed on less windy days and in tighter urban confines.

All things considered I believe the kite and rig are the ideal low-cost DIY aerial mapping platform, with plenty of applications and a promising future in my quiver of aerial reconnaissance devices.

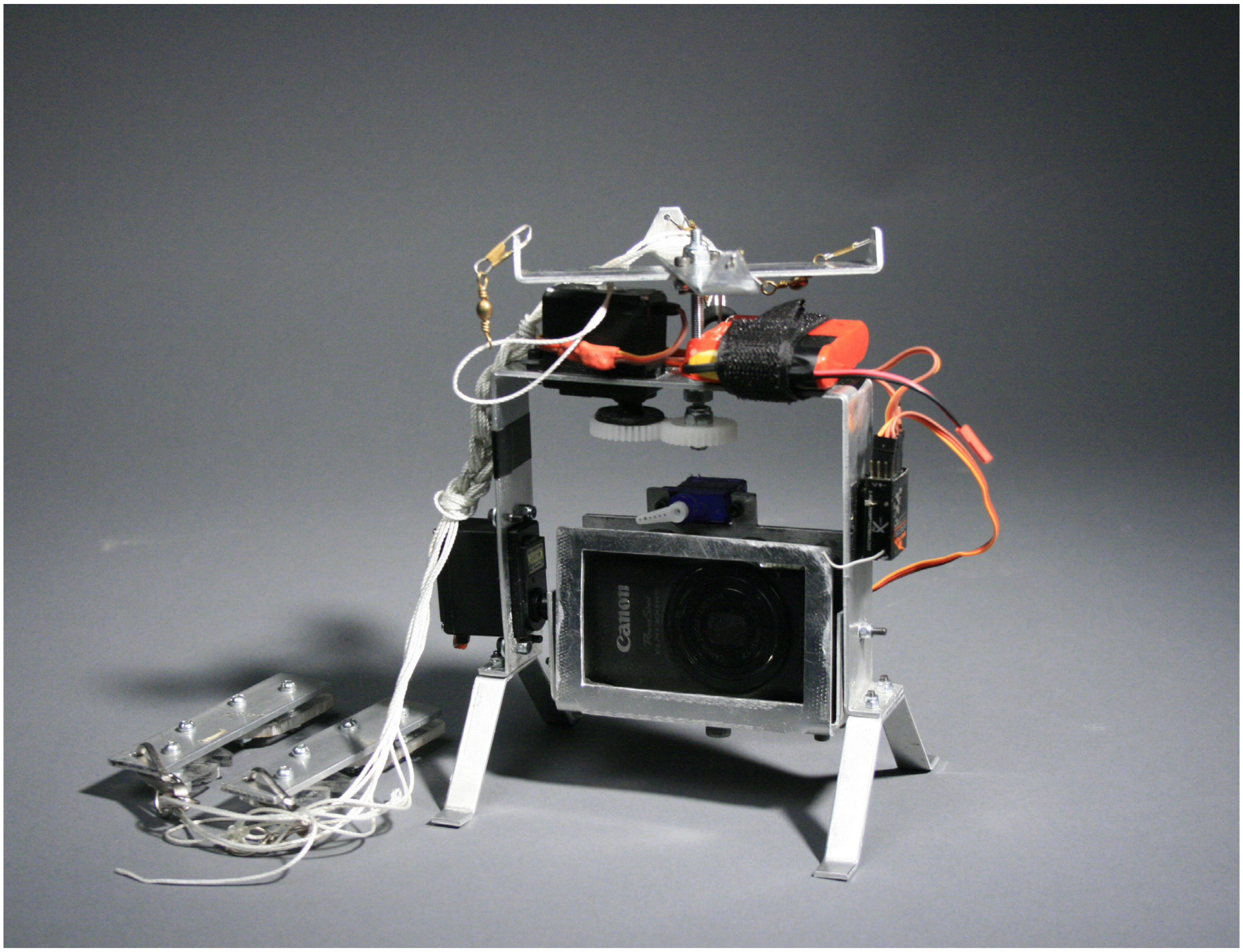



**Fig 2.1.30 -** Completed Kite Rig-03. *Photo by Author.*

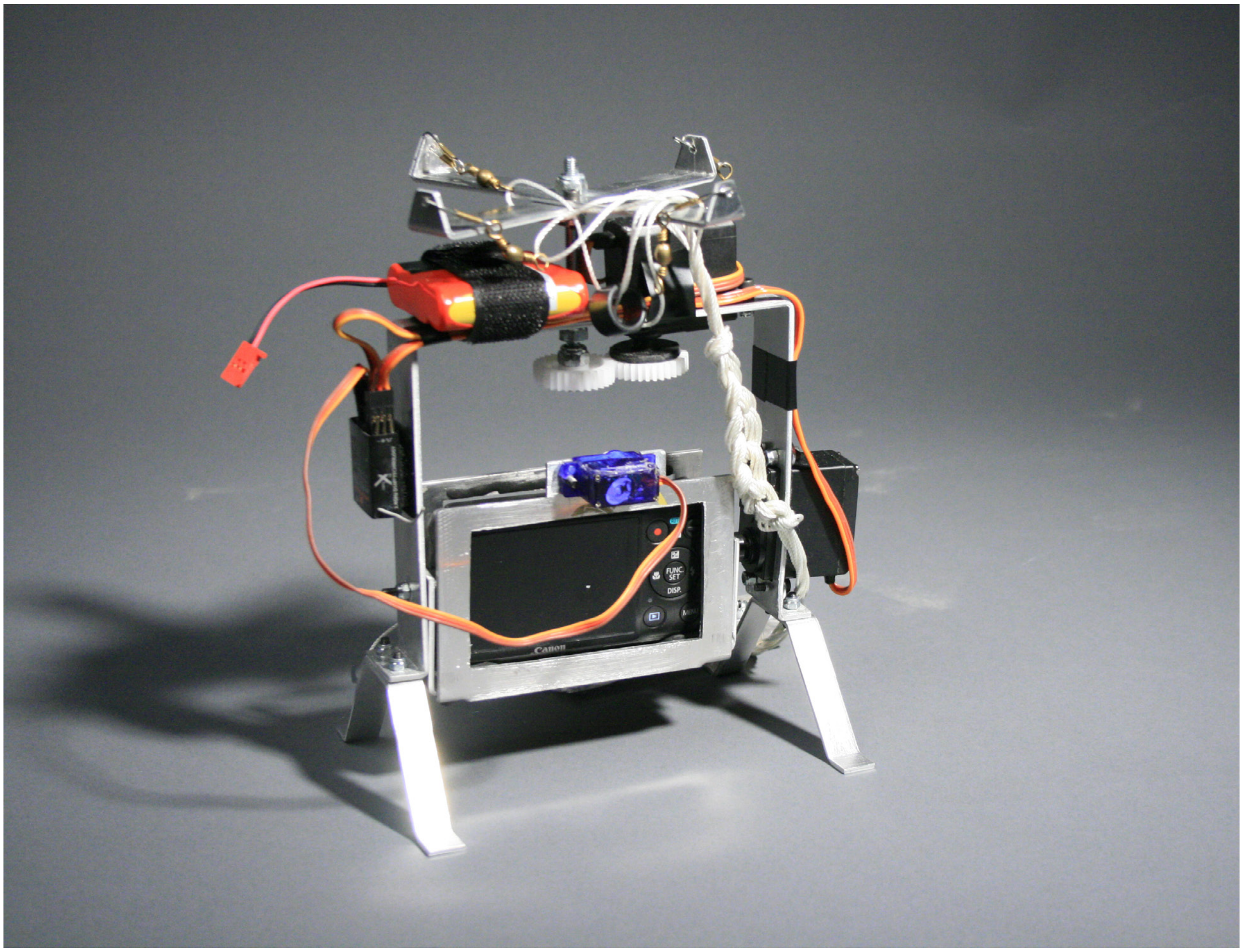


**Fig 2.1.31 -** Completed Kite Rig-03. *Photo by Author.*

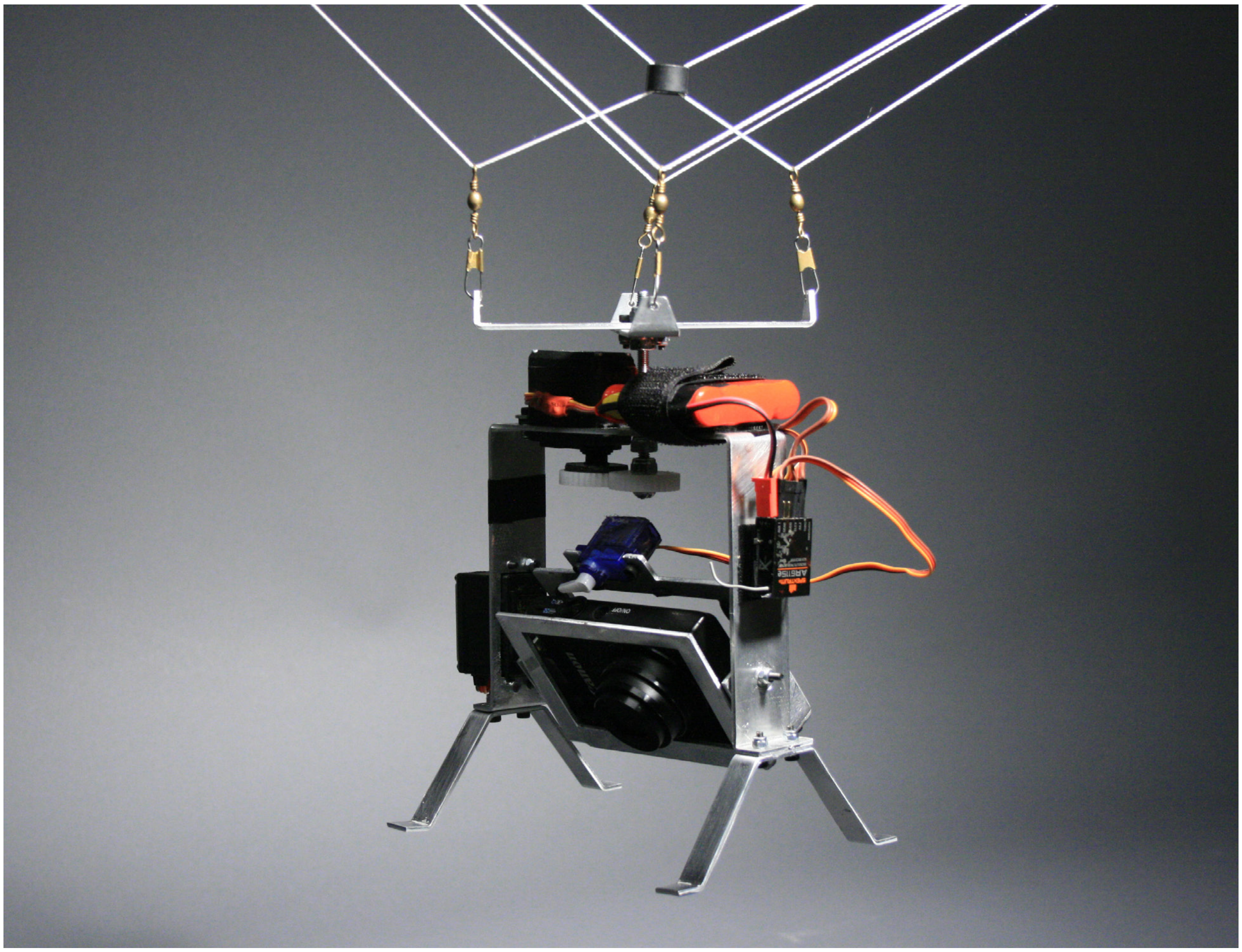


**Fig 2.1.32 -** Completed Kite Rig-03. *Photo by Author.*

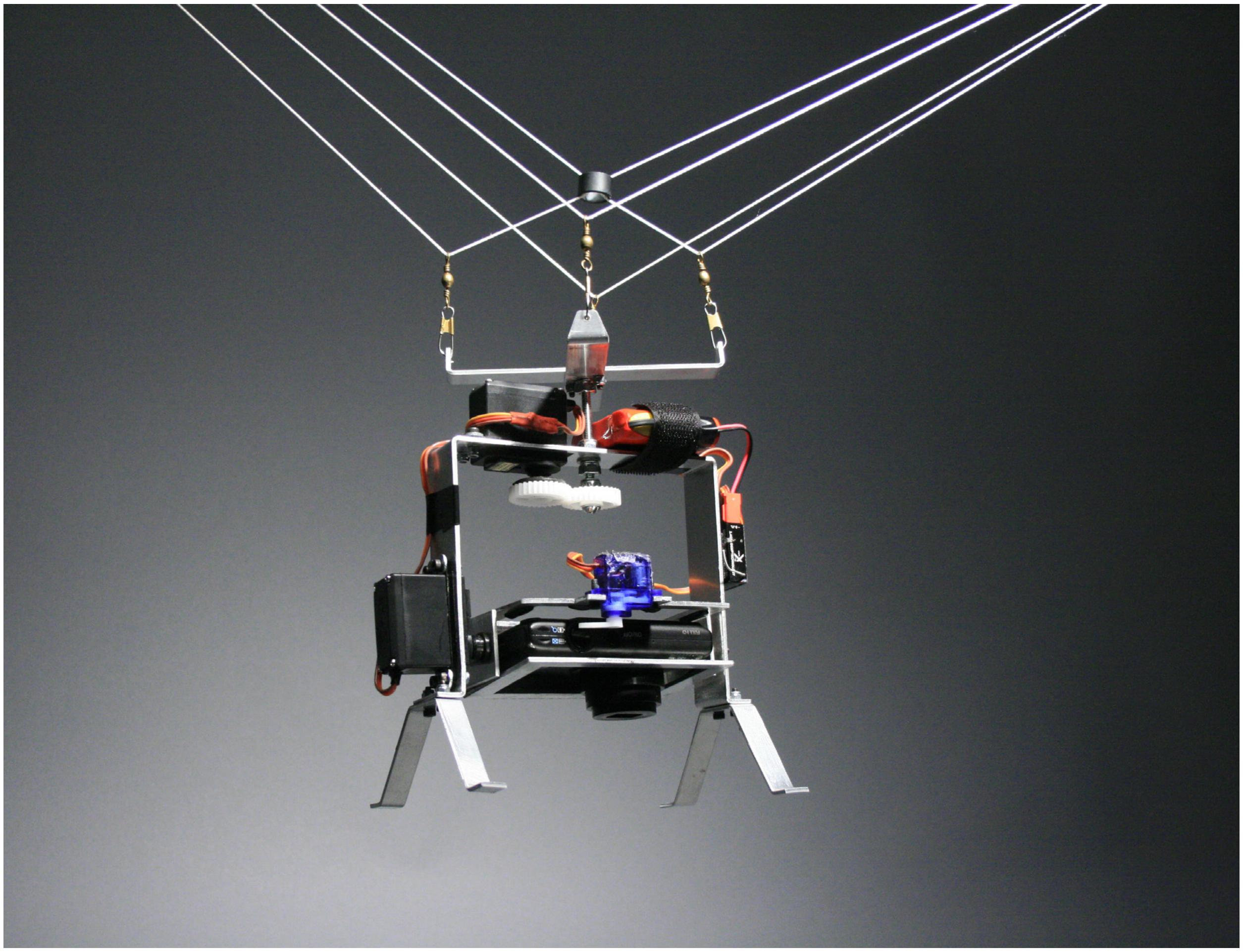


**Fig 2.1.33 -** Completed Kite Rig-03. *Photo by Author.*

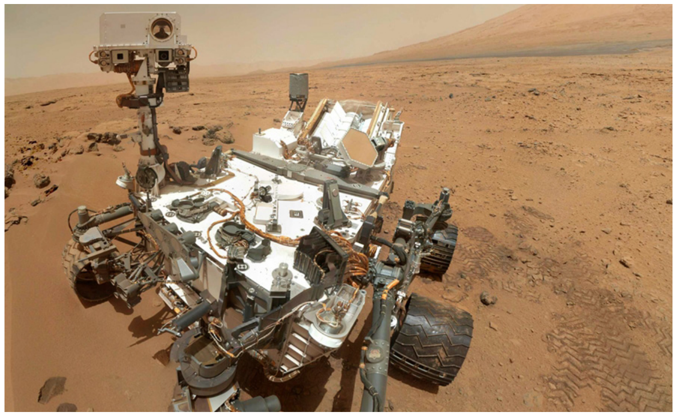


**Fig 2.2.1 -** NASA - Curiosity mars landrover *Source: http://www.nasa.gov/mission_pages/msl/index.html.*

**Fig 2.2.2 -** Ground Based Military Reconnaissance Robots Packbot *by. iRobot/Boeing Source: http://axisoflogic.com/artman/publish/Article_55830.shtml.*

**Fig 2.2.3 -** Movie Screen Captures from *Fast Five* 2011. *Universal Pictures.*

## *The Car*

As much as NASA scientists look at Mars from satellites, there is some information that is better acquired from the ground perspective: topography, temperature, terrain, and rock quality, to name a few. To that end, NASA has sent three land rovers 56 million kilometers to explore the surface of Mars. The same is true for the US military. Rooftops, trees, smoke, clouds and dense urban environments obstruct reconnaissance from the air, and instead of risking the lives of soldiers, the military sends ground-based robots - namely the *Packbot* made by IRobot - to survey and give reconnaissance information on strategic positions ahead such as buildings, caves, or tunnels.

When we were restricted access to the Rheem building during the Barton Tiffany project, I searched for holes in fences, missing windows and loose steel siding that I might be able to slip through and explore the building for myself. I began to look to urban exploration - the practice of exploring infrastructure, sewers, service tunnels, subway stations and abandoned buildings - for tools and strategies for gaining entry to restricted areas (known by the law as 'trespassing'). I even did my own urban exploration, jumping a fence and sneaking around the abandoned Massey Fergus factories in Brantford, Ontario. My visit was cut short when I sprained my ankle and was escorted off the property by a friendly security guard. Injured, I was convinced that there are places and things to be seen at the ground level that an aerial perspective can't provide.

Characters in recent Hollywood films of espionage, theft and infiltration like *Oceans Eleven, Fast Five, Dead Pool, Toy Story, The Specialist,* utilize the remote perspective of a remote control car to gain advanced insight into their future places of crime or justice; often inside a building or beyond a secure fence. I decided a remote control or autonomous ground vehicle would be a useful tool for this kind of urban reconnaissance. I imagined I could drop the vehicle over a fence or slip it through an opening to get a ground level perspective remotely. I would give it the same pan-tilt capabilities as the KAPR, enabling it to look around without needing to move position, and a GPS logger to cross reference location data with photographs and video footage.

**Fig 2.2.4 -** Various Photos of RC Restoration (tear down and full rebuild). *Photos by Author.*

When I made the KAP-01, I used the electronics from my dad's twenty-seven-year-old RC car, its steering and throttle servos and its transmitter and receiver. The car hadn't run for twenty-six years and he gave me whole thing. I planned to eventually restore it or convert it into an electric dune buggy.

The Thunder Tiger Silver Fox was one of the first four-wheel drive, gas-powered remote control cars on the market. My dad got it as a kit, assembled it, ran it a few times and lost interest. It had an aluminum chassis, a tubular steel roll cage and chain-driven all-wheel drive. It was a beast and I knew it would be strong enough to carry a camera rig, extra batteries and a GPS tracker, not to mention tough enough to scramble around gravel pits and vacant industrial lands.

The first step would be to get it running, a task that proved both educational and extremely frustrating. The car was an antique and my dad had forgotten the model name and lost its assembly manual. I found the model name on an online hobby forum and the manual turned up months later when I cleaned out my parent's garage. The car was missing parts, it had rotten fuel lines and the motor was seized. It required a full tear down, a thorough cleaning and careful reassembly, a process that I greatly enjoyed during the winter months after the Barton Tiffany project. In some way, restoring this car was a similar act of preservation and re-use, and I think it helped me with the disappointment of the Rheem building's demolition. Like an old building the car required constant maintenance, patience and resourcefulness. I would get it running and then something would break, come loose or be lost altogether. Again, and again, I disassembled it and machined new parts to match the damaged old. In the process I learned about single stroke engines, carburetors, milling machines, metric bolt sizes and gas-filled shocks. With every reassembly I got to know it better.

Eventually I was able to strap a camera to the car. The camera rig I designed was meant to enable 180° pan and 90° of tilt, it held a new camera - a GoPro Hero2 in its protective case - and a backpack which would hold the GPS data logger and the video transmitter. I designed the rig to attach to the cars roll cage to to avoid altering the original car which, as I learned, was an antique and of some value to certain collectors. Not that I ever plan on selling it.

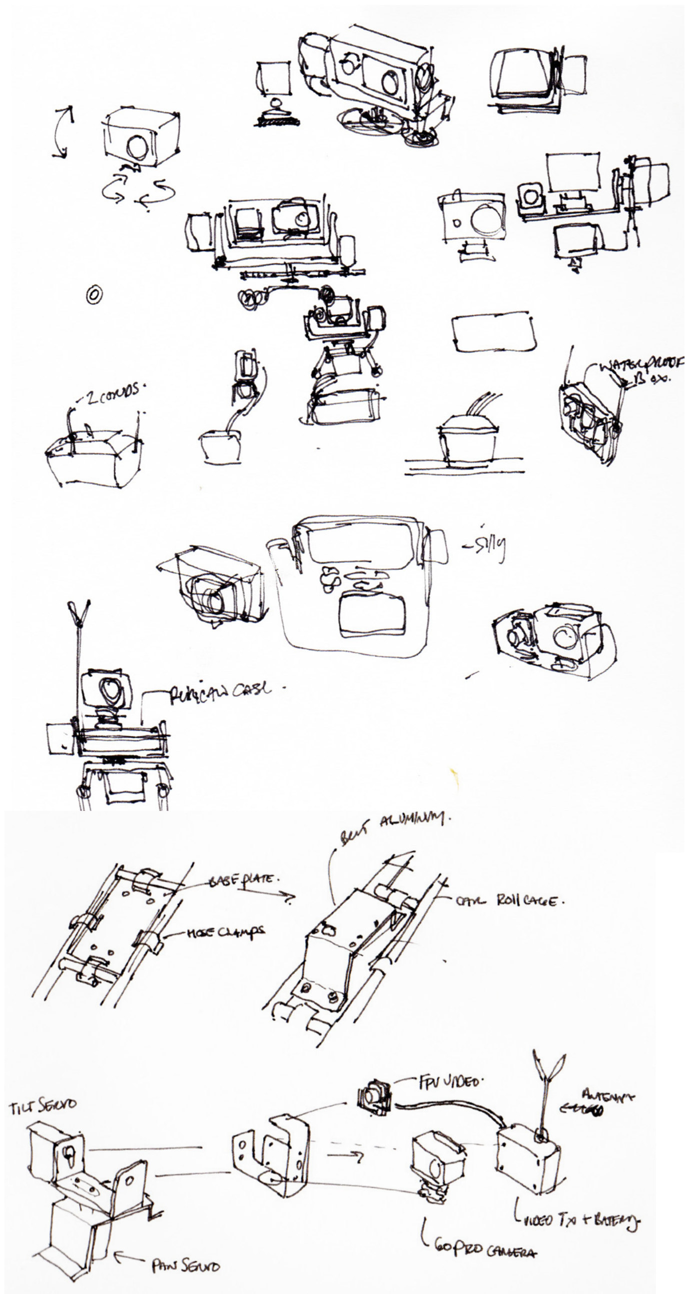



**Fig 2.2.5 -** Video Mount Design Sketches. *Drawing by Author.*

**Fig 2.2.6 -** The Car after a rough terrain test run. *Photo by Author*
**Fig 2.2.7 -** Initial Video Setup. *Photo by Author*

