VERTIGO^2 Final Business Proposal

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The nature of the VERTIGO² project is that of a continuing project from the original 2003-2004 project. In light of this, the VERTIGO² proposal does not outline extensive details of the design or progress of the initial proposal and furthermore assumes that the recipient of this proposal is familiar with the design aspects of the previous phase of the project.

Table of Contents

I. Introduction/Project Overview 3
II. Product Specifications 4
III. Product Value Proposition 7
IV. Customer Base 8
V. Competitive Analysis 8
VI. Risk Analysis 10
VII. Out of Bounds 11
VIII. Budget 12
IX. Schedule 13
X. Team Capabilities 13
XI. Team Organizational 15
XII. References 17
The first phase of the VERTIGO project saw the analysis and design of the aircraft’s geometry, its aerodynamics, and its structural integrity. Problems with the initial design included a poorly designed tilting mechanism, center of mass location, and most importantly an undeveloped control system. The later design problem was simply due to time constraints as the original project was very ambitious in its design objectives. The emphasis of VERTIGO² is to design the electrical and control systems that will render the aircraft functional as stated in its original design objectives. The design objectives of VERTIGO² are as follows:

Primary Objectives:

1. Design and integrate a proper electrical system to ensure functionality
   a. Design, build, and program a base station control mechanism.
   b. Design, build, and program an on board computer to carry out commands from the ground station.
2. Design a simple, sufficient tilting mechanism for the rotor assemblies
3. Perform laboratory testing to verify aerodynamics and functionality
4. Achieve vertical flight and vertical maneuverability
5. Land

Secondary Objectives:

1. Transition to horizontal flight via tilting mechanism
2. Return to vertical flight
3. Land without catastrophe

The objectives will ideally be met in two phases—design and testing. The designing objectives are naturally the most important and most consideration will be given to the control system.

The control system will be designed from the ground up by the ECE project team, which is being led by Mimi Phan. Initial concerns for the control and electrical systems will be centered around the type and size that the fundamental processing chip should be and to what limits and parameters the said chip will need to satisfy. In particular, the rotor assemblies of the aircraft each have three independent degrees of motion and it is possible to make each assembly independent of the other. Aerodynamic control surfaces must be integrated into the design along with the binary motion of the tilting mechanism. Apart from the mechanical controls, some auxiliary devices must be programmed into the design as well—namely the video camera unit, the cooling fans, and a possible GPS system.
Communication System

The VERTIGO² communication system will be comprised of one radio frequency (RF) controller and one receiver. The initial plan is for this system to have approximately 16 channels from which to transmit the commands to the aircraft. In this design, the one RF controller will be able to control the aircraft in both vertical mode and in horizontal mode. This will be accomplished both on the circuitry side and on the controller side. Two separate circuits on the aircraft will control separate sets of servos used in each mode of flight while on the controller a simple switch will be used to switch the commands it sends to the microprocessors. This should allow the craft to be easily flown by one person. For testing purposes, the craft will initially be tethered using a series of wires so that the mode switching and processor communication can be tested before switching to a wireless system.
This project also encompasses sending non-control related data back to the user. This data includes digital still images, digital video, and GPS information. While all these may not be in the final build, we must account for their possibility. A separate subsystem will have to be developed to send this data. Most likely it will be sent on a separate frequency than the controller, and also of a higher bandwidth. While using this method the range of the controller will outdo that of the acquired data, this will ensure proper transmission of both sets of data. A simple integration of an RF transmitter hooked to all of these components can accomplish this goal.

**Integration**

The assembly of the entire system is left to the Integration Specialists. This task will encompass the soldering, wiring, and routing of all the electrical components on the aircraft. Skill in all these areas will be required so that all the components will be reliable despite the possible abuse they may feel from the testing phases of the aircraft.

A few of the items the integration team will have to watch out for is external interference, durability, and organization. External interference can result from electrical fields generated by the motors and servos. If enough of a field is present it could interfere with the operation of the microprocessors. These electrical fields could also interfere in the communication between the controller and the aircraft. Durability must also be taken into account when building the aircraft. The craft will be subject to extreme vibrations and possible hard landings. To ensure that minimal repairs will be needed, a durable and reliable construction shall be implemented. Organization is also a key element of the integration phase. When routing wires and placing components, an organized pattern can help with trouble shooting later. Wires shall be bundled and labeled so that electrical routes can easily be tracked.