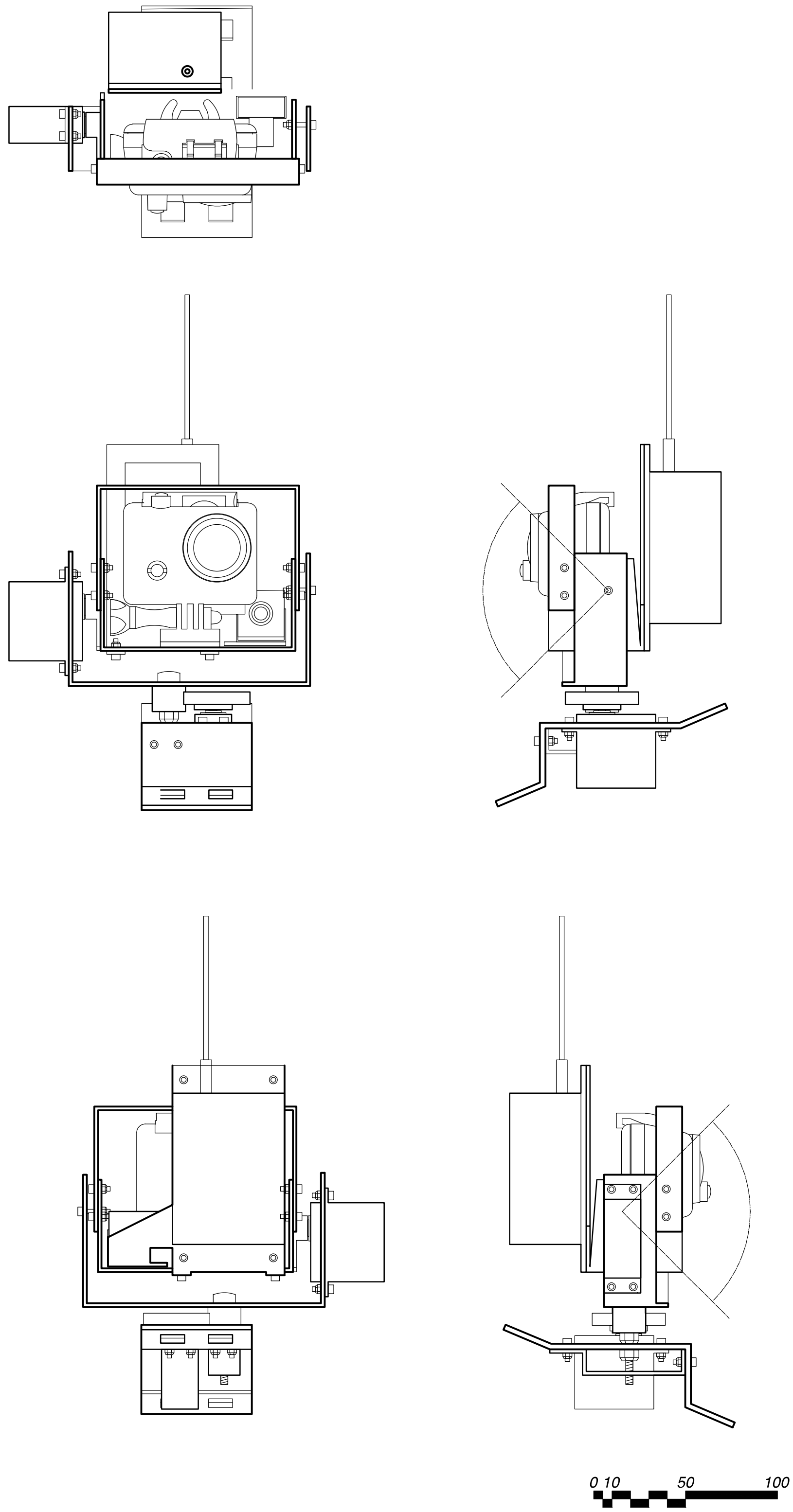



**Fig 2.2.8 -** Camera Apparatus Orthographics *Drawing. by Author.*

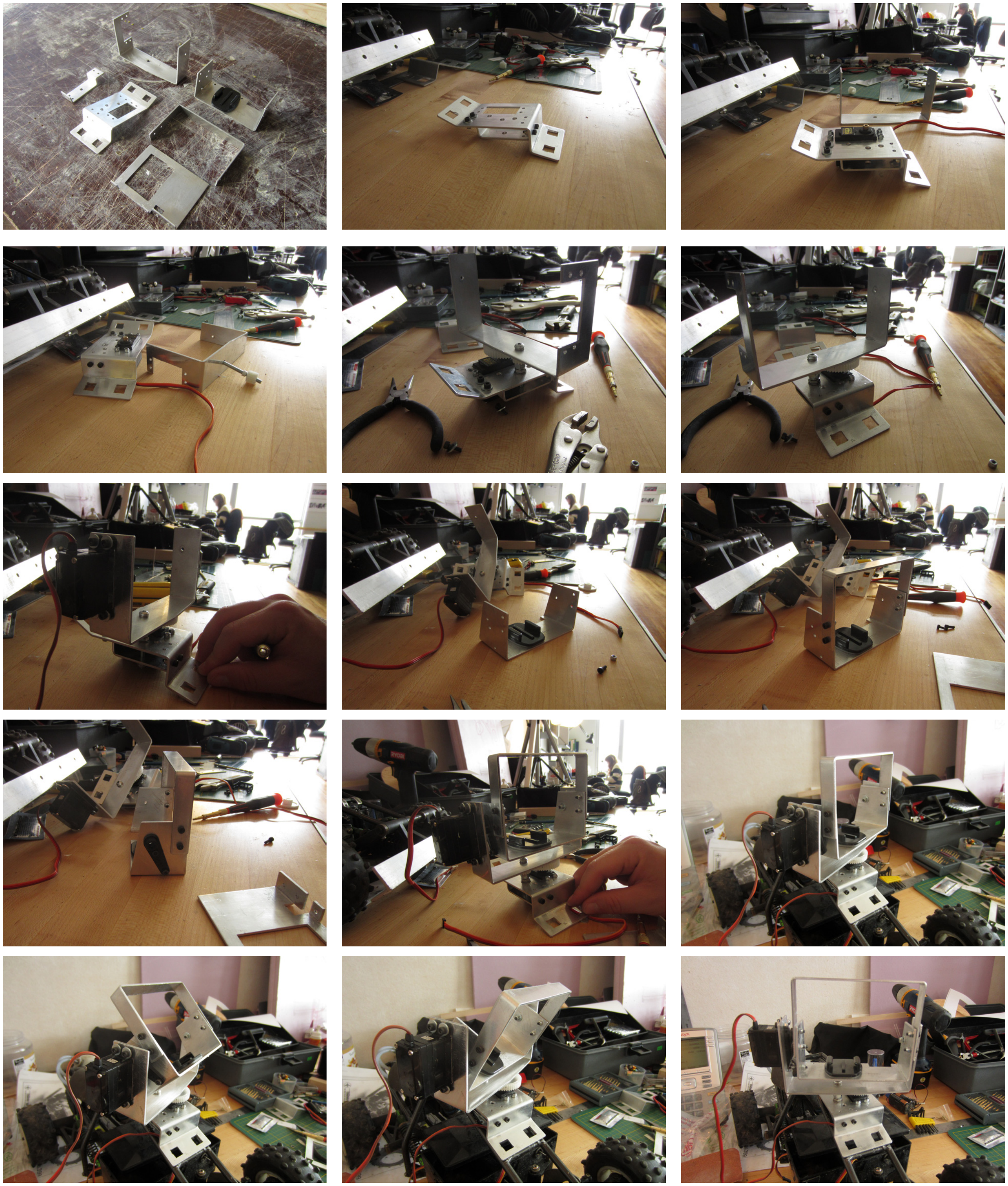


**Fig 2.2.9 -** Camera Apparatus Construction Process. *Photos by Author.*

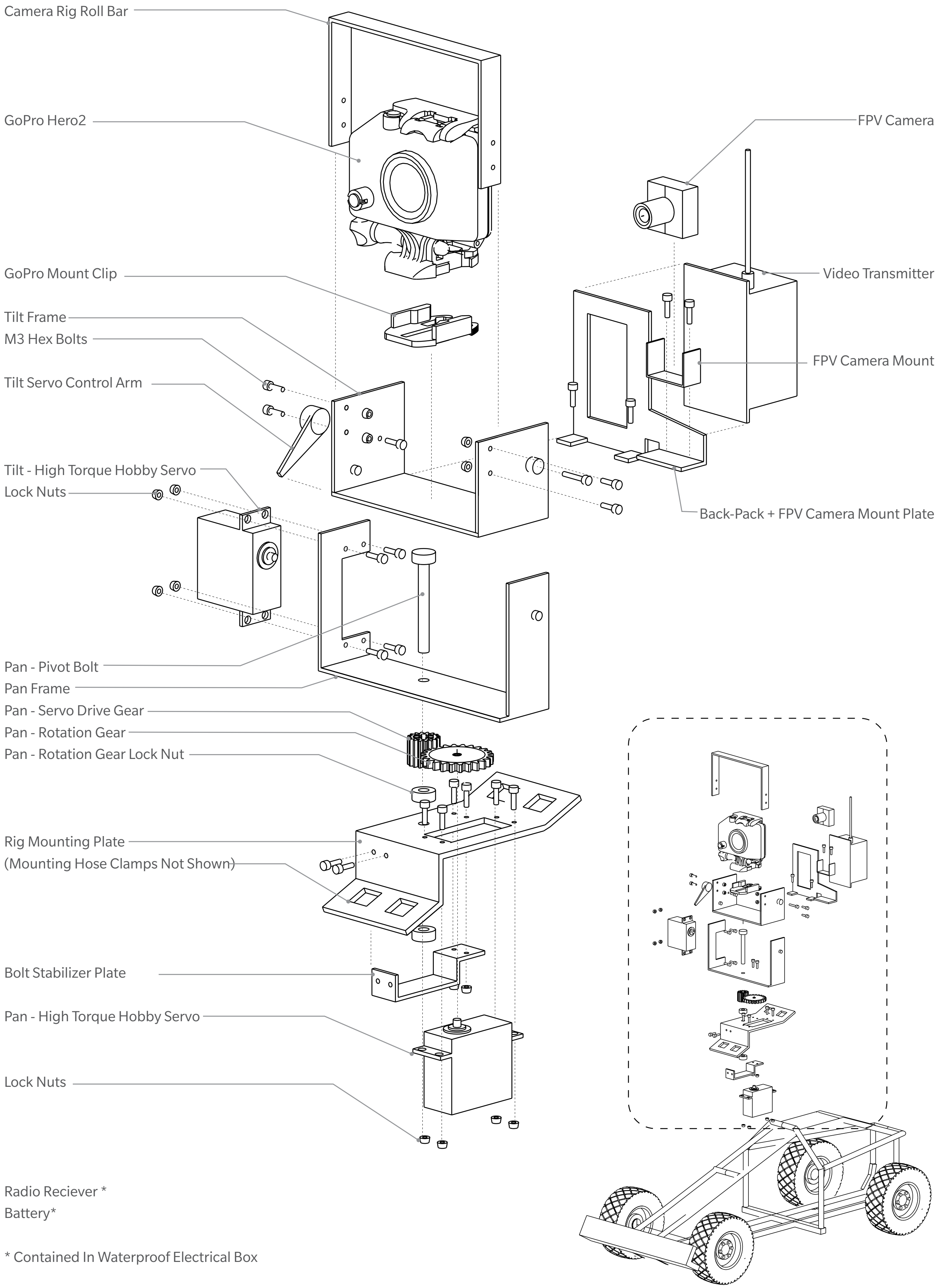
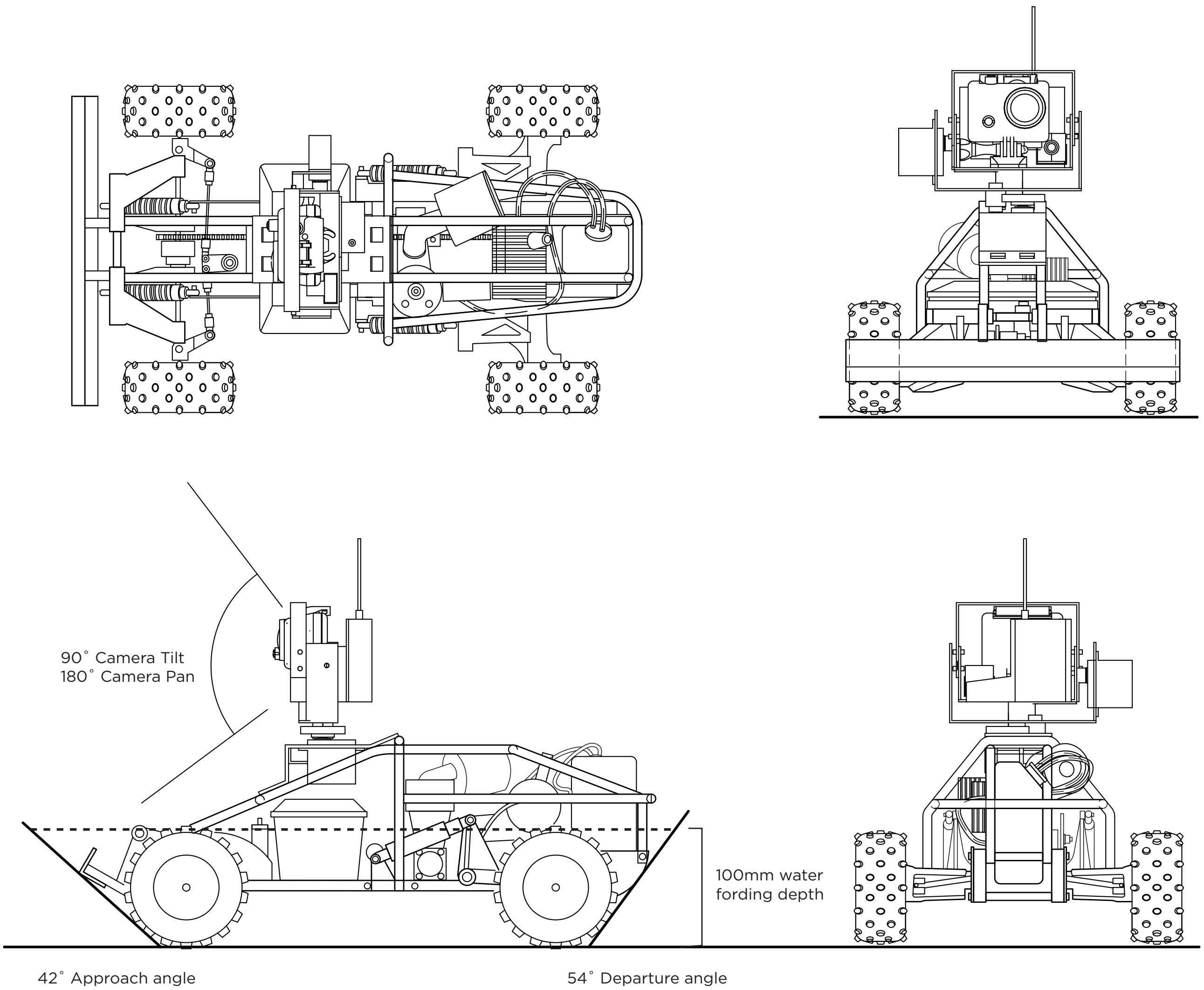



**Fig 2.2.10 -** Camera Apparatus Exploded Axonometric. *Drawing by Author.*



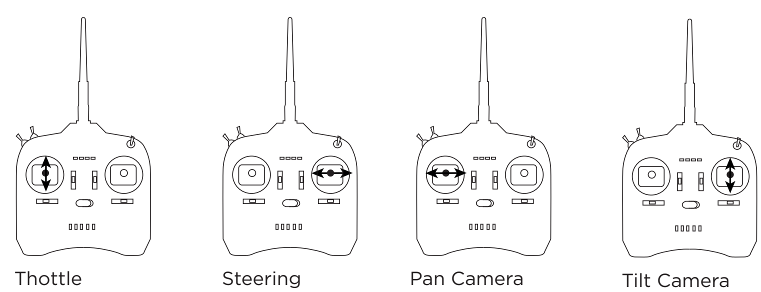




**Fig 2.2.11 -** Camera Apparatus installed on Car. *Drawing by Author.*

**Fig 2.2.12 -** Camera Apparatus and Car Control Diagram. *Drawing by Author.*

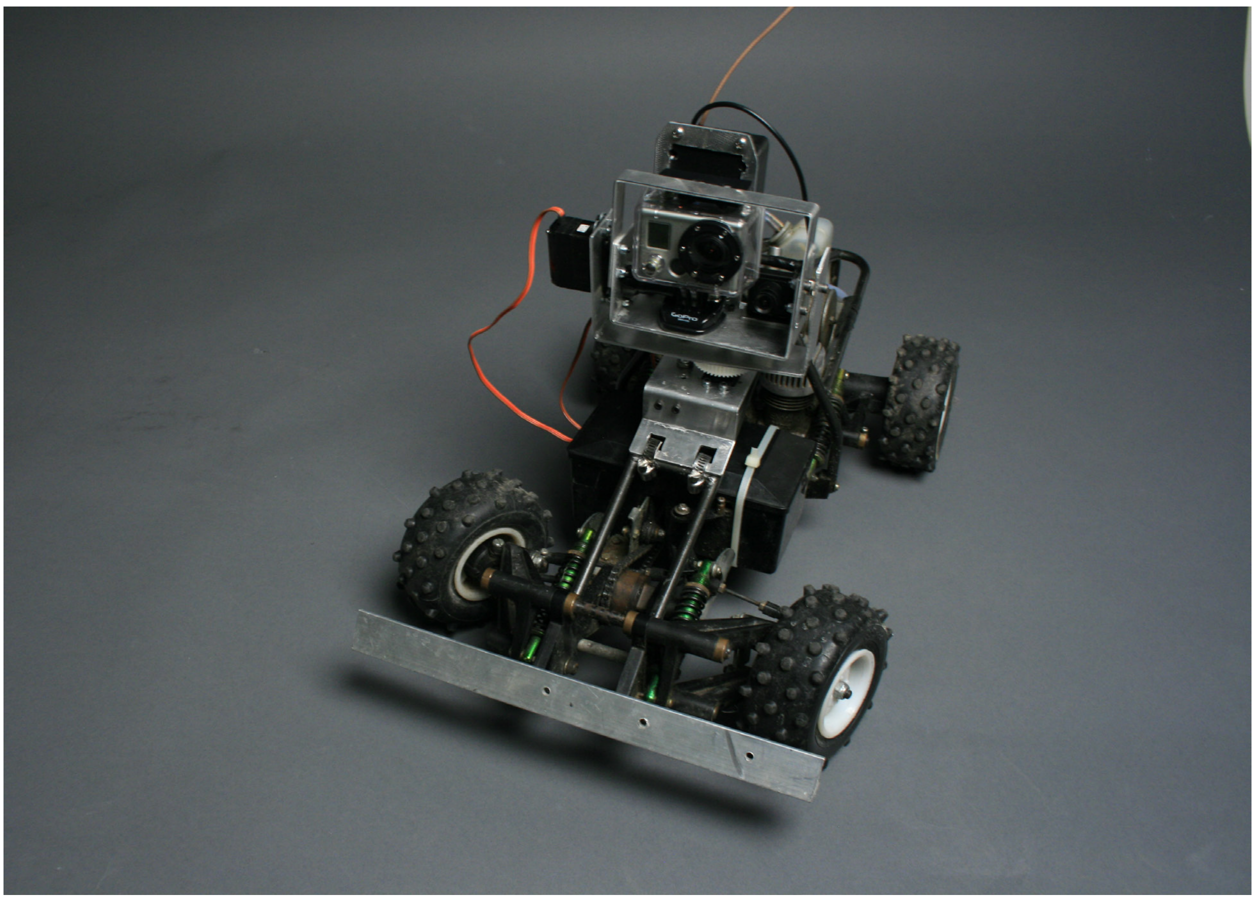


**Fig 2.2.13 -** Completed Car-01. *Photo by Author.*

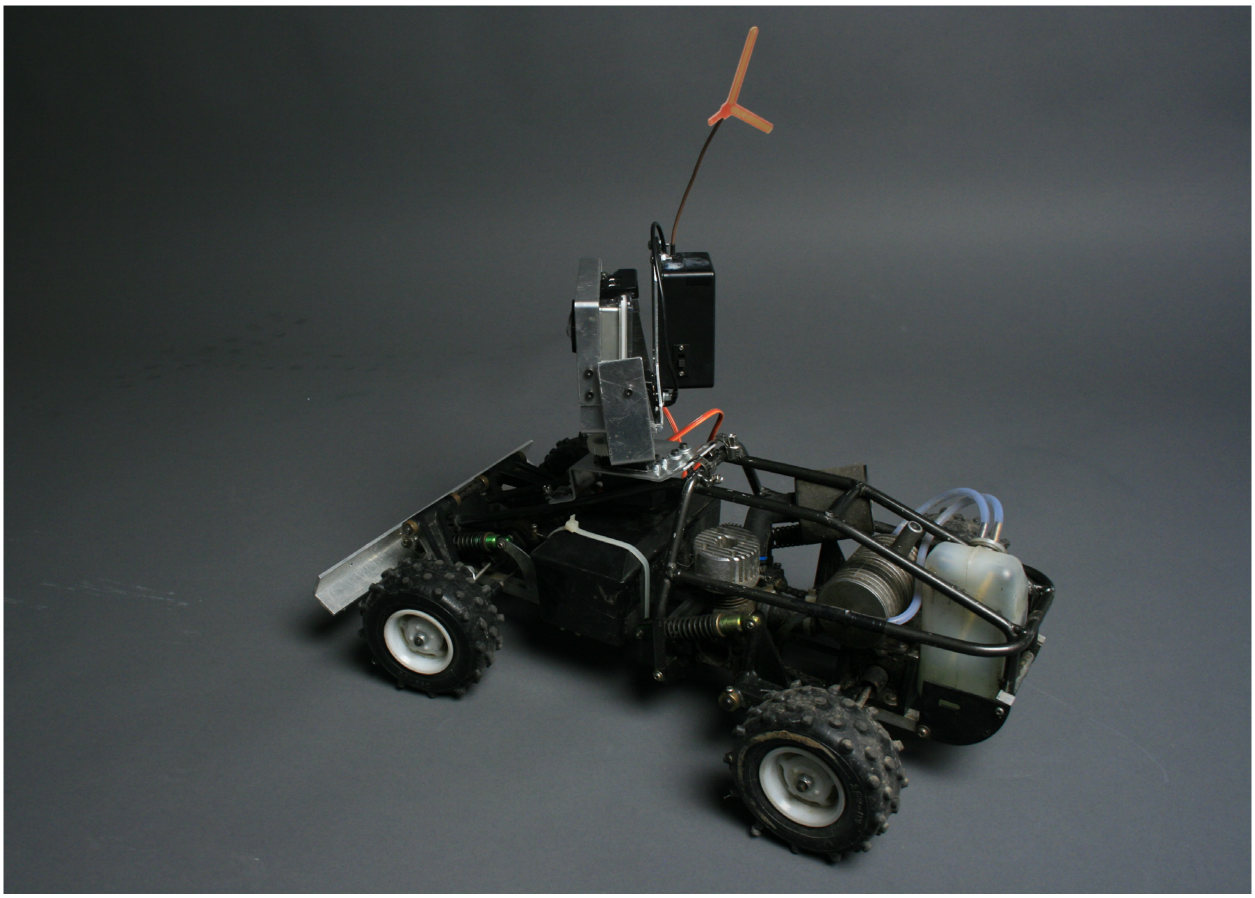
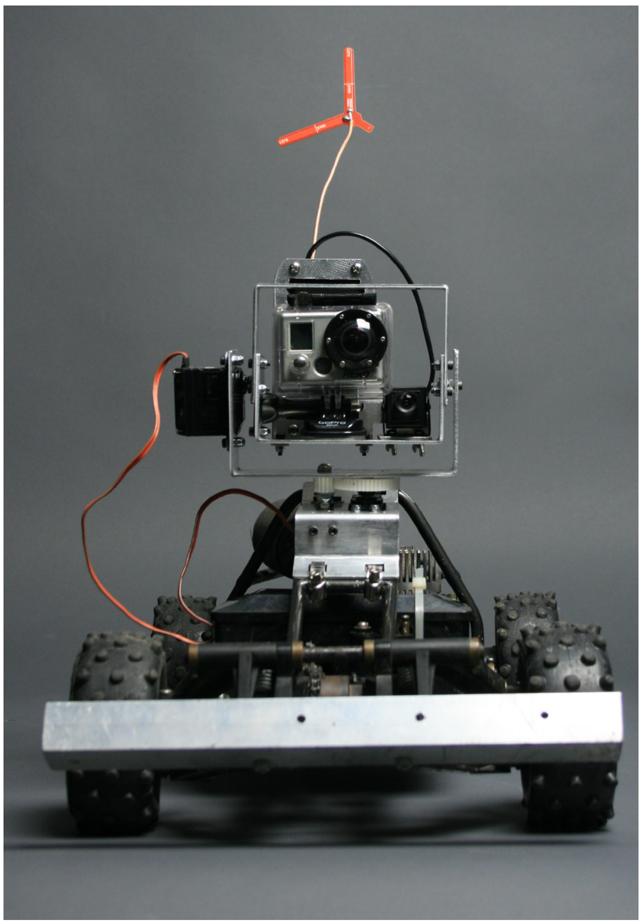


**Fig 2.2.14 -** Completed Car-01. *Photo by Author.*



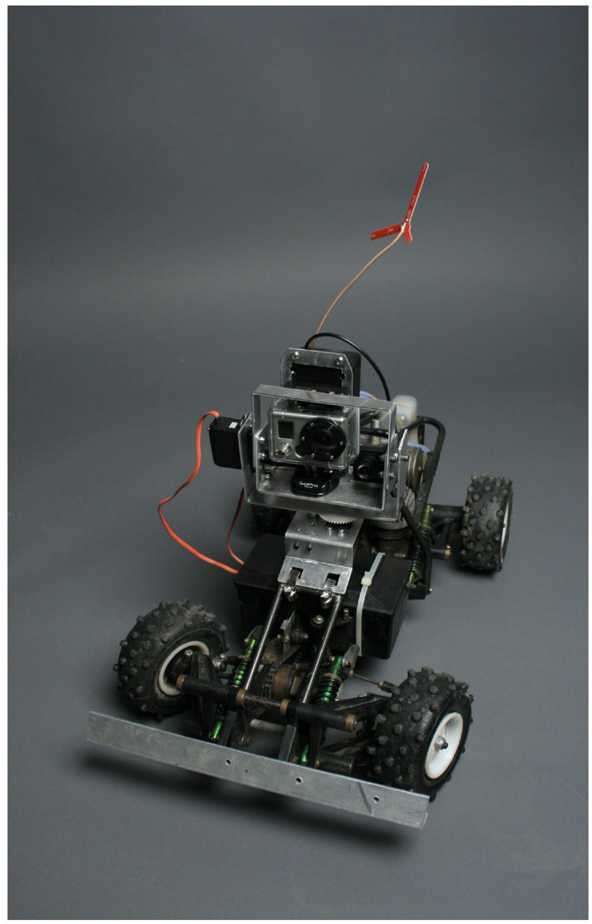
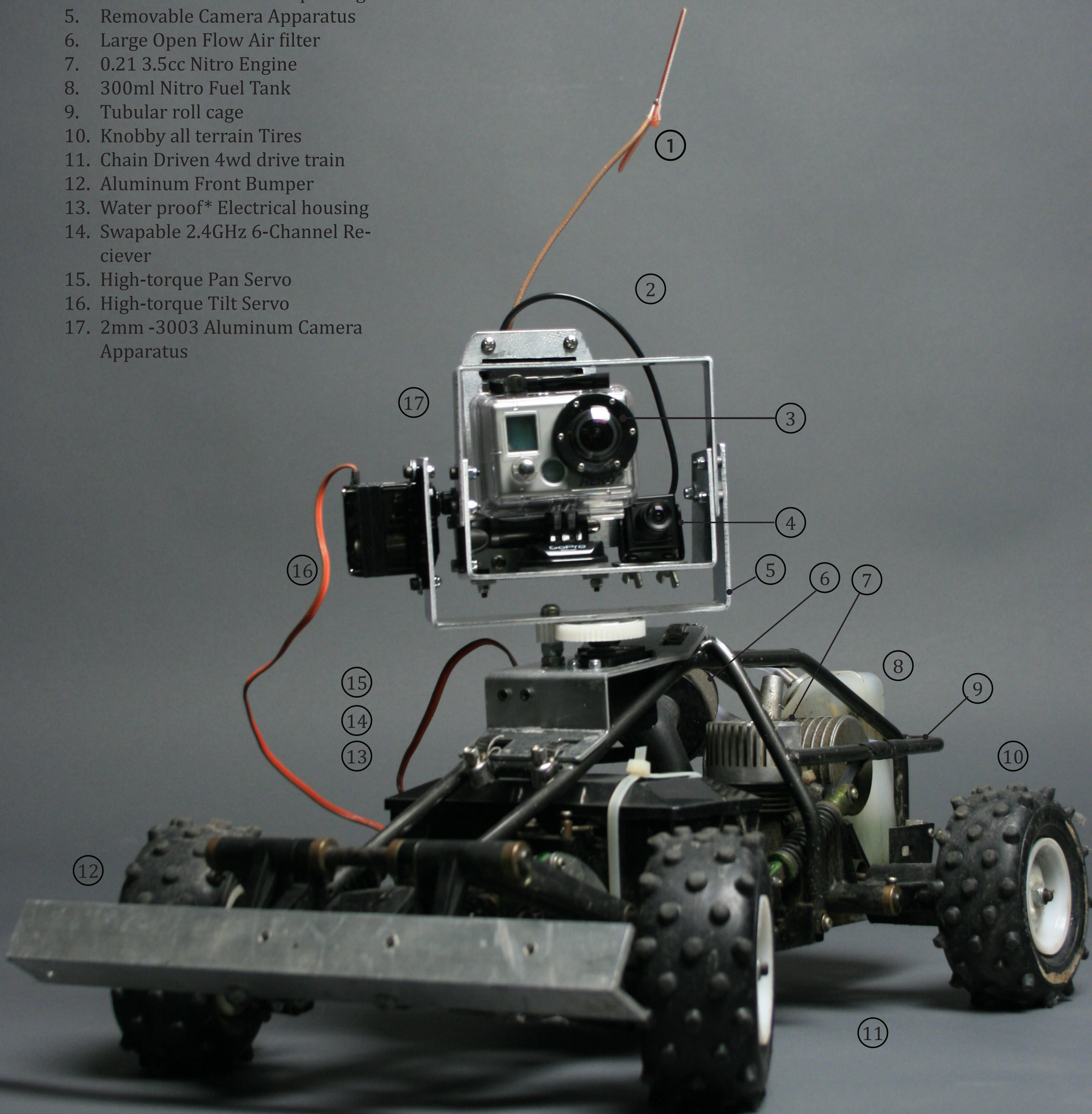


**Fig 2.2.15 -** Completed Car-01. *Photo by Author.*
**Fig 2.2.16 -** Completed Car-01. *Photo by Author.*
(Opposite)
**Fig 2.2.17 -** Completed Car-01. *Photo by Author.*

1. Video Transmission Antenna
2. 800-1300 MHz Video Transmitter and battery backpack
3. GoPro for High Definition Video Recording
4. FPV camera for remote piloting
5. Removable Camera Apparatus
6. Large Open Flow Air filter
7. 0.21 3.5cc Nitro Engine
8. 300ml Nitro Fuel Tank
9. Tubular roll cage
10. Knobby all terrain Tires
11. Chain Driven 4wd drive train
12. Aluminum Front Bumper
13. Water proof* Electrical housing
14. Swapable 2.4GHz 6-Channel Re-ciever
15. High-torque Pan Servo
16. High-torque Tilt Servo
17. 2mm -3003 Aluminum Camera Apparatus



Appropriating an old piece of technology like an antique nitro-powered remote-control dune buggy to serve a new purpose is an act of both reuse and self-torment. The AGV-01 is a heavy-duty car and is plenty durable for dropping over a fence or tearing across a vacant industrial site, but it lacks some key features needed in a remote-control land-based reconnaissance vehicle. The first is the ability to reverse. Nitro-powered RC cars have no reverse gear. If they get stuck in front of a wall, human intervention is required to get it unstuck. Second is reliability: an old motor is harder to get running and keep running. This one would overheat mid-run or refuse to start when the opportunity presented itself.  Third, and related to reliability, is the availability of spare parts. The car is twenty-seven years old and has been out of production for over twenty years. Parts are expensive and extremely rare (even on Ebay) and making replacements requires hours of custom fabrication time, taking away from hours exploring restricted areas. Fourth is stealth: I didn't know when I set out to make it, but small Nitro motors like this are loud, so loud you can hear the AGV coming from three blocks away. Fifth is video quality: these motors generate lots of vibrations, even when the car is at a stand-still. The vibrations cause blurry video and poor photo quality. Last is availability. The goal of this project was, not only to build a device for myself, but also to demonstrate how toys could be used for reconnaissance, data acquisition and mapping. It is safe to say that they don't make these cars like they used to: a similar 4WD 1:10 scale Nitro buggy today costs upward of $700.00 and requires just as much maintenance. However, due to better battery performance and cheaper electronics, modern electric hobby vehicles are in demand and can be found for under $200.00. They run quieter, are more dependable, have no vibration issues, and a plethora of available replacement parts.

My conceit with the AGV is that I had it lying around, it was free and I thought I could make it work. In the end even though its aesthetics lend to its purpose, the obvious performance issues make the antique car, and the AGV-01 ill-suited for ground-based reconnaissance.

**Fig 2.2.18 -** An example of Todays off-road Electric RC cars. The Traxxas 1:10 scale Slash 2wd Chassis. *Source: https://www.greathobbies.com/productinfo/?prod_id=TRX5803.*

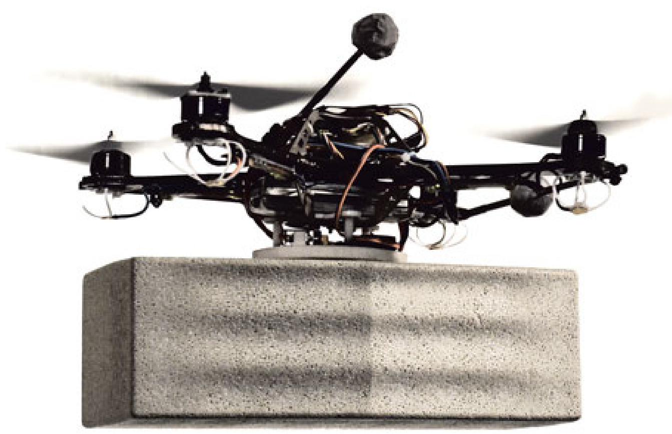


**Fig 2.3.1 -** AR Parot Drone 2.0 *Source: http://www.gizmofashion.com/parrot-ar-drone-2-0-quadricopter.html.*

**Fig 2.3.2 -** Flight Assembled Architecture. *Gramazio and Kohler. Source: http://www.gramaziokohler.com/web/d/projekte/209.html.*

# *The Quad*

Multi-rotor remote control aircraft can be deployed in the close confines of urban areas. They can be very stable and agile while still being able to carry a camera and other equipment. Due to the small size of their motors and propellers, as well as their smaller and lighter components, multi-rotor helicopters cost less and are safer to operate than single-rotor RC helicopters with similar payload capacities. Having multiple rotors can also provide redundancy. For example six-rotored Hexa-copters can loose up to three motors – as long as they are not adjacent to one another – and still be able to fly safely. Multi-rotor aircraft, like helicopters, also have the ability to hover. This allows them to loiter over a site for a sustained period while retaining the ability to move in any direction at various speeds unlike a plane that has to travel forward to generate lift. These characteristics make them extremely versatile for close-proximity photography and reconnaissance.

It was only a matter of time until I decided to build a multi-rotor aerial camera platform. It seemed everywhere I looked there one of these hovering unidentified aircrafts. Gramazio and Kohler employed them to stack bricks, while the GRASP Lab at the University of Pennsylvania, taught them to fly in formation and through obstacles. The options I found commercially were either limited like the *AR Parrot Drone* – a short ranged $300 iPhone-controlled toy equipped with a small camera that sends video back to the pilot and no extra payload capacity – or they were expensive and highly entailed like the DragonFly x6, a ready-to-fly tri-copter geared towards military and law enforcement, beginning at $18,999.

The complexity and cost-range of multi-copters intimidated me, until *FliteTest* -a YouTube channel dedicated to all things hobby aircraft- ran a *Scratch-Built-H-Quad* episode. In the video, the show's hosts build a functional quadrocopter using poplar sticks, hot-glue, and off-the-shelf electronics. They also provided links to detailed plans, a shopping list of parts, and build tips in order to enable their viewers to build their H-Quad design. Their design could carry a camera as well as transmission equipment, and seemed to handle as well as the AR-drone and the DragonFly models at a fraction of the price. The parts they specified shipped from Hong Kong and cost just under $150.00. I already had the remote and battery charger from building the other devices and the frame was made of wood.

My sketchbook filled with doodles of quadrocopters. I wanted one that could fold up, transmit video, carry a camera, and fly for around twenty minutes. I would use the same aluminum as the kite rig and car camera mount. I ordered the parts and began fabrication.

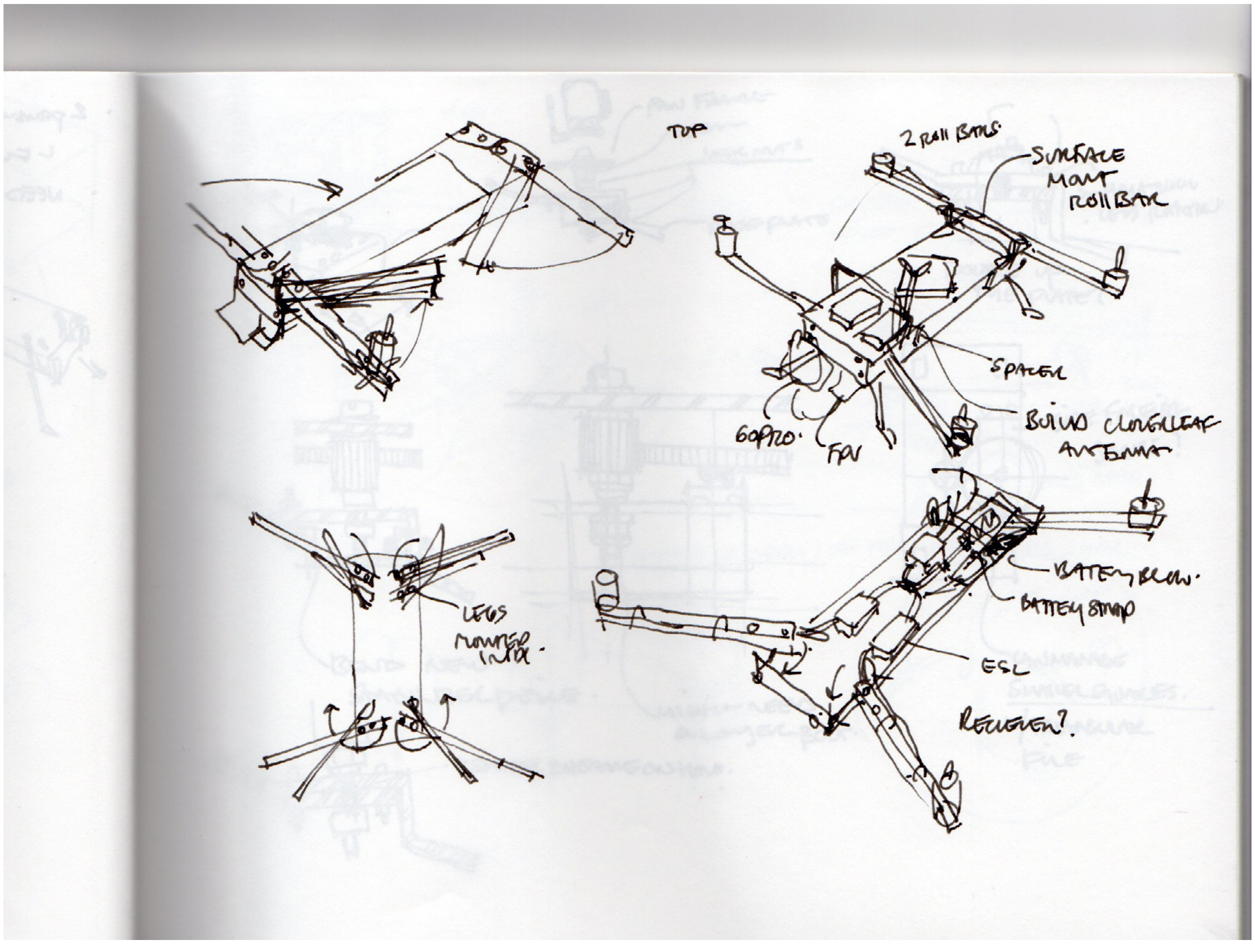



**Fig 2.3.3 -** Quadrocopter-01 Design Sketches. *Drawing by Author.*

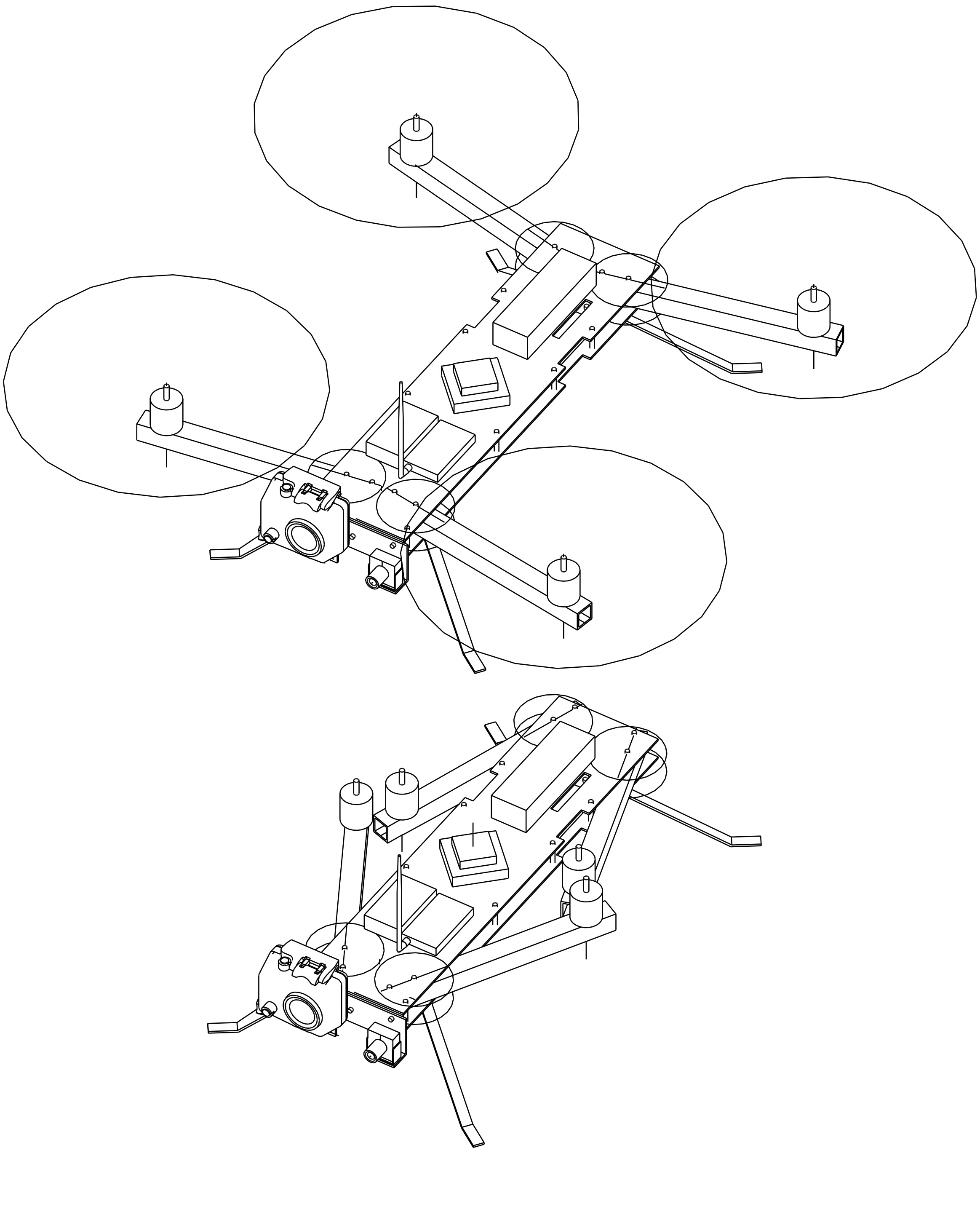


**Fig 2.3.4 -** Quadrocopter-01 3D Model. *Drawing by Author.*

Instructions

1. Print and cut out part templates.
2. Spray mount Templates onto Aluminium.
3. Rough cut all parts with stomp sheer.
4. Cut Arms to length.
5. Drill motor mount and fastner holes in arms and flat parts.
6. Machine rough openings.
7. Soak parts in soapy water to remove template.
8. Use a file to remove burrs from rough openings and drill holes.
9. Prepare for assembly, gather tools supplies and component parts.
10. Attach legs first, this provides room to work under the quad as it is assembled.
11. Position arms and top plate, place and tighten bolts.
12. Secure motors to motor mounts and install onto the quad frame arms.
13. Solder connectors and extra wire length to Electronic Speed Controllers and power distribution cable.
14. Install ESCs and power distribution cable.
15. Connect ESCs to Motors and power distribution cable.
16. Install latest firmware onto Secure Multi Rotor Control Board.
17. Install Control Board Connect ESCs to Control Board.
18. Install radio Receiver.
19. Connect receiver to Control Board.
20. Attach Battery.
21. Arm Control board and Calibrate Electronic Speed Controllers.
22. Ensure all motors are rotating in proper direction, if necessary, switch two of the three wires to reverse motor direction.
23. Ensure motors respond, speed up or slow down, while manually tilting the Quadrocopter. DO NOT INSTALL PROPELLERS UNTIL AFTER THIS.
24. Balance all Propellers by using small bits of tape.
25. Install Propellers and ensure proper rotational direction - clock wise vs counter clockwise.
26. Test flight characteristics.
27. Practice flying helicopters on a simulator program or with small toy helicopters.
28. Install flight Cameras and video transmitter.
29. Go fly somewhere, try not to hit anything.

Tool List

Foot sheer
Hand sheer
Square edge
Metal band saw
Machining press
Drill press
Pliers, needle nose, blunt nose, hooked
Soldering Iron
Helping Hands
Screw Drivers
Metal File / Rasp
Hand nibbler

Parts List

1 - 2 mm 3001 Aluminum (body, legs, mount)
4 - 200mm long 12.5mm square aluminum tubes
22 - 40mm long 3mm hex bolts
8 -15mm long 3mm hex bolts
30 - 3mm lock nuts with nylon insert
4 - 1100kv 52g Brushless motors (Turnigy 2836)
4 - 30Amp Brushless speed controllers (30A Plush)
1 - Flight control board (HK V2.1)
1 - 2.4ghz Receiver (Spektrum AR6115E)
1 -2.4ghz Transmitter (Spektrum 5xe)
1 - 2200 mah 3cell LiPo Battery
1m - 22AUG wire
20 - 3.5mm bullet connectors
1 Pair (male female) of XT60 connector
4 - JR male to male servo connector wire
2 - Right hand rotation SF 11x4.7 propellers
2 - Left hand rotation SF 11x4.7 propellers
4 - Propeller adapters
1 - Video transmitter
1 - FPV camera
1 - USB ASP programmer
1 - Battery strap (or industrial velcro)
Heat shrink tubing

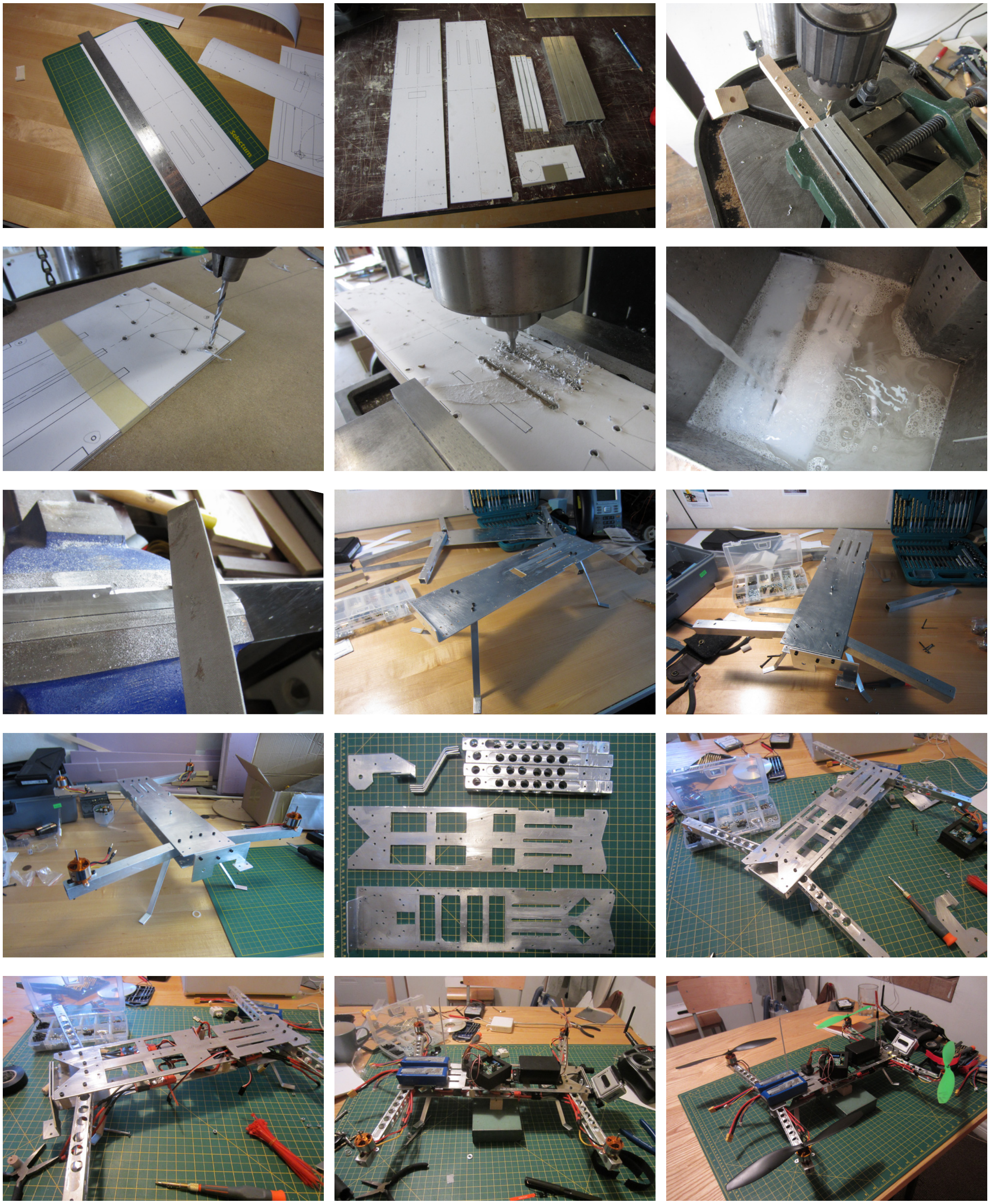
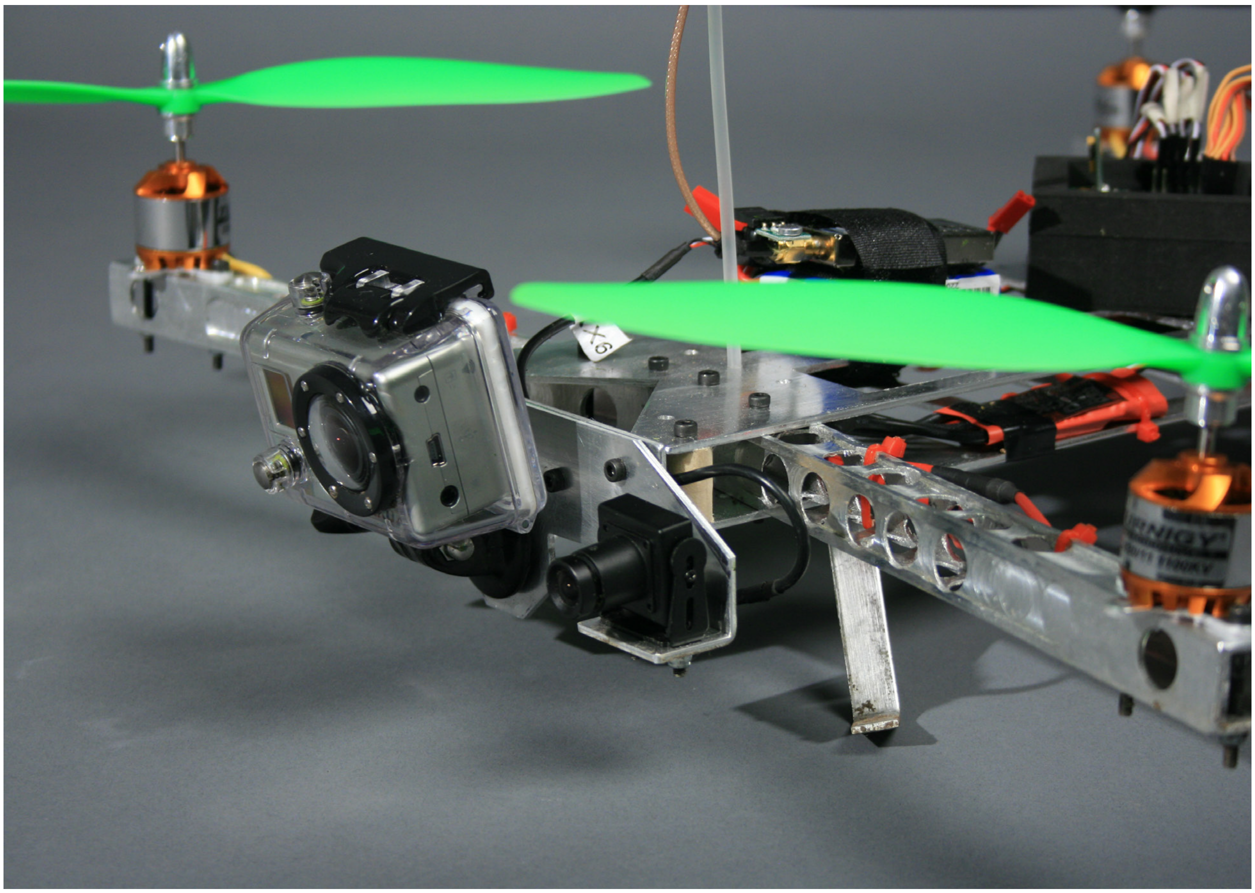


**Fig 2.3.5 -** Quadrocopter-01 Construction Progress. *Photos by Author.*



(Previous Page)
**Fig 2.3.7 -** Completed Quadrocopter-03. *Photo by Author.*

(Above)
**Fig 2.3.8 -** Close up view of GoPro and FPV camera mount. *Photo by Author.*

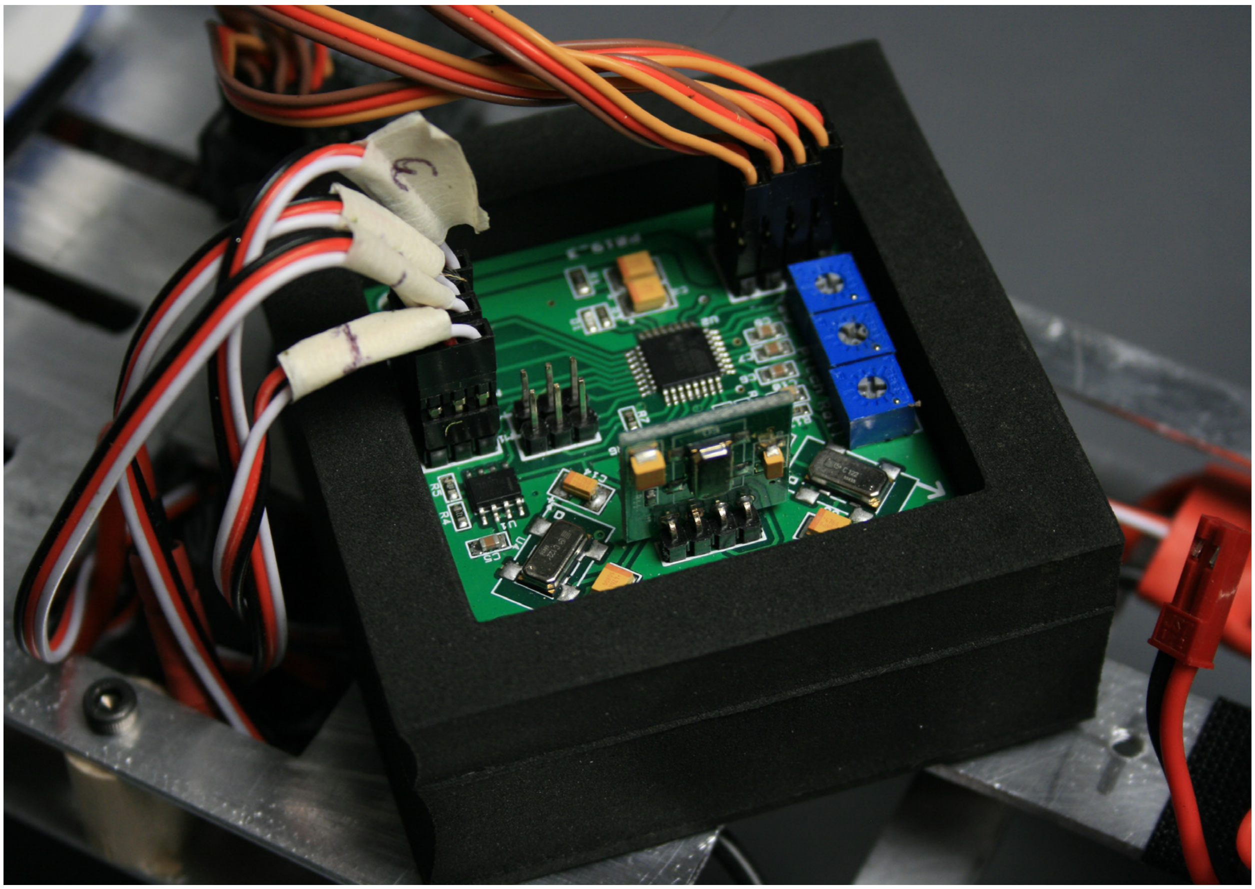


**Fig 2.3.9 -** Close up view of the HobbyKing  Multi-Rotor Control Board V2.1 (Atmega 168 PA). *Photo by Author.*

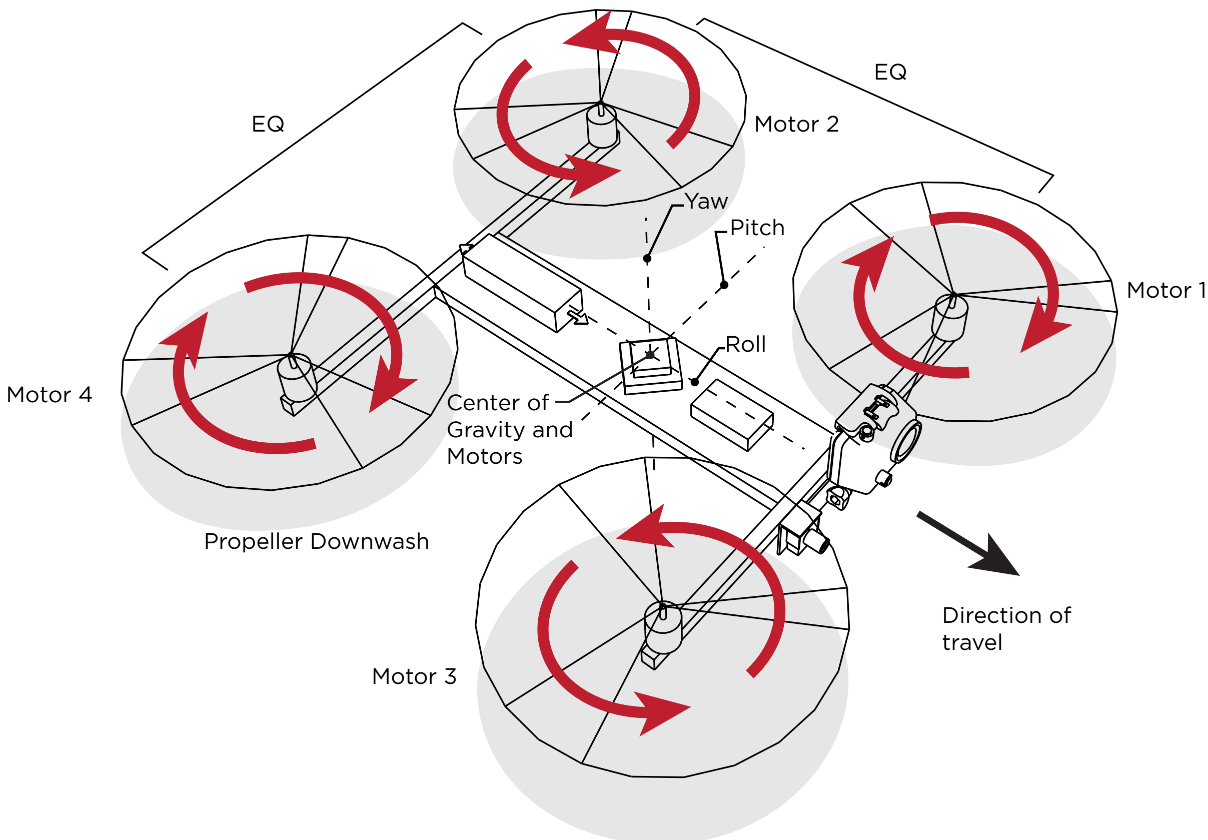



**Fig 2.3.10 -** Quadrocopter Diagram. *Drawing by Author.*

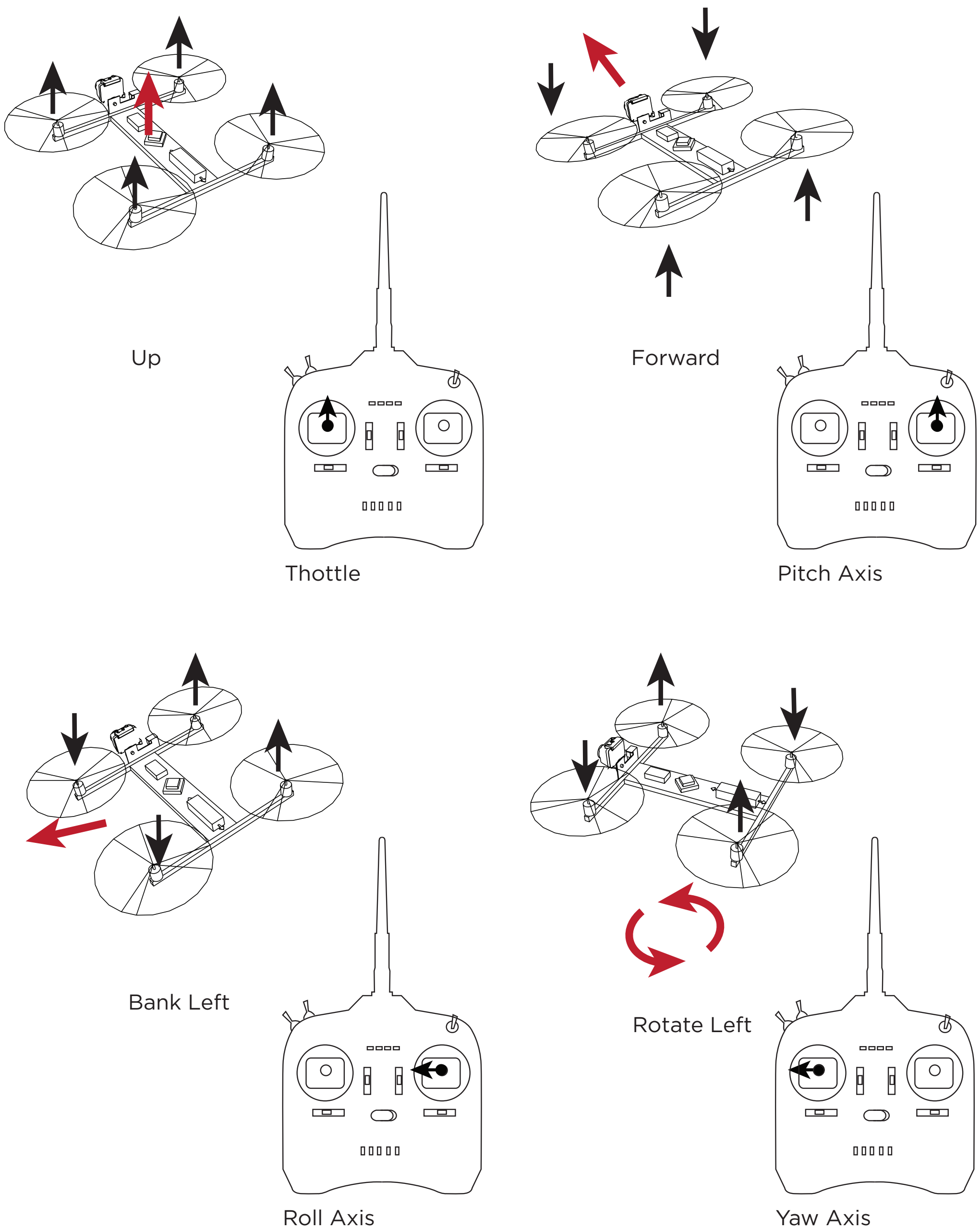



**Fig 2.3.11 -** Quadrocopter Control Diagrams. *Drawing by Author.*

How-to videos on YouTube are a lot like cooking shows, you see the ingredients, you watch the chef throw them together and then there is a beautiful product to enjoy at the end. I found building and piloting the Multi-Rotor Unmanned Aerial Vehicle both challenging and frustrating. The MRUAV-01, shown opposite, flew but not very well. The Flight Control Board required lots of tuning, programming and reprogramming, as did the Electric Speed Controllers, while wiring and testing the motors was also not as straightforward as I had anticipated.

The Aluminum frame I designed was heavier than I hoped. I went back to the shop repeatedly to try to lighten it by shaving grams from the arms and fuselage by cutting holes and machining away thickness. This extra step also made making repairs more intensive and weakened the arms to a point that when I hit our clothesline and twisted the front right arm, I was able to hand bend it back to square without tools or a vice. Even with these weight saving measures the Quad-01 was heavy and required lots of power just to take off and hover. I needed to lighten the frame or get more powerful motors.