**Software Development**

"Software runs the world", and that’s exactly how it is for this project. Without software, the aircraft would simply be a big heap of metal.

As a result, some of the mechanical processes that are electronically controlled via software range from being as simple as starting up the engine to multi-step processes as complex as maintaining the aircraft’s heading and ensuring constant radio contact throughout the course of the flight.

With software, one can’t afford to be lax in development, since any bug in the code could cause the aircraft to malfunction and unexpectedly shut its engines down. It either has to be perfect or one should be ready to face imminent failure during flight-testing.

As with other components of the aircraft, software can only run according to the specifications if the hardware operates at its most efficient and optimum level. Therefore, it is imperative that adequate steps be taken to protect the hardware and its surrounding environment from undesirable forces, such as, water, heat, cold, detrimental light
conditions and extreme atmospheric pressure. The benefits of protecting the hardware would be two-fold, since this way the software would be running as it should and the hardware would be cared for while it is tens of thousands of feet high, away from any human contact.

The programming languages that will be used for this project are C, C++, and Assembly (multiple processor families). C/C++ will be used for the ground base station, while Assembly will be used for on-board flight systems.

**Side-effects of Atmospheric Flight**

Flying doesn’t come without its share of side-effects and this project is no different.

The aircraft will be facing multiple forces that could at anytime cause the aircraft to come crashing down. The potential types of damage that could be caused to the aircraft are:

- **Atmospheric pressure:**
  At high altitudes, the atmospheric pressure can be so high that the air up there would be very thin. Therefore, an appropriate engine should be chosen that can reliably function to a certain altitude.

  There is also the extreme pressure that the aircraft might be exposed to at high-altitudes so only those materials that satisfy the minimum altitude requirement should be chosen for the hull of the aircraft.

- **Hull**
  Although the possibility of a projectile striking the aircraft is pretty remote, one shouldn’t neglect the fact that it is possible. We’re not talking about building a flying tank, but, at the very least, the aircraft should be able to withstand a strike from a bird that just happened to bump into the aircraft during its ascent.

  Atmospheric pressure is another issue that affects the hull, but has already been covered in the “Atmospheric Pressure” point.

- **Gaseous**
  Of the many things that one learns in high-school, is the fact that the atmosphere can be pretty toxic at times, due to toxic emissions from factories, therefore causing acid rains and the like. With that in mind, one should be wary that the potential of toxic gaseous vapors very much exists. If one were to forget this during the building of the aircraft, the aircraft could end up turning into dust while chemically reacting to the toxic vapors. Therefore, the material should be resistant to the common acidic vapors present in the atmosphere, at the least.
Circuitry

The entire on board system circuitry will be designed from scratch. The plan is to develop our own bread board, latch in all the chips (PICs, memory, registers, ports, etc.) needed and then making the necessary connections between these chips using an adequate amount of wiring and soldering.

The chips on every bread board that we develop will be wired using datasheets provided by the vendor of those chips, so we know which wire goes where. This is a crucial aspect for the plane to fly properly because a single bit of miss-wiring will lead to some sort of system failure or some minor failure, which might develop into a major problem. Hence, we will require time and total effort on part of the circuitry team who will have to re-check the wiring on board the plane at least twice or thrice for precautionary measures before flying it.

The above mentioned tasks apply to all control systems within the project, whether they are outside or inside the plane. The batteries from the previous VERTIGO team are currently undergoing tests to check whether they still hold an adequate amount of charge. If they do not, they cannot be re-charged. Most likely, these batteries are still rechargeable. However if not, new ones will need to be purchased. A significant amount of batteries will be needed for this project as they will be used in the ground controller unit and on the board of the VERTIGO plane itself.