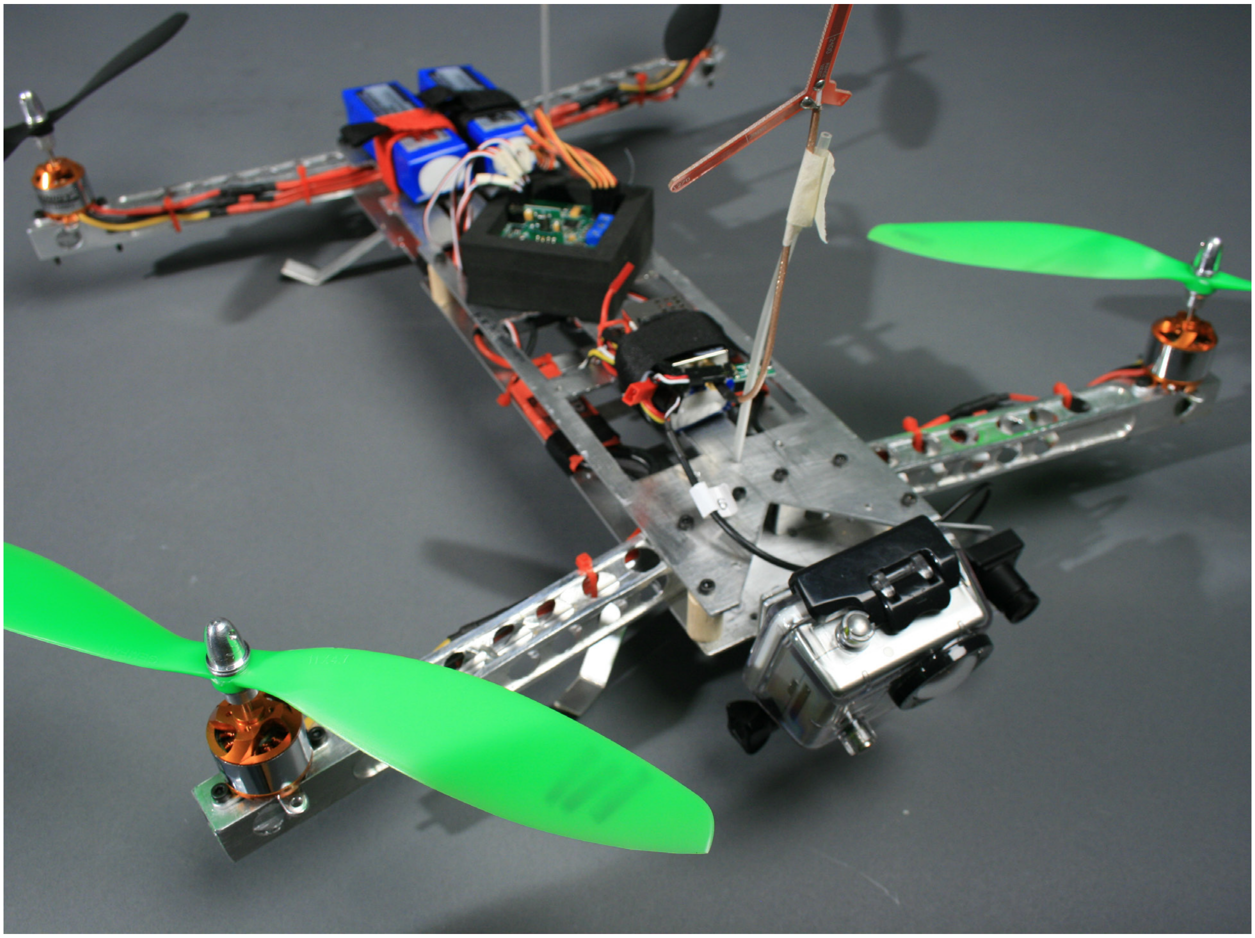


**Fig 2.3.12 -** Completed Quadrocopter-01. *Photo by Author.*

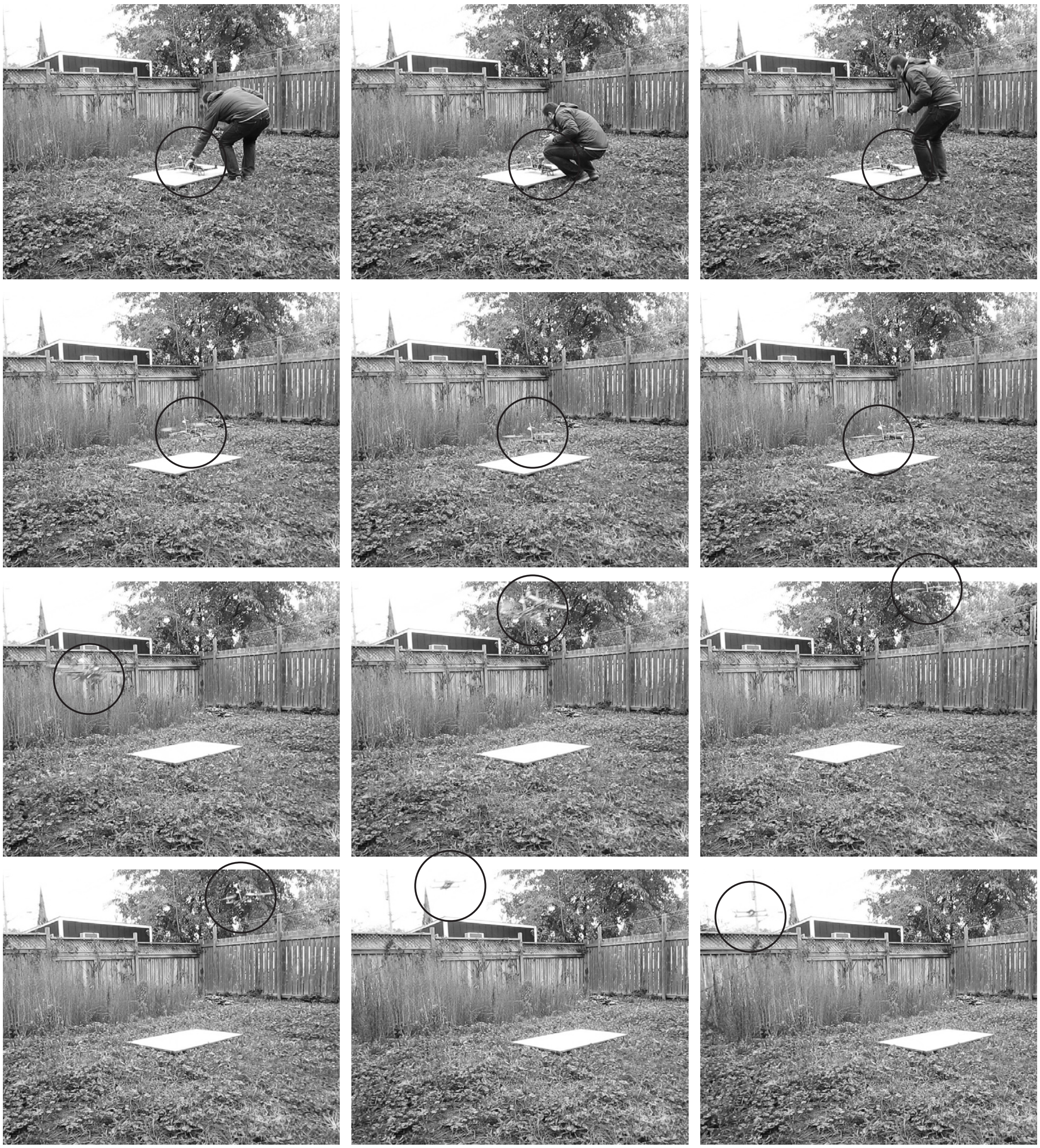
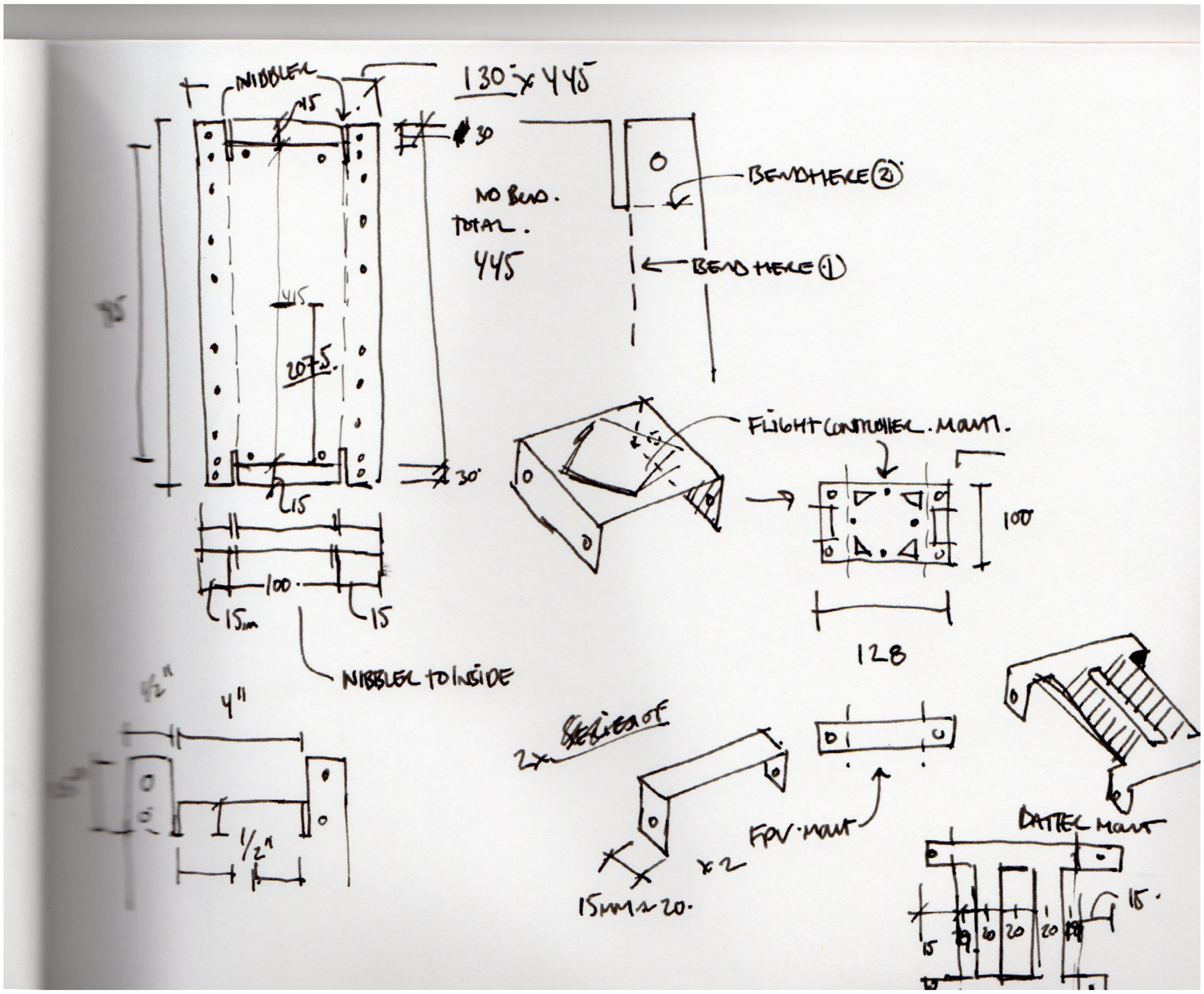


**Fig 2.3.13 -** Photo reel of Quadrocopter-01 Flight testing. *Photos by Author.*



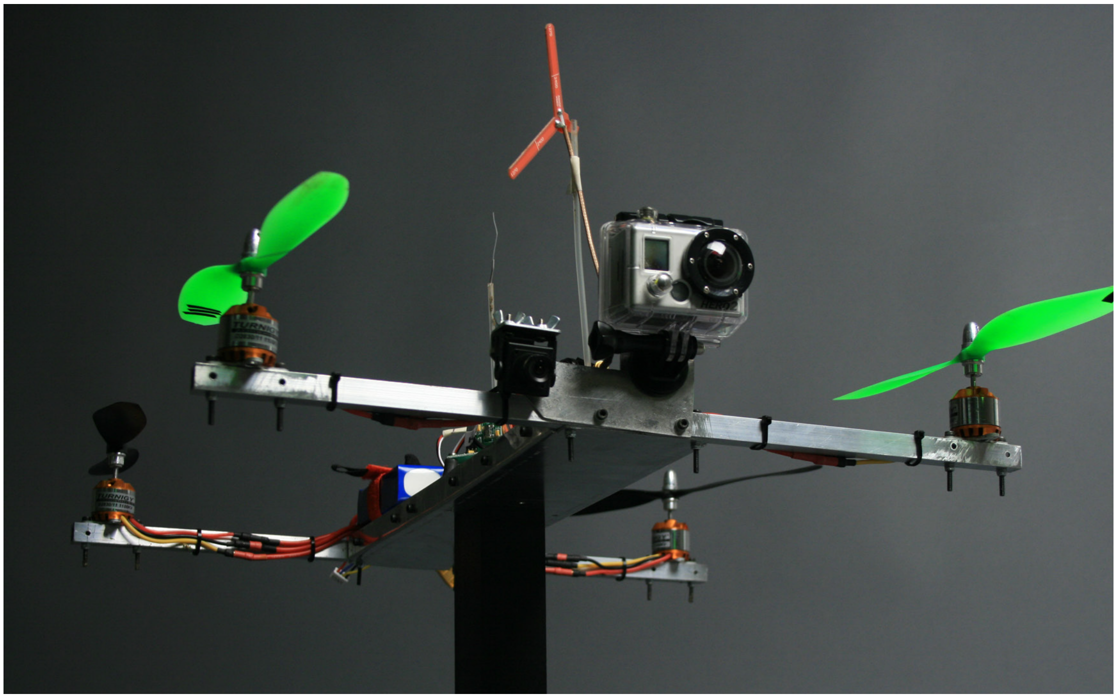

To address the weight issues of the Quad-01, I made the -02 version with thinner aluminum, smaller arm sections and a refined fuselage design. The arms were more easily replaced and I made a spare set in case I crashed. I also removed the legs and reduced the number of fasteners needed. In the name of simplicity I removed the ability to fold the arms with the hope of reducing weight while stiffening the design.

**Fig 2.3.14 -** Quadrocopter-02 Design Sketches. *Drawing by Author.*

**Fig 2.3.15 -** Quadrocopter-02 Build Progress. *Photos by Author.*

The Quad-02 was only a moderate improvement over the -01. It was lighter, but was still difficult to get off the ground and maintain control. The lack of landing gear was also hard on the components and a few crash lands caused some minor bends in the motor mounts. The fuselage design was prone to minor torsional movement through its long axis. This meant that when I tried to turn the craft, engage the yaw axis where the diagonally opposite motors increase in speed, the frame would bend and the Quad would barely respond. Also, the new design moved the GoPro out further from the center of airframe, which forced me to move the battery out to balance the aircraft. If I wanted to aim the camera down, further pivoting its weight from the center of gravity, I needed to add weight to the back.

In addition to these problems, I learned that aluminum blocks radio waves and can cause signal interference between the remote in my hands and the receiver on the aircraft; this could reduce piloting range, and could cause a dropped signal or an accident. This discovery forced me to reconsider aluminum as a suitable construction material for quads, and explained why the *Flitetest* guys used wood.



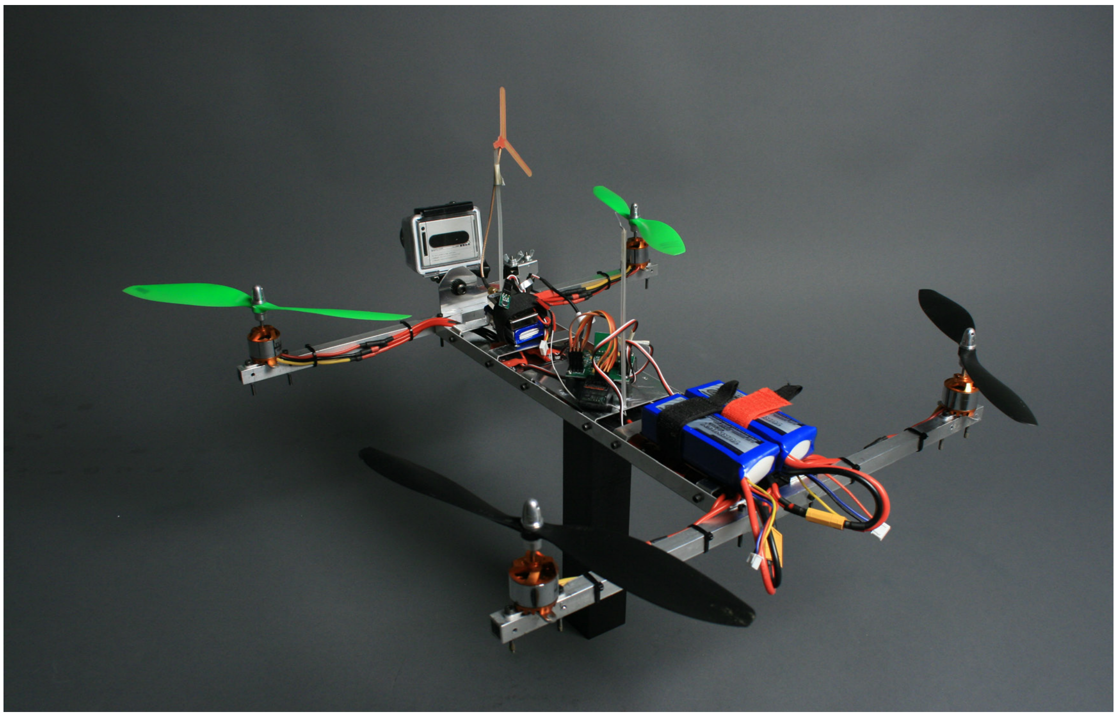
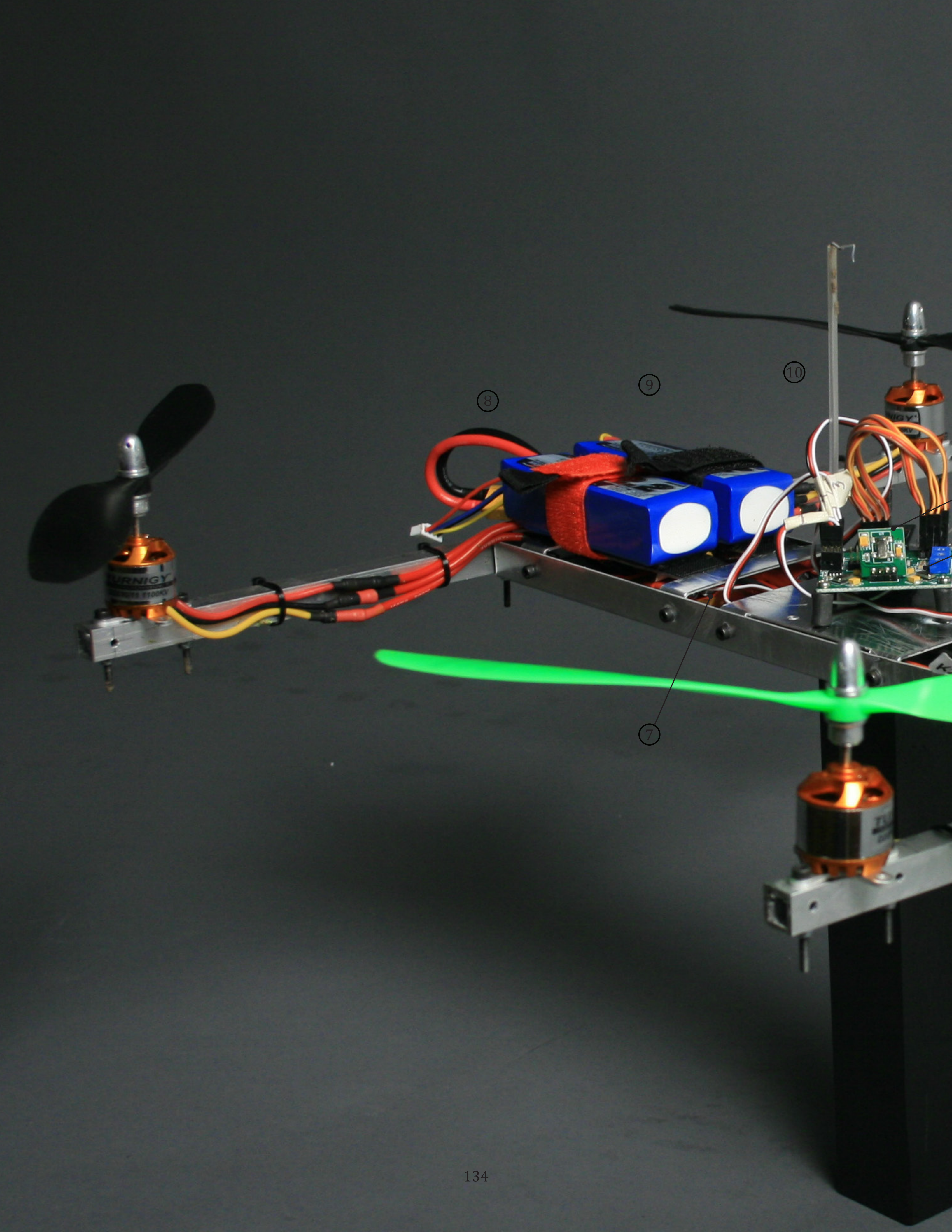


**Fig 2.3.16 -** Completed Quadrocopter-02. *Photo by Author.*
**Fig 2.3.17 -** Completed Quadrocopter-02. *Photo by Author.*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TURNIGY


1. Video transmission antenna
2. GoPro for high definition video recording
3. Slowfly 11x4.7 propellers (green for oreintation)
4. 4 - 1100kv 52g brushless motors
5. 12.7x12.7x1.5mm square tube aluminum arms
6. FPV camera for remote piloting
7. 4- 30Amp electronic speed controllers
8. Parallel 'Y' battery harness
9. 2-2200mah 3cell LiPo battery packs
10. Reciever antenna
11. 2.4GHz 6-Channel reciever
12. HK Multi-Rotor control board v2.1 with a Atimega168Pa micro-processor and 3-Murata piezo gyroscopes
13. 800-1300 MHz video transmitter

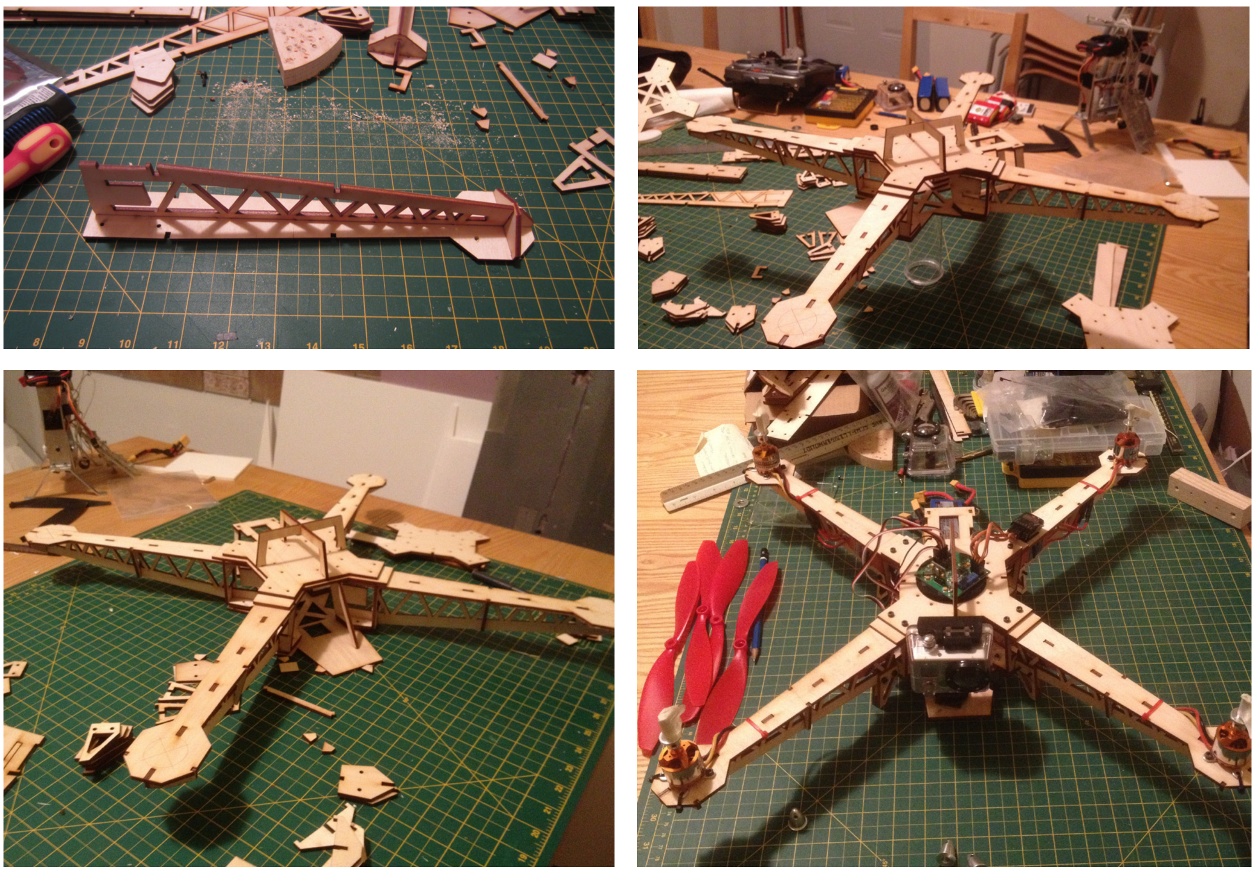

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**Fig 2.3.18 -** Completed Quadrocopter-02. *Photo by Author.*

(Above)

**Fig 2.3.19 -** Quadrocopter-03 Build Progress. *Photos by Author.*

The discovery and application of a new material enables a new vocabulary in design, the mild 3001 aluminum enabled me to detail and visualize the first two Quads, as well as the Car camera mount and the final kite rig. However, the discovery that aluminum blocks radio waves forced me to seek out a new material. Aircraft plywood is an extremely strong, lightweight wood product manufactured to high tolerances and commonly used in small passenger planes. Hobbyists also use aircraft plywood to build scale models for similar reasons. The only drawback is its cost, $70 for a 5'x5' sheet at the local lumber store. The closest thing I could find to aircraft plywood in my price range was cabinet grade birch plywood. At $18.00 for a 5'x5' sheet of 1/16" -3.2mm-thick ply, this material lacks the stability of aircraft ply but is still lightweight and soft enough to be cut on the school's laser cutters.

The Quad-03 uses this new material with the goal of drastically reducing its cost, weight, and build time. A higher degree of componentization in the design simplifies repairs, isolates forces in the event of a crash and takes advantage of computer aided manufacturing processes. The wood also helps to reduce vibrations from the motors, and increases the accuracy of the sensors in the flight control board.

The new design for the -03 brings the center of gravity, determined by the camera and battery, closer to the center of the airframe. A taller structure stiffens the arms and fuselage while providing a better battery compartment and improving ventilation to the Electronic Speed Controllers. The design adds more physical protection for the Flight Control board and simple landing gear. The height of the fuselage and landing gear together lift the motors and propellers higher above the ground, reducing the amount of turbulence cause by downwash during take offs and landings. Reduced turbulence will make the quad easier to take off.

With this design I have also upgraded the Electronic Speed Controllers (ESCs). The new controllers are *Plush 30amp ESCs*, and are easier to program, have faster response times, are smaller and have variable speed timings, allowing for more precise control through greater sensor resolution.

The Quad-03 also uses a smaller sized propeller. After I ordered them I learned the green and black 11x4.5 propellers from the first two quads were too large for this size of motor. The larger propeller actually reduces the thrust the motors can generate by forcing them to work harder. *Over-propping* a motor draws more power, reduces thrust and risks damaging the motor. The new red 10x5 propellers on this version are the most efficient size for my motor and electronics and should improve motor efficiency, flight times and throttle input.

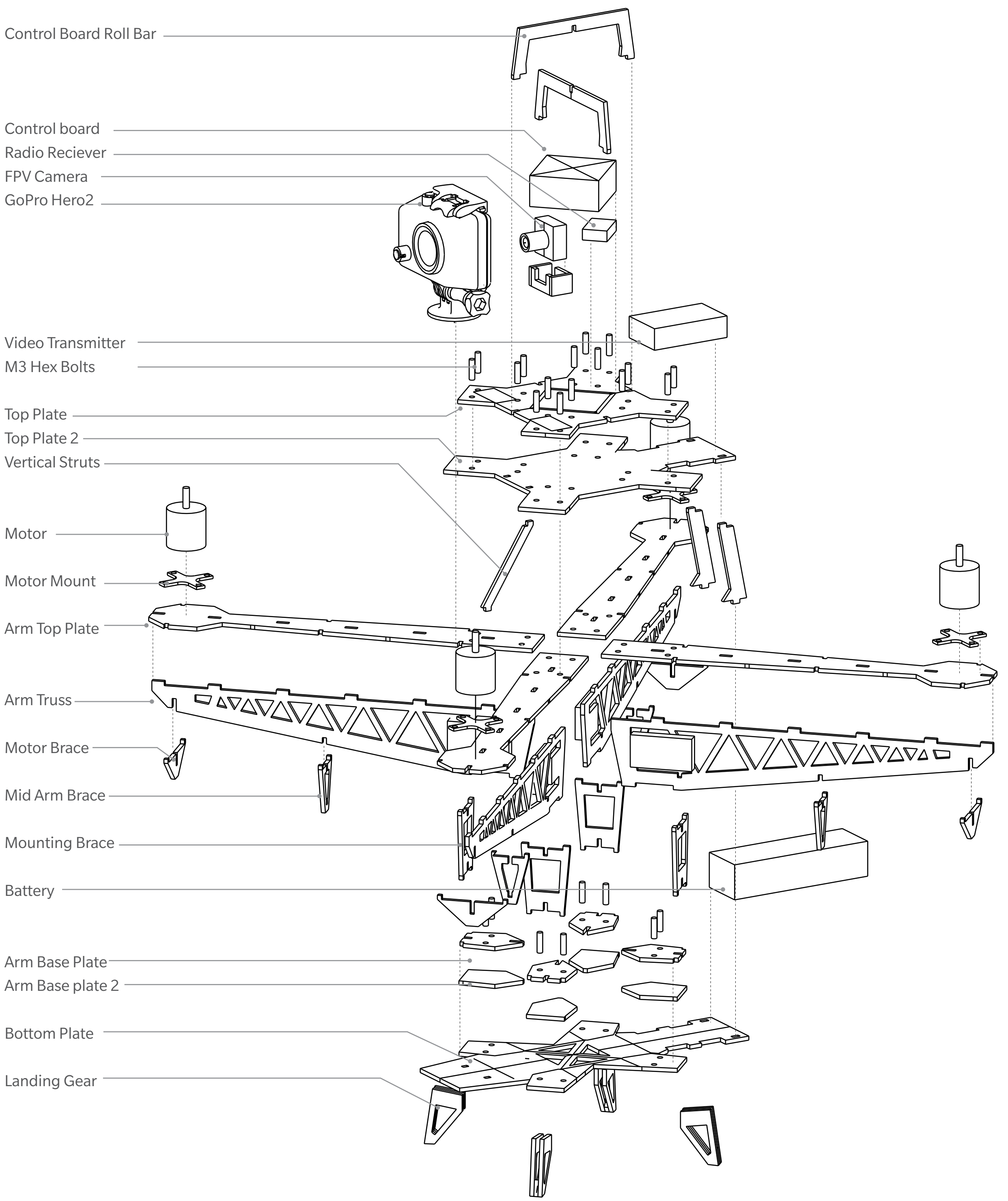



**Fig 2.3.20 -** Quadrocopter-03 Exploded Axonometric. *Drawing by Author.*

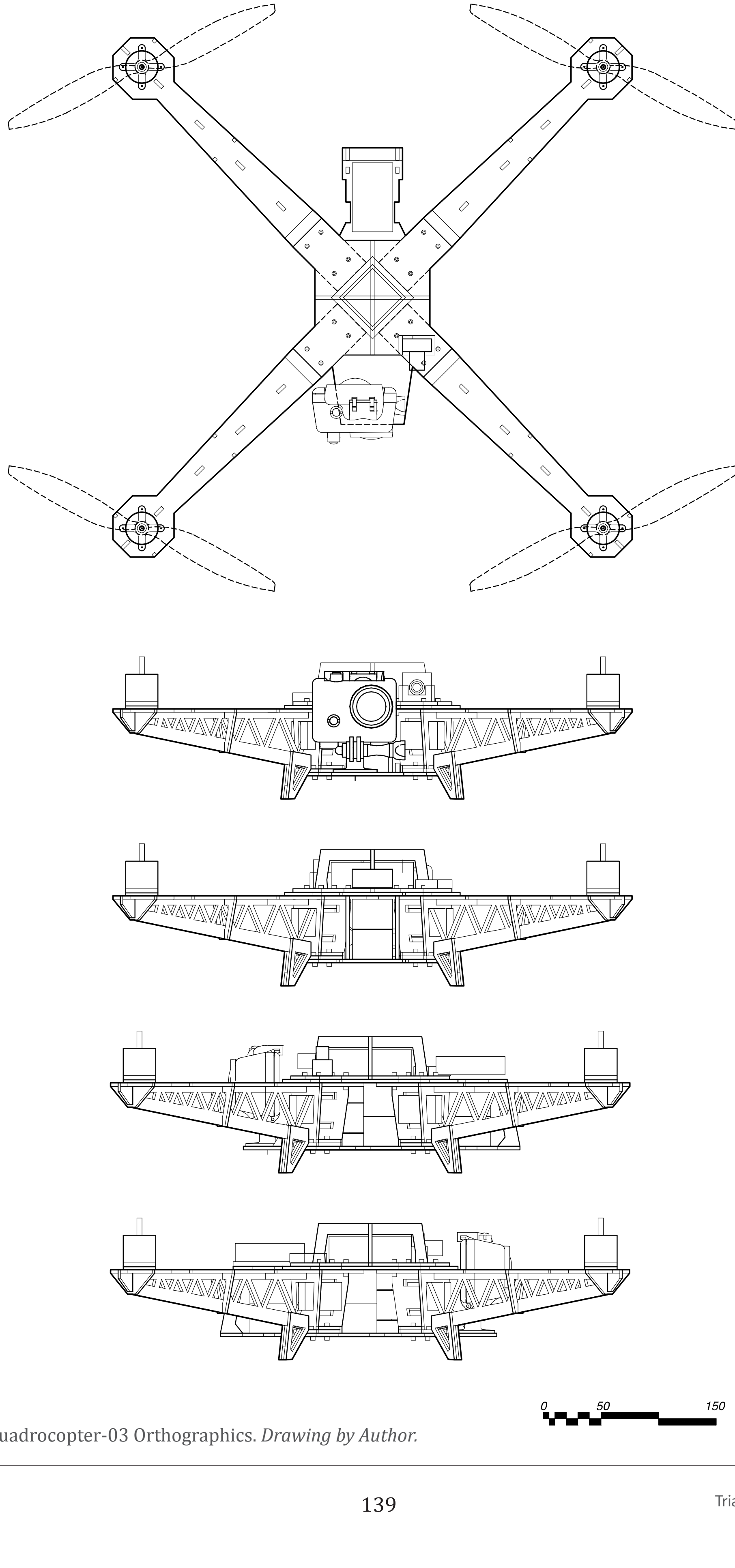
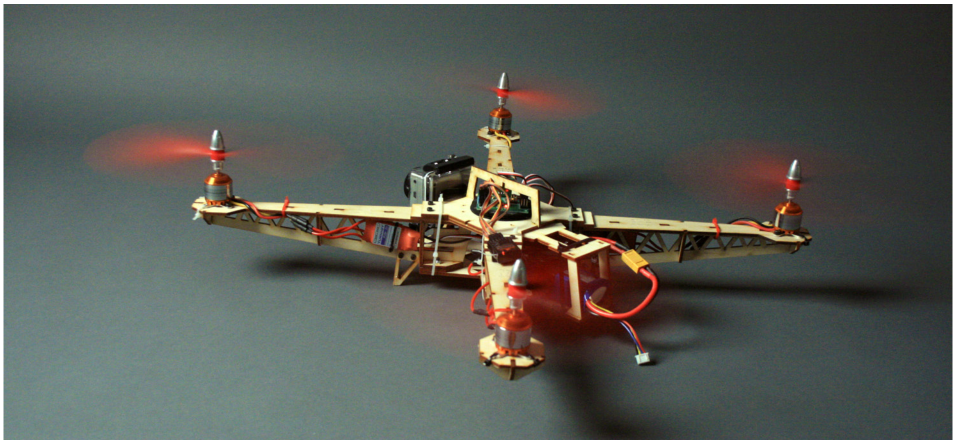



**Fig 2.3.21 -** Quadrocopter-03 Orthographics. *Drawing by Author.*

With every version of the Quad the airframe has gotten progressively lighter: the -01 weighed 450g, the -02 350g, with the -03's frame only weighing only 260g. Using an online calculator called *ecalc,* I estimated a flight time of just less than 9 min per single battery. A second battery onboard would add weight and only increase flight times by 4 minutes. In fact with my electronics and propellers every 100g of extra weight reduces flight time by 60 seconds.

**Fig 2.3.22 -** Completed Quadrocopter-03. *Photo by Author.*



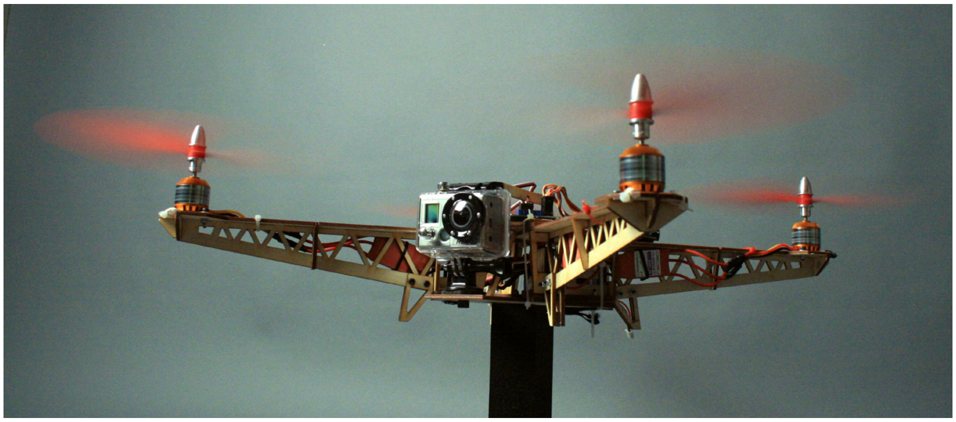


**Fig 2.3.23 -** Completed Quadrocopter-03. *Photo by Author.*
**Fig 2.3.24 -** Completed Quadrocopter-03. *Photo by Author.*

The Quad-03 model was a huge improvement over the -01 and the -02. I was able to tune the control board and have great success in my test flights. When I crashed into a wall and broke one the arms, I was able to swap in a spare in less than an hour. The refined wood frame proved lighter and more rigid, while the compact design gave a more focused center of gravity and improved its overall responsiveness and agility.

Even with these drastic improvements, the -03 model it is not without its flaws: a weakness where the arm connects to the frame had to be reinforced with zip ties, and the landing gear was too rigid, so I added foam balls them to help cushion the landings. The arms, while very rigid in their "x" and "z" direction still allow for rotational vibration along their "y" or long axis. The braces I designed dampened this vibration but did not fully stiffen the arm. The cheaper birch plywood – though easy to work with – still bows and deforms. A warping can be seen in the front right arm that changes the thrust vector of the motor and requires the others to work harder to maintain the aircrafts orientation. This warping can be addressed by introducing an additional truss to each arm, to triangulate and cross-brace it in all directions. My next version will blend the aluminum and the wood design to build one that is is easily folded or broken down to be travel-friendly.

(Opposite)
**Fig 2.3.25 -** Completed Quadrocopter-03. *Photo by Author.*
**Fig 2.3.26 -** Completed Quadrocopter-03. *Photo by Author*
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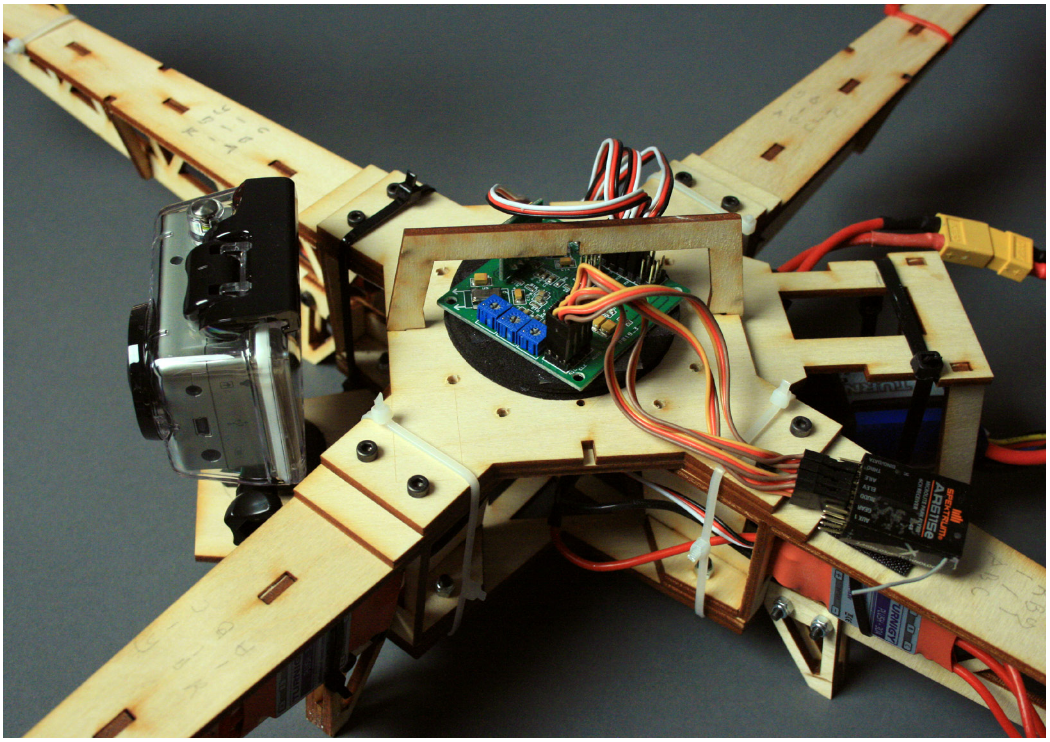
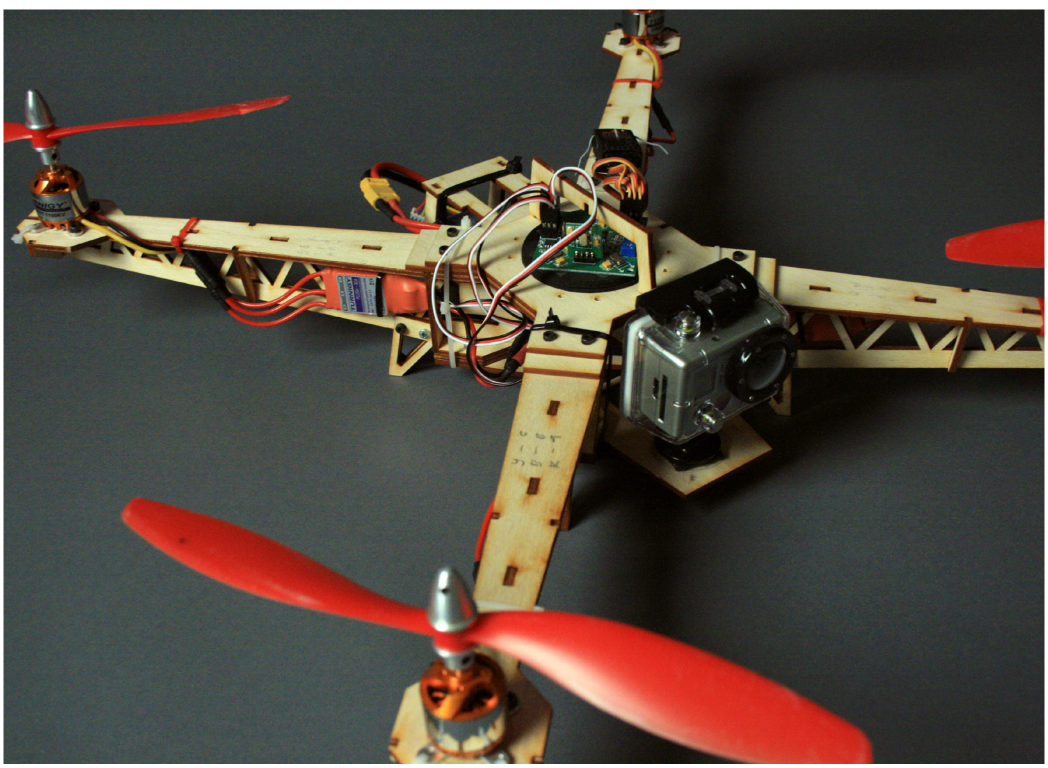
**Fig 2.3.27 -** Completed Quadrocopter-03. *Photo by Author*





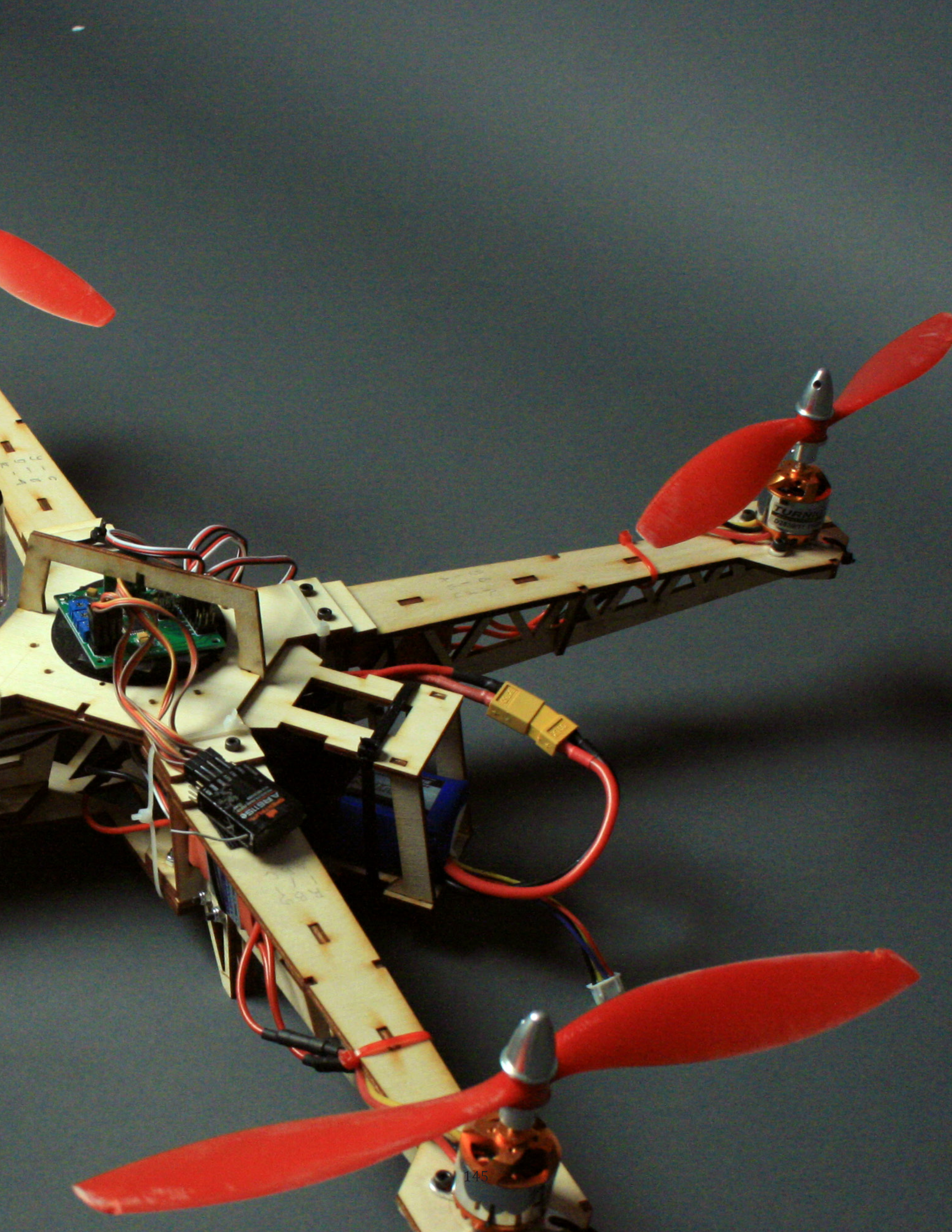



**Fig 2.4.1 -** Team Black Sheep over Brooklyn Bridge NYC. Screen Capture from: New York City*. by nastycop420, Source: http://www.youtube.com/watch?v=M9cSxEqKQ78.*

**Fig 2.4.2 -** Team Black Sheep's Zepher. *By Team Black Sheep. Source: http://team-blacksheep.com/products/prod:tbszephr.*

# *Device IV : The Plane*

On November 30, 2010, YouTube user Nastycop420 -aka *Team Black Sheep*- uploaded a video of remote-control unmanned civilian flight over New York City, namely the Brooklyn Bridge and the Statue of Liberty. The video went viral, with over one million views in a few weeks and raised controversy over security, freedom and the DIY drone movement. The public's response was both of fear and amazement. All I could think was: "look at that view."

First Person View (FPV) flying is a practice where video footage is transmitted back to the pilot. The US military's Predator drones are flown this way, as are thousands of smaller hobby aircrafts. The disembodied experience of flight and the freedom of the aircraft available virtually though interactive technology – immersive video goggles and video transmitters – is not what made me want to build the Plane. Instead, it was the thought of photographing a large geographic area, from controlled altitude, in a short period of time.

The plane I wanted to build was to carry two cameras: one that faced forward meant for piloting, the other facing down to take photos at an interval. I wanted a back-facing propeller, or pusher, so as not obstruct the video and I needed it to be collapsible so I could fit it into my miniscule Toyota Corolla. I wanted it to be able to fly for at least twenty minutes and had heard online of other FPV enthusiasts that were able fly for forty minutes on a single charge.

Initially I wanted a Flying Wing design like TBS's zephyr, but chose a glider inspired design like the Raven; a hand-launched military drone made by Aeronvironment. The Raven would provide more payload capacity and a more menacing appearance. I set out to design and build a $150.00 version of a $45,000 military drone, using hand-shaped insulation foam, hot-glue, packing tape, balsa wood and cheap Chinese electronics.

**Fig 2.4.6 -** Aeronvironment hand launched Raven reconnaissance drone. *Source: http://www.gizmodo.com.au/2007/09/26/page/4/.*

**Fig 2.4.7 -** Aeronvironment Raven Closeup. *Source: http://www.ideastream.org/news/npr/169910290*

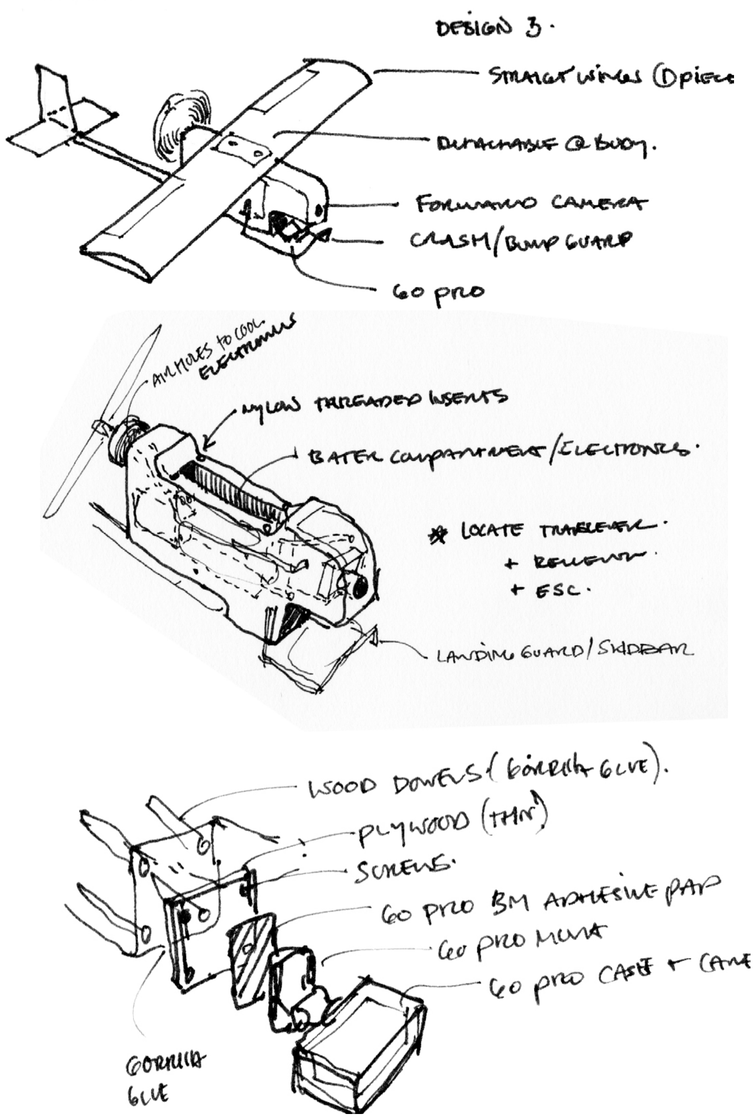



**Fig 2.4.8 -** Plane Design Sketches. *Drawing by Author.*

Part List:
Structure:
2 - 8’x2’ 1/2” thick pink insullation foam
1- Carbon fibre spar 48”
2 - 1/4” dia. wood dowels 36” long
2 - 1/4” dia wood dowels 12” long
12 -5/16” wood dowels 4” long
1 - 12”x12” 3/16” birch plywood
4 - 4”x24” 4mm balsa wood
2L - White glue (elmers)
1 - 200ml bottle of Gorrilla Glue
4 - Deck screws
Spraypaint

Specialty items:
4 - Control surface horns
12 - Nylon hinges
1 Set of landing gear
1-10”x4” 2mm thick 3001 aluminum

Electronic Components:
1 - 1400kv 130g Brushless motor (Turnigy 3542/4)
2 - 4cell 3000mah LiPo batteries
1- 60-70A Electronic speed controller
1- 2.4ghz Spectrum reciever
4 - 9g servo’s
1 - 6v NiMh reciever battery
3 pairs - Bullet connectors
3 pairs - Deans connectors
2 - Servo harness extensions
1 - Servo ‘Y’ harness

Video Equipment:
1 - GoPro
1 - FPV camera
1 - Video transmitter and reciver

Auxillary Parts:
1 - 5 Channel 2.4 ghz transmitter
1 - Battery charger

Tool List

Olpha utility knife + extra blades
Foam sculpting rasp
100grit sandpaper (or sanding sponge)
Rulers, long + short
Square edge
Band saw
Belt sander
Drill press
Blowtorch
Pliers, needle nose, blunt nose, hooked
Soldering Iron
Helping hands
Cheap foam paint brushes
Screw drivers
Cordless drill

Photo Key, from left to right, top to bottom

1. Shaping the wing with foam carving raspe.
2. Plane fuselage after rough band saw cut.
3. Plane fuselage after shaping and sanding.
4. View of tale fin after shaping and sanding.
5. Tail wings attachement detail.
6. Tail wings glued.
7. Melted holes for woodend dowels.
8. Wooden dowels glued into holes.
9. Plywood engine mount screwed into wooden dowels and glued to foam.
10. Positioning of wing squash plates and aileron servo locations.
11. Flush fit wing squash plates.
12. Plane progress photo with wing attached.
13. Feeding tail servo harness through tail and wing.
14. Harness fed though successfully.
15. Rudder and elevator servos mounted and connected