Product Value Proposition

Luke Alexandar and Mimi Phan

Our product will set the new standard in controlling dual-mode aircrafts.
## Customer Base

VERTIGO² has a wide range of customer base:

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote control pilots &amp; Hobbyists</td>
<td>• simple setup and excellent documentation</td>
</tr>
<tr>
<td></td>
<td>• learn how to fly an airplane/helicopter combination with a computer</td>
</tr>
<tr>
<td></td>
<td>• showing their friends their new gadget.</td>
</tr>
<tr>
<td>Security Agencies</td>
<td>• simple setup and excellent documentation</td>
</tr>
<tr>
<td>• Military</td>
<td>• mobility; that allows for Military and Security teams to perform</td>
</tr>
<tr>
<td>• Department of Homeland Security</td>
<td>surveillance of the front/enemy lines</td>
</tr>
<tr>
<td>• Police Department</td>
<td>• The Police department and Homeland Security will use the system for</td>
</tr>
<tr>
<td></td>
<td>public safety and surveillance of criminals or terrorist.</td>
</tr>
<tr>
<td>Commercial industries</td>
<td>• simple setup and excellent documentation</td>
</tr>
<tr>
<td>• Power companies</td>
<td>• mobility that allows</td>
</tr>
<tr>
<td>• Hollywood</td>
<td>-Power companies to survey electrical systems that are normally</td>
</tr>
<tr>
<td>• The Media</td>
<td>out of reach of conventional ways, while also flying over power</td>
</tr>
<tr>
<td></td>
<td>plants to check for pollution or damage.</td>
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<tr>
<td></td>
<td>-Hollywood/Media companies a full range of different uses for the</td>
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<tr>
<td></td>
<td>system such as capture high-speed chase scenes in movies or</td>
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<tr>
<td></td>
<td>commercials while hovering in tight places that a conventional</td>
</tr>
<tr>
<td></td>
<td>helicopter could not</td>
</tr>
</tbody>
</table>

## Competitive Analysis

<table>
<thead>
<tr>
<th>Company</th>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bell Helicopter V-22 Osprey</td>
<td>• Established 1960</td>
<td>• Expensive</td>
<td>• Produce a less expensive product</td>
<td>• Has contracts with the US government</td>
</tr>
<tr>
<td></td>
<td>• Subsidiary of Boeing and Textron Inc.</td>
<td>• Fatal crashes due to the “vortex ring”</td>
<td>• Research to fix the problem</td>
<td>• Have access to facilities, manpower and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Limited to defense applications</td>
<td>• Orient the product to civil applications</td>
<td>funds</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Extensive research</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Working product</td>
</tr>
<tr>
<td><strong>General Atomics Aeronautical Systems, Inc</strong></td>
<td>Established in 1993</td>
<td>Does not provide VTOL</td>
<td>Modify product to add the VTOL capability</td>
<td>Has a good stand on the market domestic and international</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>---------------------</td>
<td>------------------------</td>
<td>------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Affiliated to General Atomic Inc</td>
<td>Expensive</td>
<td>Lower cost</td>
<td>Available research, funds and expertise</td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Century Helicopter</strong></td>
<td>Simple Design</td>
<td>Limited capability and functions regarding speed/payload and maneuver envelope Hobby shop</td>
<td>Add more functions to improve the product’s capability product Develop product to be more business oriented</td>
<td>Presence in the market Caters to both experts and novices</td>
</tr>
<tr>
<td></td>
<td>Cheap</td>
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<tr>
<td></td>
<td>Established 1987</td>
<td></td>
<td></td>
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<tr>
<td><strong>Nascent Technology Corporation</strong></td>
<td>Partnership with MIT Access to Lockheed Martin Unmanned Vehicle Technologies Established in 1999 Specializes in Aerospace Products</td>
<td>Lack of engineering diversity Product is a helicopter so has limited flight capabilities present in a plane</td>
<td>Diversify team to generate more ideas Make product appealing by adding more flight capabilities</td>
<td>Well established and funded More experienced with aerospace technology</td>
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</table>
Risk Analysis

The following items have been identified as possible risks by the VERTIGO² project team. They have been labeled by risk type which is schedule, technical, financial, or marketing.

**Project Risk #1:**
Communication problems exist between VERTIGO² team members.

**Type:** Schedule (People)  **Probability:** Moderate  **Effect:** Tolerable

**Possible Solution:**
Arrangements between team members will need to be made. Management will use leadership to ensure that all members are aware of responsibilities. Contact information of every team member will be made available.

**Project Risk #2:**
Scheduling problems occur. Some items scheduled for completion may not meet their deadline which will cause delays.

**Type:** Schedule  **Probability:** High  **Effect:** Moderate

**Possible Solution:**
Management will need to constantly monitor the process of scheduled tasks, ensure that scheduled action items are met on time. When items need to be worked on, the engineers should be aware of their responsibilities and work accordingly.