**Fig 2.4.9 -** Plane Construction Progress. *Photos by Author.*

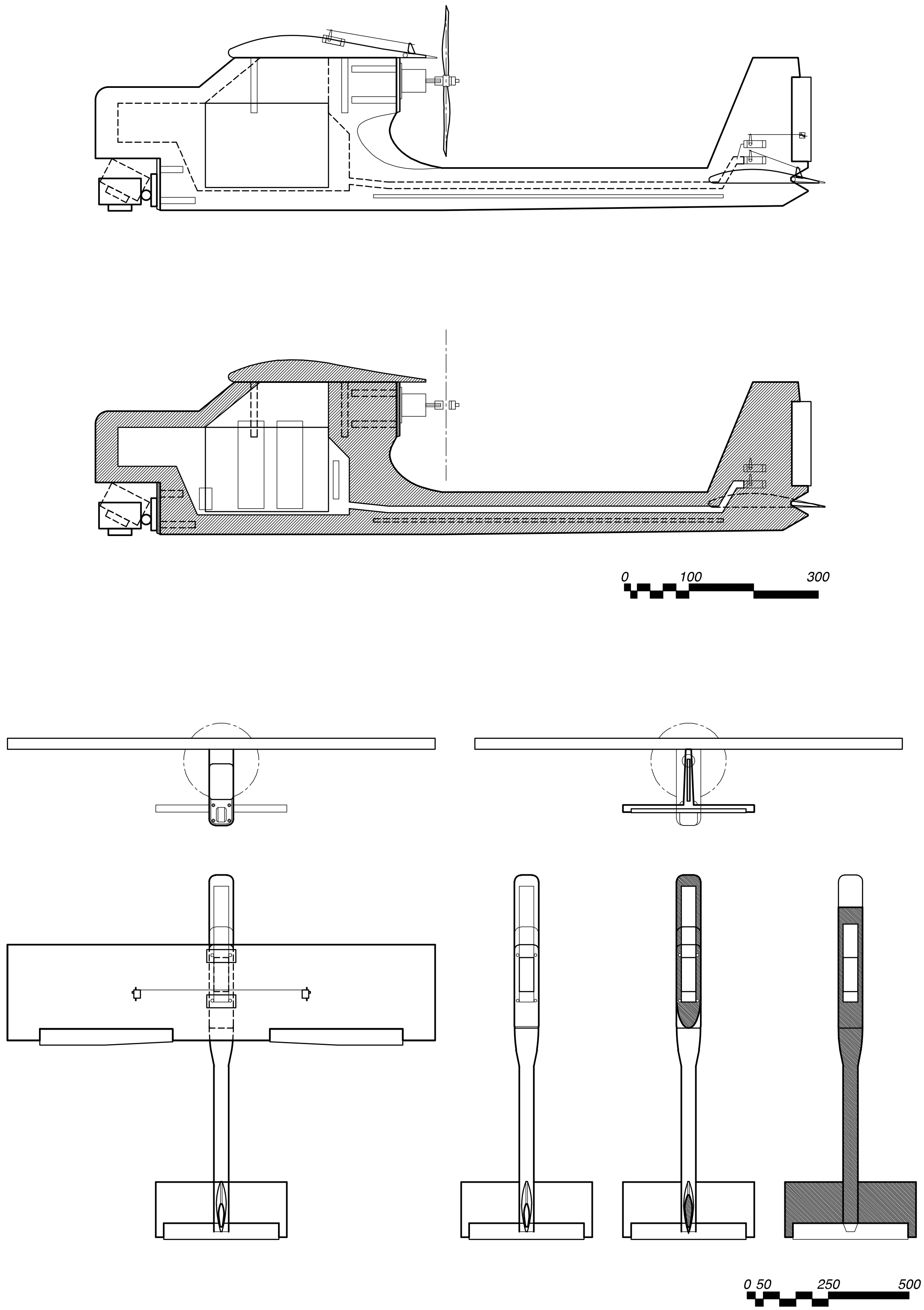



**Fig 2.4.11 -** Plane-01 Orhographics. *Drawing by Author.*

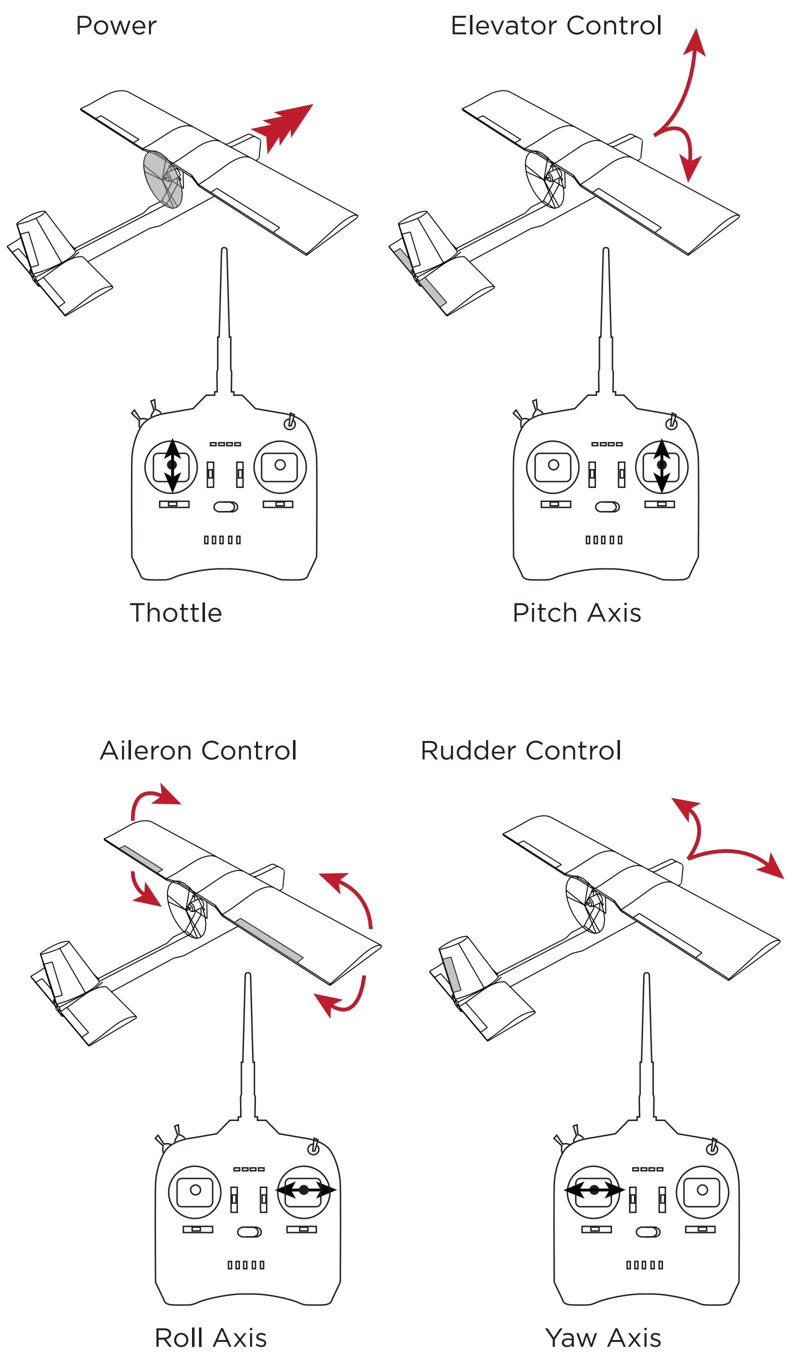



**Fig 2.4.12 -** Plane-1 Flight Control Diagram. *Drawing by Author.*

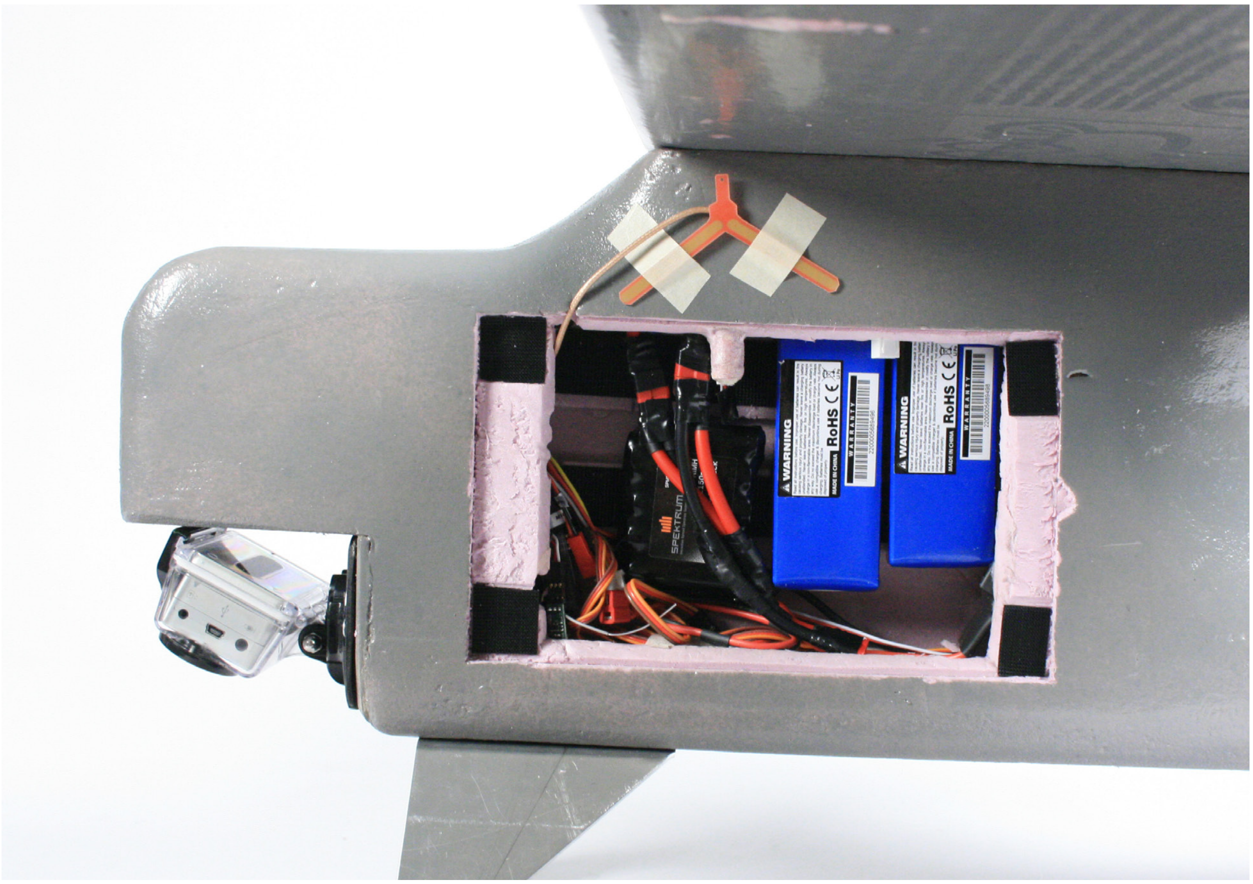



**Fig 2.4.13 -** Completed Plane-01 showing internal components and camera position. *Photo by Author.*

**Fig 2.4.14 -** Completed Plane-1. *Photo by Author.*


1. Video transmission antenna
2. 1320mm removable wing
3. 9g Aileron servos
4. 1450kv 130g Brushless motor: 1420g thrust, 690W power
5. APC - 10x5 Propeller
6. 9g Rudder and Elevator servos
7. ‘Taildragger’ rear landing gear
8. Reinforced tail arm
9. Hollowed fuselage with removable door. Inside is: 2-3000mah 4cell LiPo battery packs, 70Amp Electronic Speed Controller, Swapable 2.4GHz 6-Channel Receiver with a 6V 2200 mah Receiver pack, and a 800-1300 MHz Video Transmitter
10. Landing gear
11. Receiver antenna
12. GoPro for High Definition Video Recording
13. Airflow hole
14. FPV camera for remote piloting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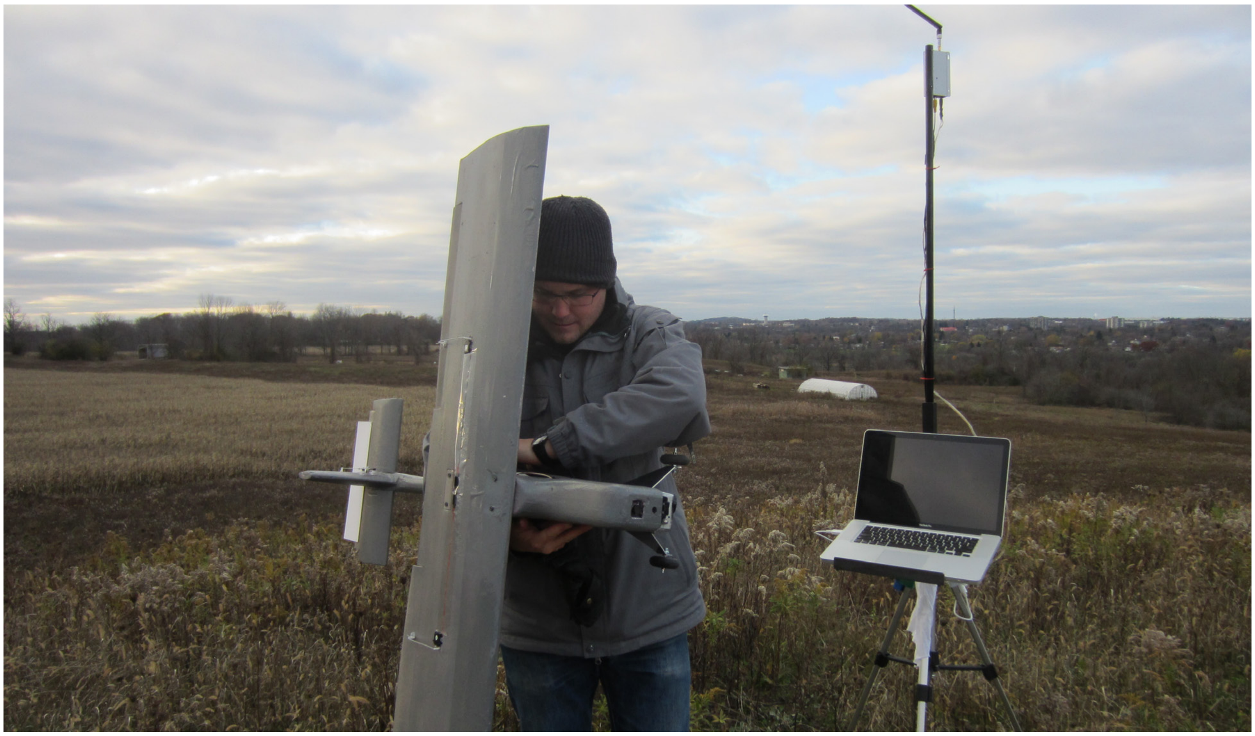

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**Fig 2.4.15 -** Completed Plane-01. *Photo by Author.*

(Above)

**Fig 2.4.16 -** Stills from Plane_01 Maiden flight Video. *Photos by Lindsey Nette.*

**Fig 2.4.17 -** Plane-01 After Maiden Flight Attempt. *Photo by Author.*
**Fig 2.4.18 -** Plane-01 After Maiden Flight Attempt. *Photo by Author.*

A few lessons were learned that day in the field at the RARE Conservation Area. Lesson one: a tool that you are afraid to use is not a useful tool. Lesson two: sometimes things don't work on the first try and you should build it so that you can try it more than once. Lesson three: keep it simple. Intricacy, delicacy, and complexity should be introduced slowly as the design is tested and refined. Start with the basics and build up from a working prototype. And finally, lesson four: if you have doubts about your design, address them before throwing your precious airplane into the air.

The truth is that even an experienced pilot would have had difficulty getting and keeping the -01 model in the air. The power-to-weight ratio was barely acceptable, the stall speed high, the landing-gear small, the wingspan short, the airfoil drastic. All things I learned after I had built it, which I should have addressed during the design stage. Due to the time investment and arduous construction process, I wasn't willing to go back and start fresh, not without first seeing if my invention would fly. These doubts, however, made me afraid to test it, afraid to know for certain that I was wrong. My infatuation with the formal qualities of the final product, and my investment of time and labour held me back from moving onto another prototype immediately.

In the end, on a nice calm afternoon, the plane proved too heavy, and its pilot, myself, too much a novice. The fragility of the laminated insulation foam was apparent and the first was toss was fatal. The foam did not absorb the impact. Instead, the forces traveled deeper into the fuselage finding the first weak points and snapping along them.

I admit that my initial reaction was that of disappointment and frustration. I was humbled in an instant. But failure can lead to learning. By the time I had the wreckage home, I was ready to try again. I removed the electronics, salvaged all the components from the disparate bits of foam and immediately set to work designing another plane.

**Fig 2.4.19 -** Practice Flying with F-22 Trainer. *Photo by Lindsey Nette.*

Piloting an aircraft, regardless its size, is a formidable skill. When I decided to build a remote control plane for carrying expensive camera gear, I began by looking for a cheap trainer model to learn to fly with. My search led me to the F-22 foam board flyer – shown opposite. The F-22 was showcased on my new favorite YouTube channel *Flitetest*. *Flitetest* reviewed the design -initially by Kosh from a forum called *wattflyer*- and then ran a second scratch-build video to show people at home how to build their own. It was a simple-enough looking plane, so I downloaded the plans, ordered the parts and made my first flying aircraft, a trainer plane for under $30.00.

My first attempts with the F-22 were moderately successful. I was able to hand-launch the plane and have it glide around at a low altitude. The motor I purchased was insufficiently sized for the size of the plane I built. This lack of power meant that the plane would stall and crash whenever I tried to gain some altitude, but being only a few feet from the ground damage from the landings was minor and I was able to practice the basics of remote-flight with this model.

The foam-board design would stand up to about twenty or so crashes, some into football uprights and trees, before I would have to quit and go home to repair it. The Plane-01 crash had exposed the fragility of the insulation foam and had reminded me of just how much abuse these foam-board designs could take.

The F-22 is compact design when compared with the Plane-01. It is essentially an elongated flying wing – the fuselage of the aircraft blends into the wings – so it has fewer appendages to be knocked off and only two control surfaces: the Ailervators – Ailerons mixed with Elevators – which require only two servos. The F-22 also offers vertical stabilizers, fins that are well protected in the case of crash landings, unlike the fragile nature of the tail fin in the Plane-01 design.

After I crashed Plane-01, I decided to go back to the cheaper, faster, and easier to build foam-core design of the F-22. My second attempt at building a Plane would start from this already proven design. I re-weighed my parts, estimated an airframe weight and using *webocalc* – another online calculator for estimating the flying characteristics of model planes – I began to design a desired wingspan and surface area. I re-opened the plans I had downloaded months before and began to alter them toward a new iteration of my own.

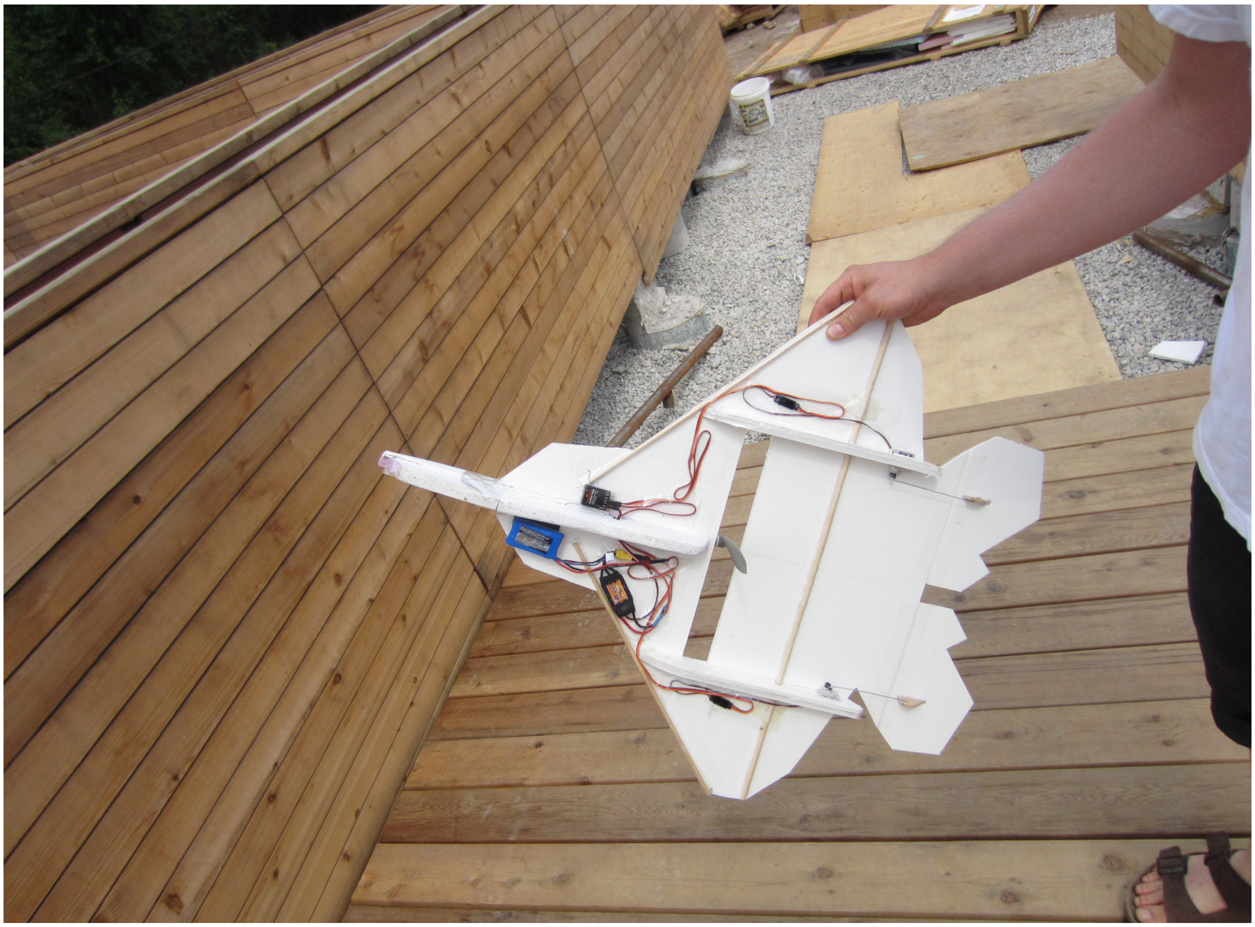


**Fig 2.4.20 -** Scratch Built Foam Core F-22 Trainer. *Photo by Lindsey Nette.*

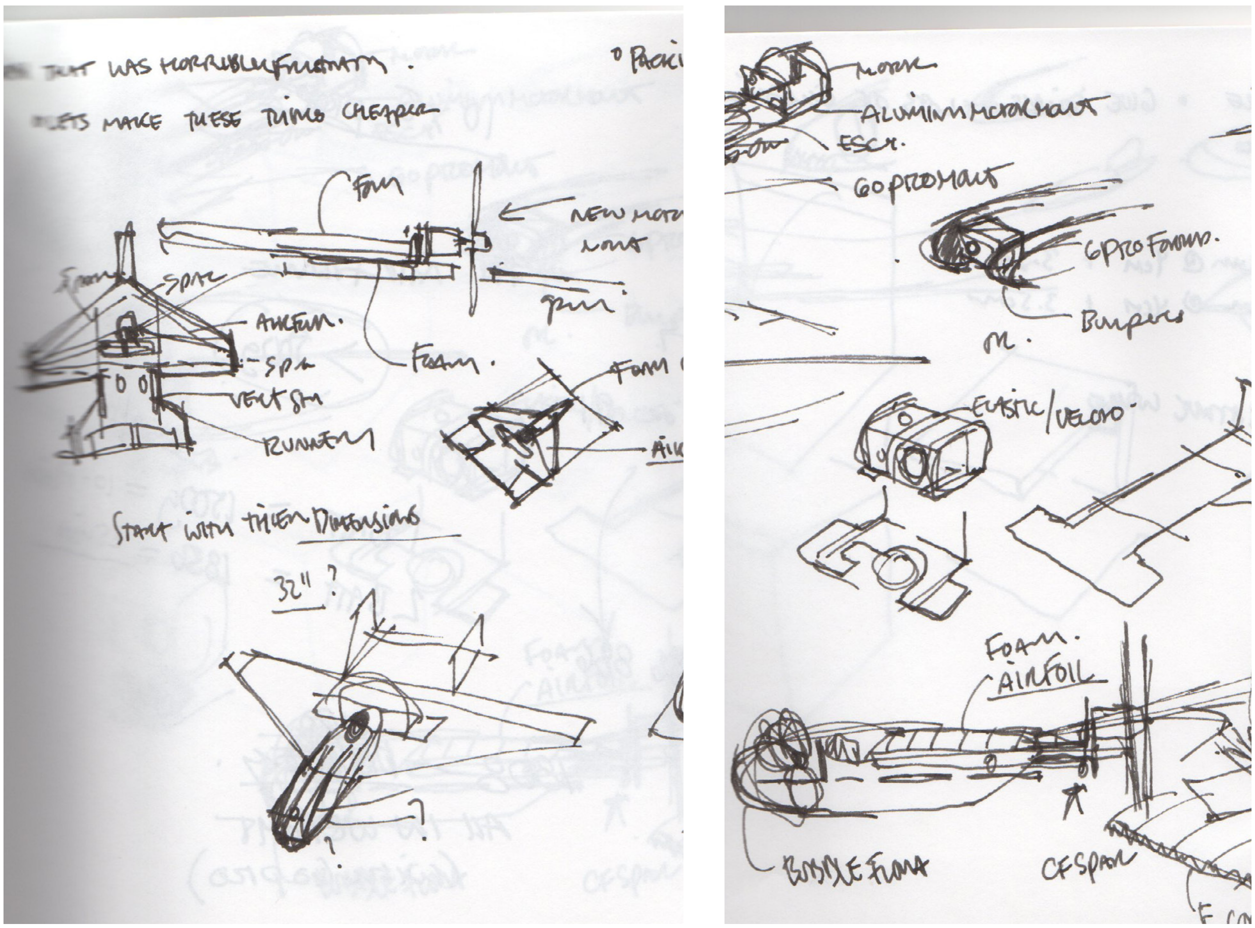



**Fig 2.4.21 -** Plane-02 Design Sketches. *Drawing by Author.*

Part List:

2- 4'x3' Sheets of foam core
Extreme packing tape
Hot glue
2 -  wooden dowels
1 - 4"x12"x1/8" piece of plywood
3 - Control Horns
1 - Carbon Fiber Spar 48"
2 - 9g Servos
1 - Standard hobby servo
1 - 1400kv 130g Brushless motor (Turnigy 3542/4)
1 - 4cell 3000mah LiPo batteries
1 - 60-70amp Electronic speed controller with UBEC (Hobby King 60amp)
1 - 2.4ghz Receiver (Spektrum AR6115E)
3 pairs - Bullet connectors
3 pairs -  Deans Connectors
1 - 2"x6" 2mm thick 3001 aluminum
1 - Servo harness extensions
1 - Servo Y harness
1-10x5  APC propeller

Video Equipment:
1 - GoPro
1- FPV camera
1 - Video Transmitter and receiver

Auxiliary Parts:
1 - 5 Channel 2.4ghz transmitter (Spektrum 5xe)
1 - Battery charger

Tool List:

Olpha Utility Knife + extra blades
Rulers, long + short
Square Edge
Pliers
Soldering Iron
Helping Hands
Glue gun

Instructions

1. Gather all parts and tools.
2. Draft design onto foam-board.
3. Cut out all parts.
4. Glue wings together tape both sides.
5. Cut and tape all control surfaces.
6. Cut propeller opening.
7. Install motor mount.
8. Glue and tape carbon fibre strut to underside.
9. Assemble and install fuselage.
10. Install all electronics.
11. Install control servos, control horns and tape down excess wires.
12. Center servos and install control rods.
13. Glue and tape dowels to leading wing edges.
14. Glue vertical stabilizer fins and landing skis.
15. Install propeller.
16. Install camera.
17. Go try to fly it.

**Fig 2.4.22 -** Plane-02 Build Progress. *Photos by Author.*

My design changes to the F-22 began with the wingspan. I enlarged the plans, taking a 24” wingspan to a 60” – the limitation of my foam board sheet size and the width of the truck of my car. I compressed the front of the wings, elongated the tail, and simplified all the geometry by eliminating curves and excess details. To allow room for the camera and other electronics I shortened the fuselage and widened it. I also added a separate shelf under the plane for the battery and two wooden skid-plates flanking the fuselage for added impact protection.

With the extra wingspan and shortened nature of the plane, I added ailerons to the wings and converted the Ailervators to a single elevator. By splitting these apart I gained more authority from my elevator, and better steering response from my ailerons.

During this design phase, I worked back and forth between AutoCAD, hand sketching and WebOcalc. I tweaked the design until I got a flyable estimate I liked.

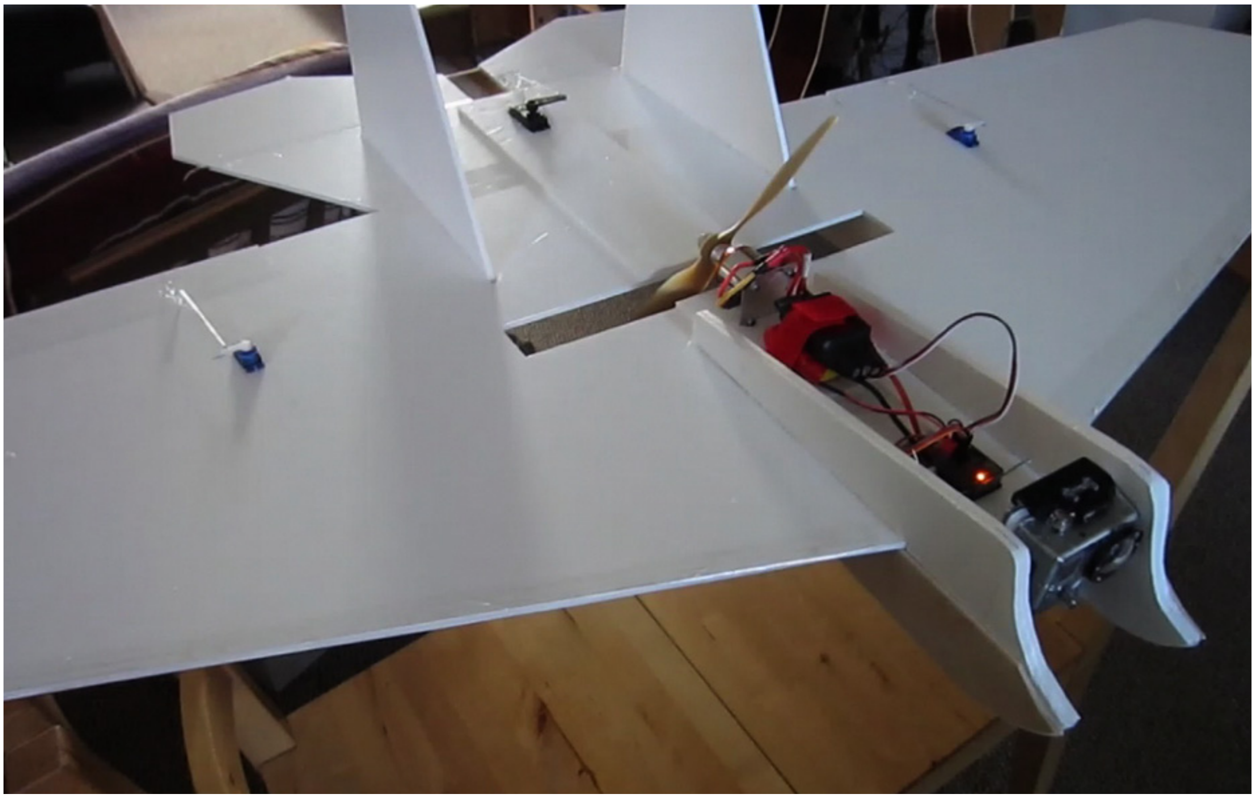


**Fig 2.4.23 -** Finished Plane-02. *Photo by Author.*

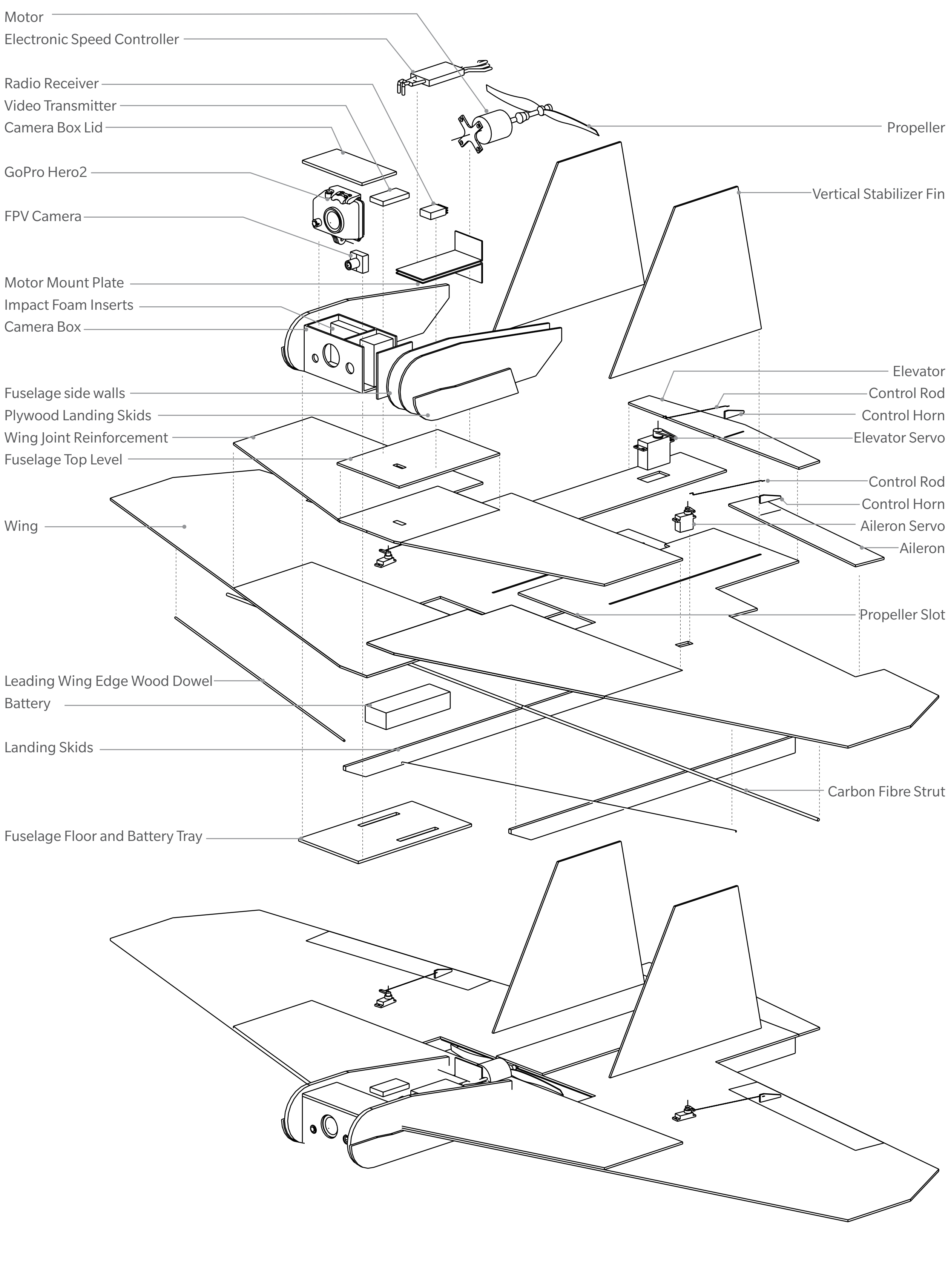



**Fig 2.4.24 -** Plane-02 Exploded Axonometric. *Drawing by Author.*

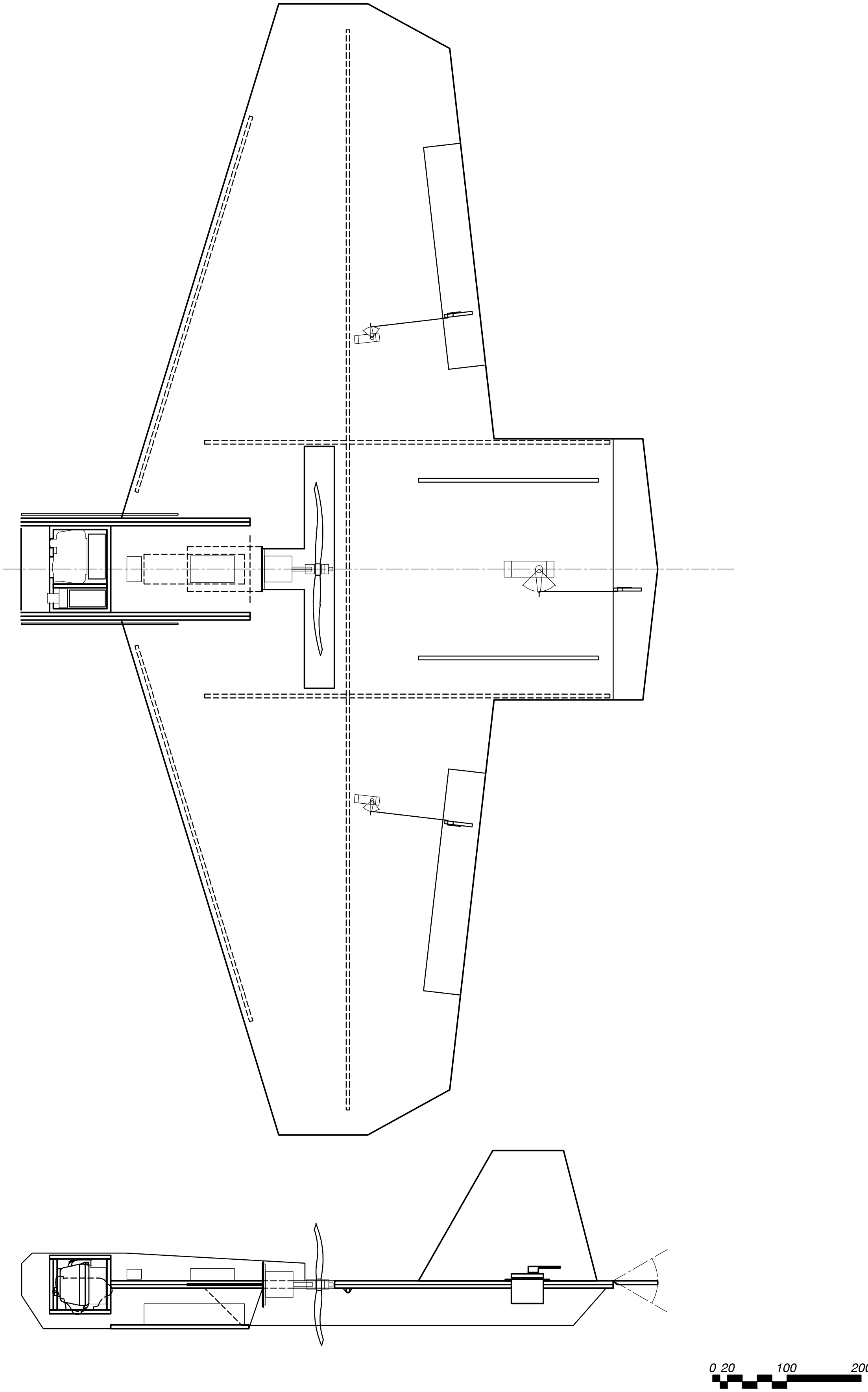



**Fig 2.4.25 -** Plane-02 Orthographic. *Drawing by Author.*

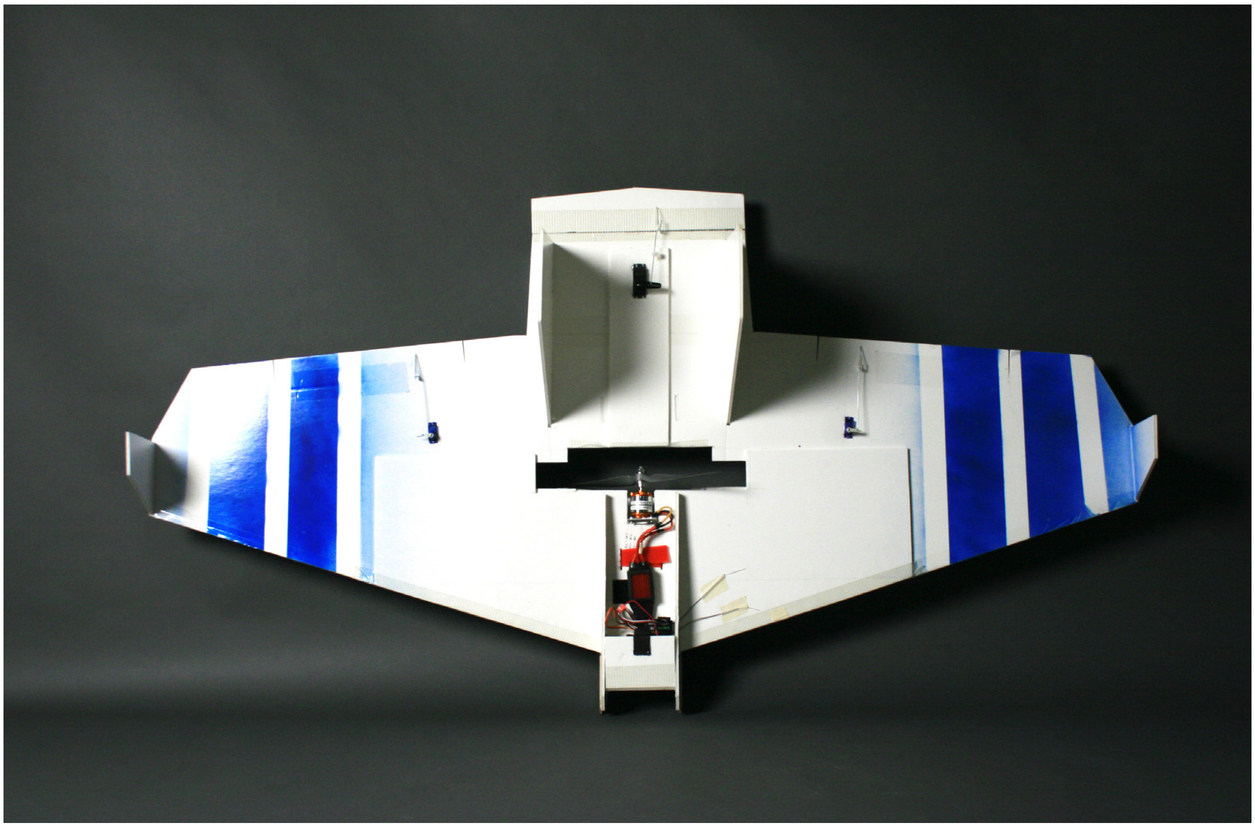
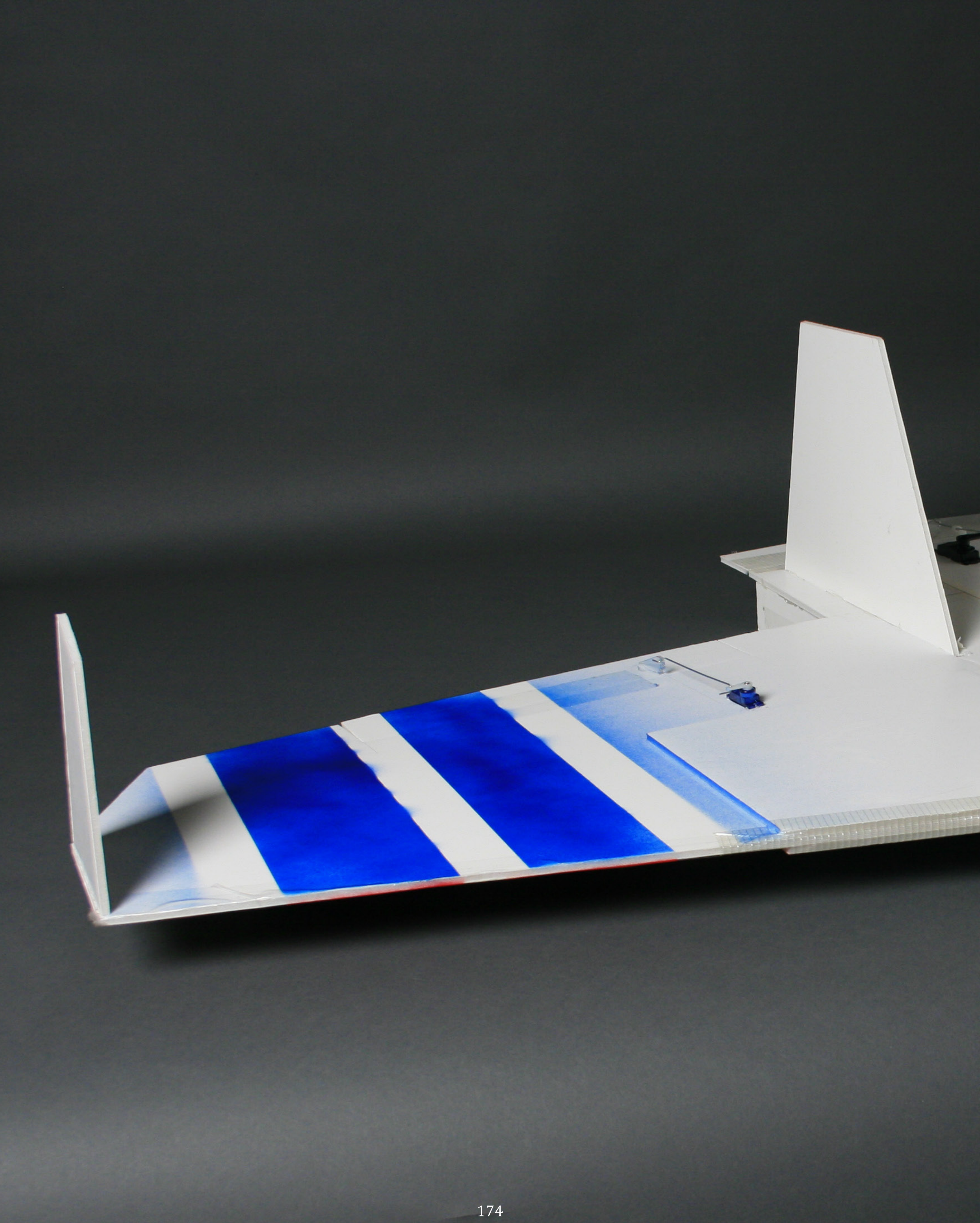


**Fig 2.4.26 -** Completed Plane-2. *Photo by Author.*

**Fig 2.4.27 -** Completed Plane-2. *Photo by Author.*



The final input numbers for the WeboCalc :

- Weight: 1700
- Wingspan: 1520mm
- Total Wing Area : 57 $dm^2$
- Propellers size: 11x4.5
- Top Speed: 80km/h
- Thrust (gm): 1420
- Motor Efficiency: 80%
- Battery: 3300mah 4S Lipo 14.4v
- Current per motor: 30A
- Motor Kv (rpm/volt) 1450

Output Flight Characterics From WeboCalc.

- Feels like: Backyard/ Light Park Flyer.
- Power Level: Aerobatic. 70° climbout
- Min. Pilot Skill Needed: Beginner
- Min. Flying Field size: 310x220m
- Flight Duration: 13-18 minutes depending on throttle use
- Suggested ESC: 39-45A (I have 60-70a)
- Power to Weight Ration: 254.12Watts/kg
- Estimated Stall speed: 24.6km/h
- Wing loading: 29.8gm/$dm^2$
- Suggested prop size: 11x5.5

WeboCalc also suggested using a larger Propeller size to increase the efficiency of the motor and generate more power and thrust. A propeller sized at 14x5 would give an aerobatic power level with "Unlimited Vertical Climb-outs". In other words, it could be scary fast.

(Previous Page)
**Fig 2.4.28 -** Completed Plane-02. *Photo by Author.*

**Fig 2.4.29 -** Plane-02 Maiden Flight. *Photo by Lindsey Nette.*

**Fig 2.4.30 -** Plane-02 Maiden Flight. *Photo by Lindsey Nette.*

# *OBSERVATIONS*

**Fig 3.1 -** Photos from Kite Rig-01 Taken over Grasslands National Park Saskatchewan. *Photos by Author.*

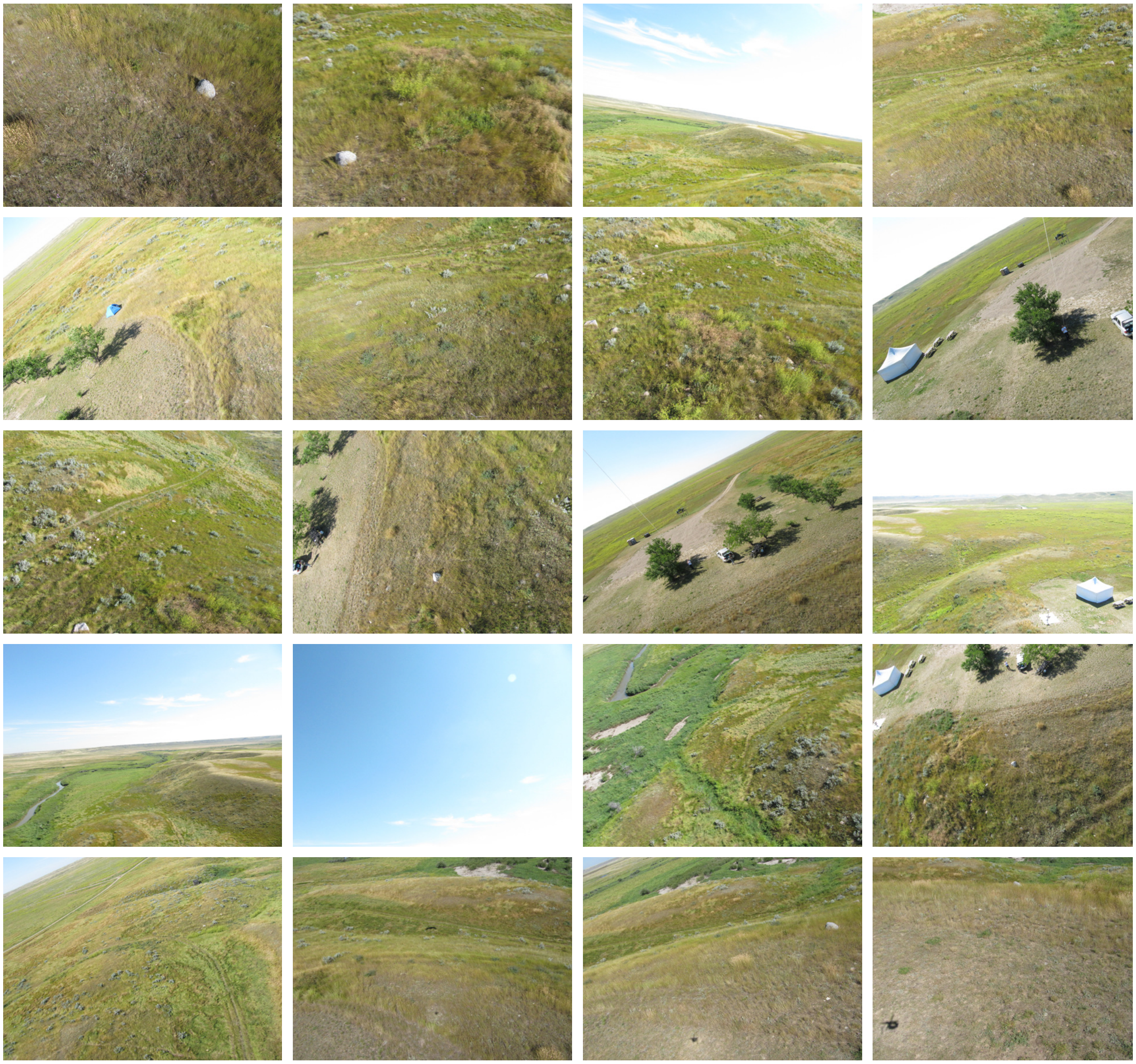


**Fig 3.2 -** Photo taken from the KAP-01 over a field somewhere in Saskatchewan. *Photo by Author.*

**Fig 3.3 -** Photo taken from the KAP-01 over a field somewhere in Saskatchewan. *Photo by Author.*

**Fig 3.4 -** Photo taken from the Kite Rig-03 over the Dundas Gravel Pit. Hamilton, Ontario. *Photo by Author.*

**Fig 3.5 -** Photo taken from the Kite Rig-03 over the Dundas Gravel Pit. Hamilton, Ontario. *Photo by Author.*

**Fig 3.6 -** Sampling of Photos taken from the Kite Rig-03 over Dundas Gravel Pit Hamilton Ontario. *Photos by Author.*

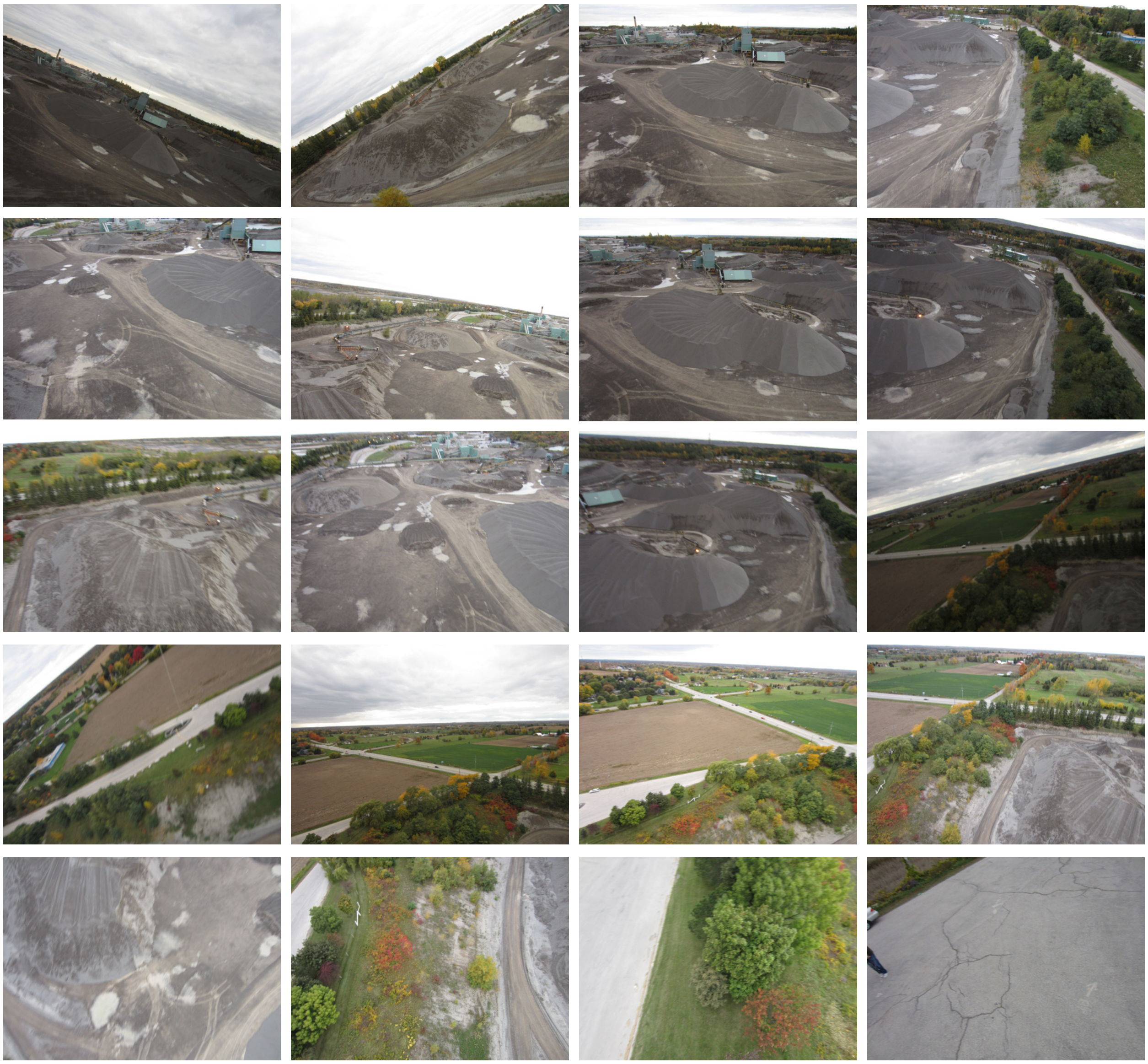


**Fig 3.7 -** Two photos from the KAP-03 from over the Dundas Gravel Pit. Hamilton, Ontario. *Photo by Author.*

**Fig 3.8 -** Two photos from the KAP-03 from over the Dundas Gravel Pit. Hamilton, Ontario. *Photo by Author.*

**Fig 3.9 -** Sampling of Photos taken from the Kite Rig-03 over the Blair Gravel Pit. Cambridge Ontario. *Photos by Author.*












**Fig 3.10 -** Photo taken from the Kite Rig-03 over the Blair Gravel Pit. Cambridge, Ontario. *Photo by Author.*

**Fig 3.11 -** Photo taken from the Kite Rig-03 over the Blair Gravel Pit. Cambridge, Ontario. *Photo by Author.*

**Fig 3.12 -** Photo taken from the Kite Rig-03 over the Blair Gravel Pit. Cambridge, Ontario. *Photo by Author.*

**Fig 3.13 -** Photo taken from the Kite Rig-03 over the Blair Gravel Pit. Cambridge, Ontario. *Photo by Author.*

**Fig 3.14 -** Sampling of Photos taken from the Plane-02 over the RARE conservation area. Cambridge Ontario. *Photos by Author.*

**Fig 3.15 -** Photo taken from the Plane-02 over the RARE conservation area. Cambridge Ontario. *Photo by Author.*

**Fig 3.16 -** Photo taken from the Plane-02 over the RARE conservation area. Cambridge Ontario. *Photo by Author.*


**Fig 3.17 -** Photo taken from the Kite Rig-03 over Mohawk Industrial Area. Brantford Ontario. *Photo by Author.*

**Fig 3.18 -** Photo taken from the Kite Rig-03 over Mohawk Industrial Area. Brantford Ontario. *Photo by Author.*

**Fig 3.19 -** Aerial photo looking north over south Galt, Cambridge Ontario. *Photo by Author.*

**Fig 3.20 -** Aerial Photo over field, Blair township, Ontario. *Photo by Author.*

**Fig 3.21 -** Aerial photo looking west over the Grand River, south Galt, Cambridge Ontario. *Photo by Author.*

**Fig 3.22 -** Aerial photo looking east over south Galt, Cambridge Ontario. *Photo by Author.*

**Fig 3.23 -** Aerial Photo over The University of Waterloo School of Architecture, Galt Cambridge Ontario. *Photo by Author.*

**Fig 3.24 -** Aerial Photo over The University of Waterloo School of Architecture, Galt Cambridge Ontario. *Photo by Author.*

**Fig 3.25 -** Aerial Photo over Cambridge Ontario. *Photo by Author.*

**Fig 3.26 -** Aerial Photo over Cambridge Ontario. *Photo by Author.*

**Fig 3.27 -** Aerial Photo over Cambridge Ontario. *Photo by Author.*

**Fig 3.28 -** Aerial Photo over Cambridge Ontario. *Photo by Author.*

**Fig 3.29 -** Aerial Photo over Cambridge Ontario. *Photo by Author.*

**Fig 3.30 -** Aerial Photo over Cambridge Ontario. *Photo by Author.*

**Fig 3.31 -** Aerial Photo over Massey Fergus Plant, Brantford, Ontario. *Photo by Author.*

**Fig 3.32 -** Aerial Photo over Massey Fergus Plant, Brantford, Ontario. *Photo by Author.*


**Fig 3.33 -** Aerial Photo over Massey Fergus Plant, Brantford, Ontario. *Photo by Author.*

**Fig 3.34 -** Aerial Photo over Massey Fergus Plant, Brantford, Ontario. *Photo by Author.*


**Fig 3.35 -** Aerial Photo over Massey Fergus Plant, Brantford, Ontario. *Photo by Author.*

**Fig 3.36 -** Aerial Photo over Massey Fergus Plant, Brantford, Ontario. *Photo by Author.*

**Fig 3.37 -** Aerial Photo over Massey Fergus Plant, Brantford, Ontario. *Photo by Author.*

**Fig 3.38 -** Aerial Photo over Massey Fergus Plant, Brantford, Ontario. *Photo by Author.*

**Fig 3.39 -** Aerial Photo over Massey Fergus Plant, Brantford, Ontario. *Photo by Author.*

**Fig 3.40 -** Aerial Photo over Massey Fergus Plant, Brantford, Ontario. *Photo by Author.*

**Fig 3.41 -** Aerial Photo over Massey Fergus Plant, Brantford, Ontario. *Photo by Author.*

**Fig 3.42 -** Aerial Photo over Massey Fergus Plant, Brantford, Ontario. *Photo by Author.*

# *LEVELLING THE FIELD*

**Fig 4.1 -** Railroads across the Survey Landscape. Castleton, North Dakota. *Corner and MacLean, 1999, 45.*

## *The View from Above*

Architects use the aerial perspective – the map, plan and survey – to understand, communicate and design space. In his essay *Aerial Representation and the Making of Landscape*, James Corner writes about how the aerial perspective precedes the shaping of space. Corner also discusses how a map is curated and controlled by those who create it, and how maps determine what we perceive and, consequently, what we design:

> The Power of the aerial image lies less in its descriptive capacity – compelling as that is – than in its conditioning of how one sees and acts within the built environment. Like other instruments and methods of representation, the aerial view reflects and constructs the world.[1]

According to Corner, maps and aerial photographs are never impartial, similar to paintings and writing. They are subject to bias and interpretation just like any other media, and should, therefor be treated as such, imperfect in their representation. Corner warns,

> One must view with skepticism, then, those who claim to act upon the land with confidence and certainty, because such actions are always predicated upon a particular fiction, a representation that is not only ideologically loaded but also subject to shift and revision over time.[2]

If our designs are based on what we learn from maps, do we actually have control over those designs?

Though architects have utilized the aerial view as a tool for shaping and understanding space, they have had little control over its production. Whether it is the surveyor's map, the aerial photograph or a cloud of satellite-triangulated data points, the production of maps is a powerful tool in shaping the way someone perceives the world around them. Governments and corporations have access to tools: satellites, helicopters and jet planes, and employ surveyors, technicians and pilots thus controlling the aerial perspective. For example, the Global Positioning System, (GPS) is a technology that is utilized by most of the worlds population for positioning, navigation and timing. It is also a system that Geographic Information Systems, (GIS) references and depends on to opperate. GIS is the primary cartographic tool of most companies, universities, and governments. However GPS, is owned and controlled by the US government, and was developed by the US Department of Defense to coordinate military operations.[3] This ownership gives the US government absolute power to restrict commercial and civilian GPS navigation systems from guiding civilian users to sensitive government locations.[4] In this case, the map is not only a tool for understanding space, but is also a tool for controlling a population's perception of reality. This tool is used not only to communicate geographic information,

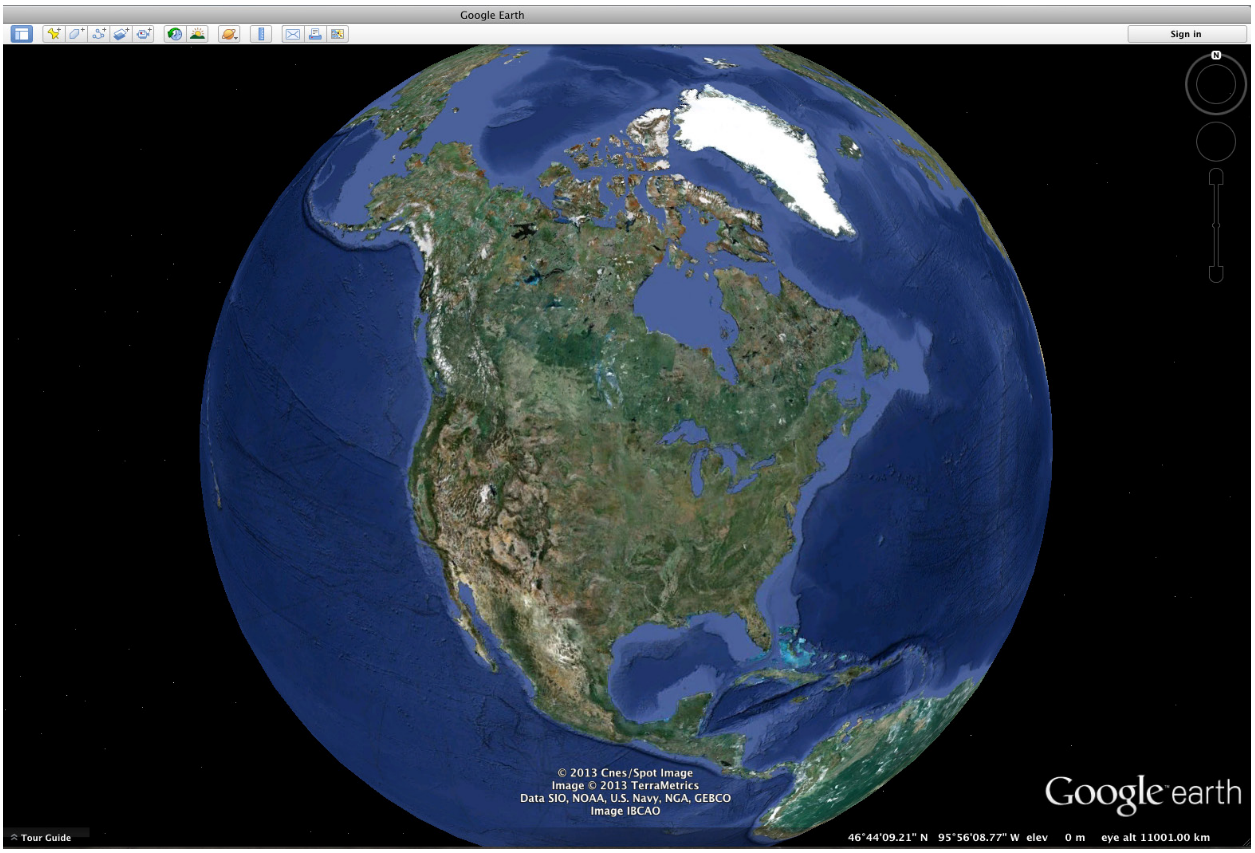



**Fig 4.2 -** Google Earth free application. *Screen shot by Author.*

but also to keep secrets.

In today's world millions use the aerial view each day. Smart phones relay directions to us as we walk, ride, or drive to our destinations, and we can remotely visit almost any place on earth from our Internet connections, thanks to Google. Google, founded as a web search service has grown into an information technology giant that tracks, filters and analyzes huge amounts of online data and traffic. In 2005, Google released Google Earth, a service that provides Internet users with satellite imagery superimposed on a virtual globe. Made interactive, Google Earth allows a user to zoom in on anywhere in the world and see in great detail the aerial top down perspective. This proprietary software can be downloaded for free, enabling anyone with a web connection to experience and create their own aerial perspective and generate their own maps from the available imagery. Through the release of Google Earth, and its later additions, Maps and Street View, Google has changed the way architecture is practiced and how the world uses maps and perceives space.

The aerial view granted by Google is, however, still limited in many ways. Governments can restrict its population's access to the technology, and Google has cooperated with international bodies to obscure aerial images of sensitive locations.[5] The imagery itself is biased and favors certain conditions like late fall when tree canopies no longer obscure the streets below. Aerial information on Google Earth can also be many years old due to irregular updates. Clouds can obstruct geographic locations at the time of documentation, and often the resolution in remote areas is very low. The aerial view provided by Google is limited to a singular abstract perspective from the extremely high altitude of an orbiting satellite. Lastly, this aerial perspective can only be experienced in a two-dimensional way, a printed photograph or static image viewed on a screen.

Google and it peers may have made the aerial perspective accessible online, but they have not succeeded in democratizing it. Through corporate ownership, government interests and restricted access, it remains a controlled medium. The ability to generate the aerial view remains outside of the public's capacity. That is, until recently.

The overlap of individual online communities: hobby-aircraft-enthusiasts, activists, students, photographers and amateur cartographers, has bred the DIY Drones community and social network. The DIY Drones community is focused on grassroots aerial photography, mapping and reconnaissance, and actively publishes detailed instructions for creating low-cost aerial mapping platforms – remote control planes and helicopters – capable of gathering high-resolution aerial information, all for free. The rise in smartphone technology – making sensors and cameras cheaper and smaller – has enabled the DIY community to develop ArduPilot, an open-source Autopilot.[6] The ArduPilot is now made by *3D Robotics,* a company founded by Chris Anderson,

**Fig 4.3 -** The astronauts view from the International Space Station. *Photo by Chris Hadfield. Source: http://www.facebook.com/AstronautChrisHadfield/photos_stream*

who also started the DIY Drones social network. The ArduPilot and can be purchased for under $200 USD. ArduPilot is capable of autonomously piloting small hobby sized aircrafts – possibly large ones too – along a predetermined flight path and allows people to remotely experience, document and understand the world around them, through the privileged aerial view.

Astronauts who venture out into space look back on their blue planet and experience a phenomenon called the *overview effect*. The overview effect, first theorized by Frank White, is the realization that planet Earth is a complete system, which stands alone in space, and all of the forces of man and nature are encompassed within it.

> From space, the astronauts tell us, national boundaries vanish, the conflicts that divide us become less important and the need to create a planetary society with the united will to protect this 'pale blue dot' becomes both obvious and imperative.[7]

The overview effect is the power of the aerial perspective taken to its ultimate limits: space. I believe the same phenomenon can be experienced, albeit at a lesser dosage, while still in the earth's atmosphere.

The space occupied during flight, the atmosphere, engenders a feeling of connection. The air itself is a commons, an invisible gaseous medium we move through, which is without perceivable borders and boundaries. There exists, of course, protected airspaces – generally over airports and military sites – but these are *invisible* boundaries. From the air, the perception of space is uninterrupted. The airplane, helicopter and bird have the ability to move in any direction with minimal resistance. A freedom of movement is afforded in aerial space.

Le Corbusier, after experiencing the aerial view over South America, proclaimed in his book *Aircraft:*

> The airplane has given us the bird's-eye view. When the eye sees clearly, the mind makes a clear decision.[8]

Michel de Certeau also observes:

> One's body is no longer clasped by the streets that turn and return it according to an anonymous law... His elevation transfigures him into a voyeur. It puts him at a distance. It transforms the bewitching world by which one was "possessed" into a text that lies before ones eyes. [9]

Corbusier and Certeau both describe a feeling of freedom and clarity once they are released from the confusing boundaries present at ground level. The ability to see over obstructions without perceiving boundaries is an empowering perspective. It prompts a feeling of interconnection by the ability to perceive a greater context. From the air, patterns of settlement are recognizable, city boundaries visible, and geographic landforms legible. The viewer can comprehend his surroundings and is no longer

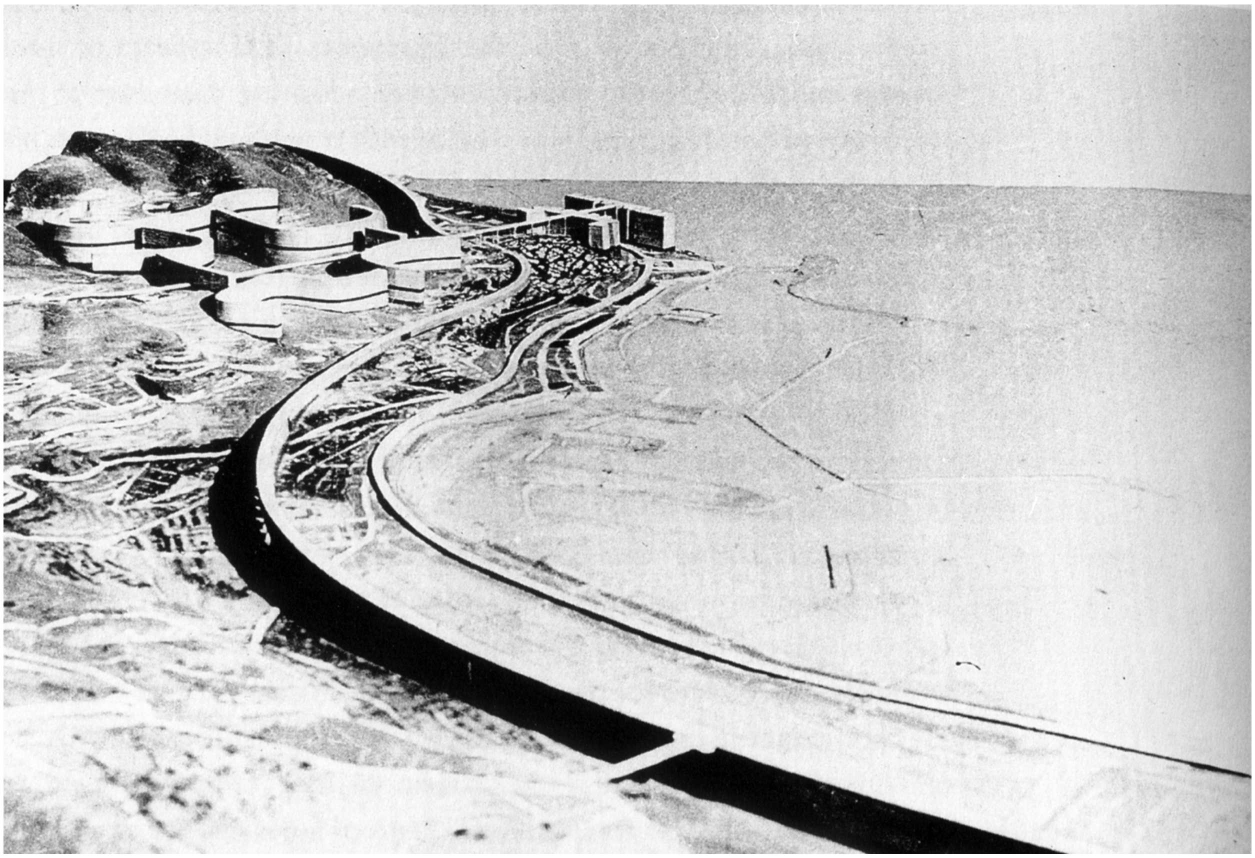


**Fig 4.4 -** The Plab Obus Algiers. Le Corbusier 1933.
*Source: http://classconnection.s3.amazonaws.com/856/flashcards/749856/png/plan_obus1322583523527.png.*

overwhelmed by them. As Corbusier stated, this allows the viewer to act with greater confidence in his intentions.

Michel de Certeau also writes that the aerial view is a means of disconnecting oneself from the realities of the ground:

> Is the immense texturology spread out before one's eyes anything more than a representation, an optical artifact? It is the analogue of the facsimile produced, through a projection that is a way of keeping aloof.[10]

The aerial perspective distorts the way the world looks. From a certain height, massive physical elements look insignificant: a city looks like a blemish on the fabric of the landscape. This distortion plays a part in the empowering phenomenon of the aerial view, and is what enables Le Corbusier to draw with conviction a massive 100m high viaduct along the Algiers coast, supposedly to unify a city. This distortion and disconnect allows pilots of high altitude bombers to disconnect their actions with the reality of the ground. It allows for a fiction, a willful ignorance, and a disassociation with the realities affected below.

Altitude, the measurement of height above the earth's surface, is a scale with ranges of perception and phenomena. Satellites like the GeoEye-1 made by General Dynamics, for example, operate from 681 km above the Earths surface, considered a low earth orbit, and provides a near perfect planimetric view of the earth below.[11] It is the primary source of aerial images for Google Earth. The international space station, located 400km above the earth surface, is the height where astronauts are able to experience the profound *overview effect* mentioned earlier.[12] From this height, astronauts experience the rotation of the earth below them, and can perceive geologic formations during the day and areas of human settlement at night. From 400 km, they experience the earth as a whole. Within the earth's atmosphere, aircrafts like Boeing's B-52H bombers, and most commercial airlines, operate in the 8000-10000 m altitude range.[13] The abstraction of scale and distance at this height makes a feeling of disconnect possible; detail is lost and the canvas of the earth reads as patterns.

Predator Drones, made by General Atomics and favored by the US military for precision airstrikes and constant surveillance across borders, operate below 9000 m, the same range as commercial airlines where the naked eye still only sees patterns. However, the powerful sensors and camera equipment these drones carry, allows the pilot to see their targets remotely with intimate detail and can "read the label on a milk carton from 60,000 feet."[14] A recent study showed that pilots, who operate these aircraft safely from an easy chair half the world away, showcase the same level of mental health disorders as other combatants stationed on the front lines.[15] The resolution and detail afforded by their instruments negate any ability to disconnect themselves mentally

**Fig 4.5 -** Aerial photo looking South East over
South Galt, Cambridge Ontario. *Photo by Author.*

from the places and people they affect.

My devices, the Kite, the Quad, and the Plane, afford the lowest perspective in this sliding altitude scale. These small remote-controlled model aircraft are regulated to fly under a 300 m ceiling. At this height helicopters and conventional aircraft are disruptive and dangerous. The view afforded remotely from these devices is akin to that of a bird, a unique balance between detail and vantage point, between resolution and breadth, immediacy and connection. Also, due to their short flight range, the information is always local and immediately usable for understanding, manipulating and operating within the surrounding environment, perception at a neighborhood scale.

So the question then becomes: if the aerial perspective is used to understand space, does it allow for mastery over space? By perceiving the world this way, does it inspire a sense of responsibility, awareness and empowerment? I believe it does.

## *Watching the Watchers*

In 1786, Jeremy Bentham envisioned the Panopticon: an architectural expression of surveillance and the exercise of power. The Panopticon is a circular drum lined with cells. At the center of the drum stands a watchtower; the watchman in the tower can see into all the cells that line the outer drum[16], their occupants backlit and visible. Bentham imagined this building being used for factories, schools, hospitals, asylums and most famously, prisons – buildings that required supervision as well as control, together with the expression of hierarchical power. Central to his vision of the Panopticon was the inability for the watched to see the watchers. The watched knew that they were under surveillance, but never knew precisely when or by whom. Michel Foucault, in his 1975 book *Discipline and Punishment*, writes about Panopticism, defining the Panopticon as more than just a "dream building":[17]

> It is the diagram of a mechanism of power reduced to its ideal form [...] it is in fact a figure of political technology.[18]

Foucault establishes that hierarchical observation – surveillance – is coercive and has played, and continues to play, a key part in the normalization of Western civilization. If you are different or act out you will be seen, and therefore can be disciplined.

Another element to Foucault's argument is the informer; not only is there a hierarchical surveillance, but any peer could also be a watcher. With the introduction of a mediating authority like a police force, the populus begins to act as its own surveillance system, pointing the finger at irregular cells and turning them over to the authorities. The informer is only possible in the presence of an external authority.[19] Societies can outsource their fear of the abnormal, the pathogen, the perverse, and the unique onto an authoritative body imagined to be moral, unfailing, and capable of acting in the best

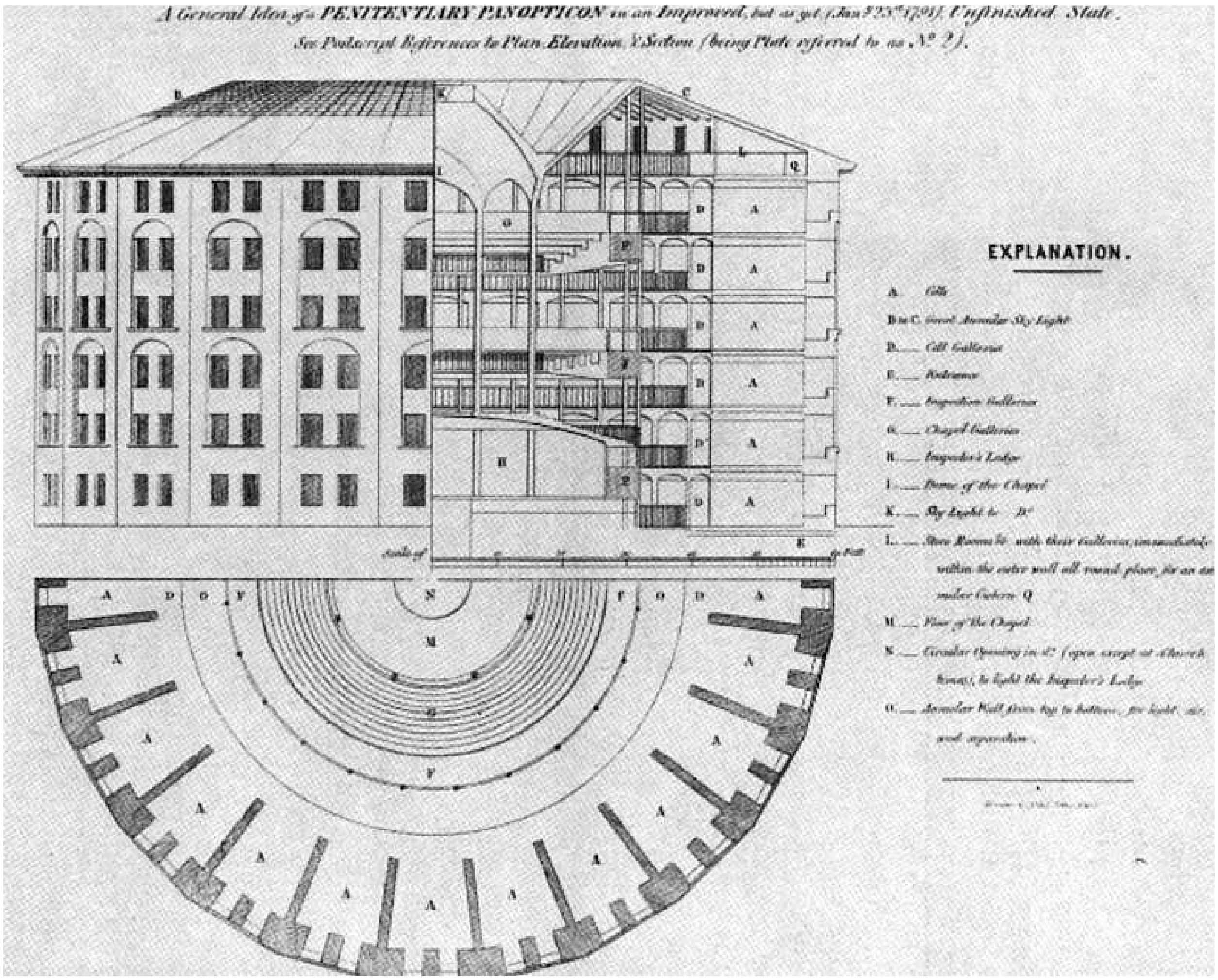



**Fig 4.6 -** Jeremy Benthams Panopticon. *Source: http://publishing.cdlib.org/ucpressebooks/view?docId=ft638nb3db;chunk.id=0;doc.view=print.*

interest of the common good, on behalf of the *polis.*

Normalization is a product of industrial production: if a worker, product, or citizen can be normalized, production can be streamlined and increased. Normalization in society, as a result of surveillance and exclusion, is often a self-reinforcing system where the product is self-replicating, normalized people rearing ever more normalized people in a positive feedback loop, creating a monocultural society.

The latest additions to the legacy of the Panopticon, to the lineage of surveillance technologies and mechanisms for power include: orbiting satellites, computer algorithms for pattern recognition, – specifically facial recognition software – information tracking online, NSA data bases in the Nevada desert, GPS-equipped mobile phones that can locate users within a few meters, night vision goggles, infrared cameras, and body heat sensing devices, to name a few. [20],[21]This paraphernalia of surveillance joins the preexisting infrastructure for telephone recording and networks of closed circuit television cameras mounted on telephone poles and building facades, clinging like black eyeballs to dropped ceilings at the manifold circulatory control points of universities and city halls. The Panopticon in today's technologically-dependent society has become polyvalent and ubiquitous; huge computers comb the data for irregular cells. George Orwell's Big Brother finally comes to call.

The prospect of a nameless, invisible watcher put forth by Bentham and identified by Foucault evokes the 'they' that has, for so long, been the arbiter of our misfortunes. Deciding how we live our lives, what we eat, how we sleep, how we learn, and how we love. We need a 'they' to blame for our situation, 'they' behind the one way mirrors, 'they' behind the wall of televisions and computer monitors. Over the last century we have had many 'theys'. Ivan Illich railed against the school as a source of normalization; Lewis Mumford against the machine, the clock and its regimentation;[22] Foucault against the compartmentalization of space that makes observation, surveillance, and the exercise of power over the individual possible.[23] Stuart Brand raged against the managers and Org-men of corporate America and the military industrial research models that threatened to assimilate him into their monoculture.[24] Outliers have tried countless times to release the public from the control, regimentation of 'they' who watch, the *other* other, the ones who control us. Most recently that other has been embodied in the top 1% of society that controls 98% of the wealth and seems to oppress and exploit the other 99%. [25]

But is the 'they' we rage against just a reflection of ourselves, and the systems that we have constructed, and evolved, to live within? Is it possible that we fight to maintain this system from fear of the unknown? Are 'they' just a way of outsourcing our anxiety so we can remain apathetic? Or is it our

**Fig 4.7 -** MQ-1B Predator Drone. General Dynamics. *Source: http://en.wikipedia.org/wiki/General_Atomics_MQ-1_Predator.*

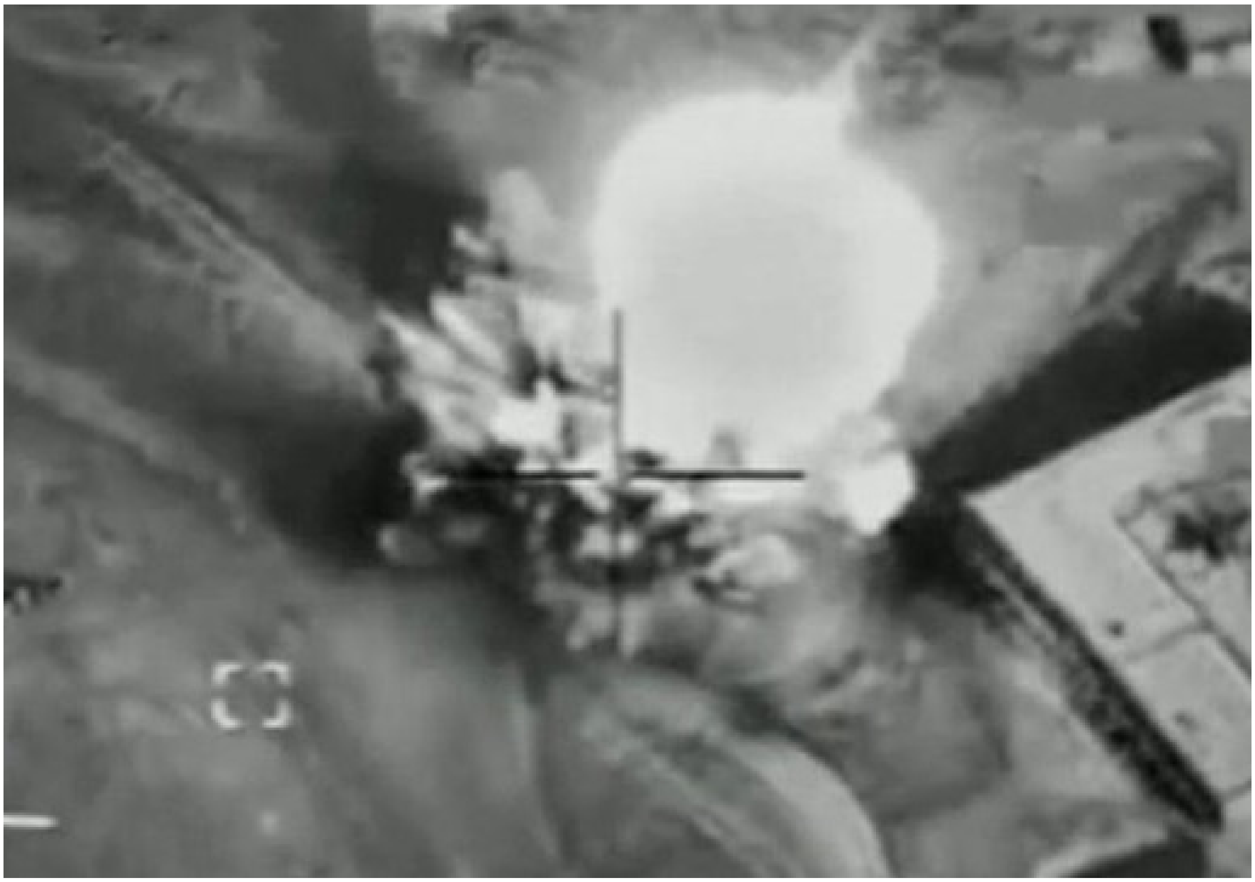


**Fig 4.8 -** Drone Strike View. *Source: Adam Rothstein: Future Strikes http://www.thestate.ae/future-strikes/.*

**Fig 4.9 -** Closed Circuit Television Cameras *Photo: Getty. Source: http://www.telegraph.co.uk/news/uknews/4958034/Britain-nation-of-form-fillers-watched-by-quarter-of-worlds-CCTV-cameras.html*

inability to take responsibility for the world we live in?

> Given enough eyes, all bugs are shallow[26]
> - Linus Torvalds

I feel my optimism shining through this web of control, illuminating something going on here: an ever-present but invisible arms race. The public is quickly acquiring political technologies. Our tiny cameras, voice recorders and GPS-guided waypoints all wrapped up in our cellphones, our distributed computing and communication technology – getting smaller and faster every month – represent the thousands of eyes that are looking around, the tens of thousands who are sharing what they see: the system we live in, the system we affect and are affected by.

David Brin, in his 1998 book *The Transparent Society*, explores the notion of *sousveillance*. Sousveillance

> is generally meant to imply that citizens have and exercise the power to look-back at the powers-that-be, or to 'watch the watchmen.'[27]

While "sur" means 'above' in French, "sous" means 'below': watching from below.[28] Brin imagines that as surveillance technologies become more accessible and pervasive, a society has two options. The first leaves a central authority to controls these technologies, an ever-vigilant eye on everyone all the time. In the second, everyone has the technology, capable of monitoring everyone at anytime, even the monitors. Leaving George Orwell's vision in *1984* to stand for the former, Brin speculates on the latter, imagining a society where the flow of information equalizes and a "best of both worlds"[29] reality emerges. People would do no wrong because their peers would hold them accountable to the collective. Some level of privacy would still be upheld where no dangers for abuse exist, enabling transparency, accountability and responsibility, without crippling human interactions. Brin's transparent society, the ideal utopia of a golden rule civilization, is made possible by a leveling of the observation-information-power hierarchy, present in human society since our nomadic tribes divided into agrarian societies, and exemplified in Bentham's Panopticon.

There is evidence that we are stepping closer to Brin's transparent society of bi-directional observation and accountability. During riots of recent years, demonstrators, even rioters, have used cell phones to broadcast police action and document excessive force, streamed live over the Internet. In the aftermath following the G20 summit in Toronto, photos from civilians were used to charge police officers with abuse of power during the orchestrated conflicts.[30] After the Argentine president Cristina Fernandez de Kirchner restricted the airspace[31] over Buenos Aires during the November 8th anti-government rally of 2012 – to restrict news helicopters from reporting on the protest – a group of civilian journalists flew a small camera equipped

**Fig 4.10 -** People Boxed at Queen and Spadina. *Photo by Jonas Naimark http://www.flickr.com/photos/jonasnaimark/4739841273/.*

**Fig 4.11 -** Crowds of protestors in Buenos Aires during Anti-Government riots. *Screeshot from YouTube video by user El Cipayo URL: http://www.flickr.com/photos/61221198@N05/8170542188/.*

**Fig 4.12 -** Nathan Kotylak is nabbed on Facebook trying to light a police car on fire. *Photo Garry Kahrmann http://abcnews.go.com/Technology/nathan-kotylak-charged-rioting-arson-tagged-facebook-social/story?id=13894317*

multi-rotor helicopter over the crowds to document the scale of the protests.[32] And as suggested by Brin it appears to be a two way street. In a riot following the 2010 gold medal hockey game in Vancouver, many of the individuals involved in vandalism were photographed by their peers using cell phones; the resultant images, uploaded to Facebook, were used as evidence to prosecute active members of the mob.[33] This balancing of power is made possible by the democratization of documentary technologies of cameras and videophones; in an unorganized state, they couldn't even be called surveillance technologies, just devices that can be coordinated to gather evidence.

In addition to these steps toward equalized accountability, there is a newly-emerging relationship to privacy. What is considered private, and what is the role of the secret? At some level, we fear what we do not understand. In order to be feared, you can make yourself incomprehensible – a tyrant government, a massive bureaucracy, or an irrational madman are all fearsome because they cannot be understood. But to be accepted, loved, and helped, you make yourself understandable. The secret once concealed a weakness that your enemy might exploit – Achilles' heel, Samson's hair. But having secrets has become a weakness in itself. Secrets frustrate understanding. It is in our nature to help others, but if we do not understand we cannot help. Our human ancestors developed language to facilitate cooperation, to coordinate resources in order to survive.[34] The cooperative model depends on everyone contributing something to the group. Like an open-source project, our society benefits from the "with enough eyes" mantra; it can be polycentric, and resilient. If diversity engenders the resilience of a species, then more choices from more and different people can enable a more robust strategy for continued survival.

The Hacker movement, based on an open exchange of information, is a microcosm of this emerging collaborative and cooperative society, and has grown a politically radical offshoot in the *Anonymous* hacker organization. *Anonymous* during the last five years has donned Guy Fawkes masks and crashed corporate servers, disseminated sensitive information of security executives and government officials, supported the Arab Spring protests of 2011 in Tunisia by disabling government websites and providing tools to avoid government surveillance online; they protested unnecessary violence by traffic police in San Francisco, stood up for the little guy and mobilized an online population into an active and distributed engine for political activism. [35],[36]This societal immune system, embodied in *Anonymous Sec's* actions – holding corporations and governments accountable for their misdoings – is embryonic of the collaborative accountability that Brin imagined in *Transparent Society*.

Perhaps that's why I've latched onto hackers as a new agent of change. For a long time now, we have known that the system is broken, imbalanced,

**Fig 4.13 -** *IMG_9120.jpg* Protestor wears Guy Fawkes mask, Cairo Al Qahirah Egypt Nov 21,2011. *Photo by Flickr user: Mosa'ab Elshamy URL: http://www.flickr.com/photos/mosaaberising/6374221919/*

and inefficient. Hackers are setting out to fix it – to *change the system* and balance out the information-power playing field by unlocking and distributing technologies and information for everyone to use for themselves.

In his 1963 volume *Ideas and Integrities,* Buckminster Fuller described the "Comprehensive Designer" as an individual that;

> would not be another specialist, but would instead stand outside the halls of industry and science, processing the information they produced, observing the technologies they developed, and translating both into tools for human happiness [...] The Comprehensive Designer would be aware of the system's need for balance and the current deployment of its resources. He would act as a 'harvester of potentials of the realm' gathering up products and techniques of the industry and redistributing them in accord with the systemic patterns that only he could perceive.[37]

As a student of architecture coming to this idea long after Fuller's time, I recognize his influence on my education. And without fully understanding it, this 'comprehensive designer' is what I have set out to become in my thesis: redistribute the products of the system – information, architecture, the city, and the aerial perspective – to enable the ability to alter one's own environment.

The devices I have designed are multi-functional tools, which enable me – the aspiring comprehensive designer – to stand outside of society – in this case 50-150m above it – and search for opportunities to make it legible and redistribute my understanding of it. They enable me to see a larger local picture and to see the system and its interactions differently. They seek to bring the public eye up to the top-down aerial perspective of the planner, leveling the playing field for city building. At the same time, they circumvent the restrictions presented by trespassing laws and high fences, by slipping into a free airspace below the 200m ceiling. They gather information on a landscape or urban fabric to see its potential, to expose the injustices to neighborhoods and ecosystems that are hidden from ground-level view, yet legible from the sky.

If the Panopticon was Bentham's architectural expression of one-directional observation – a model of the exercise of power – then these devices are an architectural expression of the democratization of space, the reclaiming of the commons. These acts accumulate like the pebbles before a mountain slide; they level the field, look back at the watcher, and rebalance the scales of power in the perception and dominion of space.

**Fig 4.14 -** Aerial photo over Brantford. *Photo by Author.*

(Endnotes)

1 Corner, *Taking Measures Across the American Landscape, 16*

2 ibid. 11

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