**Project Risk #3:**
Some items may have been missed or overlooked during scheduling. Frequent revisions to the schedule will cause major backup during the development of the controller.

**Type:** Schedule  **Probability:** Moderate  **Effect:** Moderate

**Possible Solution:**
Scheduling delays or changes are common problems when dealing with projects or working in the real world. A solution could be having the schedule thoroughly planned in the beginning of project stage to prevent frequent changes. Management and other authorized individuals should ensure that all items are known before the development of the controller. If there are changes made to the schedule, commitment and hard work from all team members should solve the problem.

**Product Risk #1:**
The team has issues getting certain aspects of the controller working whether it is communication of controller with the system or interfacing the electronic system with the airplane.

**Type:** Technical  **Probability:** Moderate  **Effect:** Catastrophic

**Possible Solution:**
Seven members consisting of Computer Engineers and Electrical Engineers are sufficient enough to solve any technical problems that may occur. With each person’s knowledge and experience combined, the team should not have any difficulty with the project. If a
solution isn’t found, the team will refer to outside resources such as books/references or even professionals in this specific field.

**Product Risk #2:**
Poor testing can cause major problems. The lack of testing of the VERTIGO electrical system could allow for bugs to go unnoticed.

**Type:** Technical  
**Probability:** Moderate  
**Effect:** Serious  

**Possible Solution:**
Extensive testing must be done. A detailed testing procedure can be written ahead of time to ensure all aspects of the temperature and pressure control system has been reviewed.

**Business Risk #1:**
A problem could result from lack of resources. Additional and necessary hardware or other resources needed for building the electronic system are not easily obtainable due to low finances or difficulty in finding area retailers who carry the items.

**Type:** Financial (Tools)  
**Probability:** Low  
**Effect:** Tolerable  

**Possible Solution:**
The team will need to look into getting more funding so the resources can become available. There should not have a problem in finding the resources necessary for the completion of controller. If the team can’t find something, they can dedicate an hour or two to going to a wholesale place in Melbourne. This wholesale store carries items such as resistors to capacitors, second-hand motors, wires, and etc. The great thing is that it is fairly inexpensive.

**Business Risk #2:**
The team has difficulty finding project sponsors.

**Type:** Marketing  
**Probability:** Moderate  
**Effect:** Tolerable  

**Possible Solution:**
The VERTIGO² team members will need to plan on marketing their project early on in the fall semester. The project CEO will be working with the school’s financial advisor to gain sponsors and additional funding.

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**Out-of-Bounds Criteria**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Situation</th>
<th>Project Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plane Crash</td>
<td>The prototype happens to crash during testing, or sustains damages during any other situation.</td>
<td>Due to lack of time, materials, human resources, we might not be able to repair damages.</td>
</tr>
<tr>
<td>2. Lack of Funding/Sponsorship</td>
<td>We are not able to get any sponsorship, or any other kind of monetary assistance.</td>
<td>Without funding, we would not be able to obtain materials to complete project.</td>
</tr>
</tbody>
</table>
3. Integration
   Integrating the controller and the aircraft
   Would not be able to meet our target completion date

4. Lag in processing data due to microprocessor
   The microprocessor may take too much time in receiving data or processing data once it is received causing a delay in response.
   If problem cannot be fixed, it will cause the controls on the plane to be clumsy.

5. Burned/overheated microprocessors on circuit
   Due to heat caused by plane or incorrect voltages on the circuit, the microprocessors may fail.
   Alterations will have to be made to the plane to keep the chips cooler, and burned parts must be replaced.

6. Loss of transmission
   Due to noise in transmission, parts of signal may be lost.
   If not compensated for, the plane may respond to noise as commands or not receive commands that are sent.

**Budget**

Mimi Phan

Since the VERTIGO project is in the second year, parts of the project have already been completed. The aircraft has already been built, and only needs a few minor repairs. The main focus of the project this year is to produce a control system that will be able to move the aircraft.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>High End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcontrollers</td>
<td>10</td>
<td>$400.00</td>
</tr>
<tr>
<td>Data Transceivers</td>
<td>1</td>
<td>$125.00</td>
</tr>
<tr>
<td>Video Transceiver</td>
<td>1</td>
<td>$200.00</td>
</tr>
<tr>
<td>Joystick</td>
<td>1</td>
<td>$100.00</td>
</tr>
<tr>
<td>Microcomputer</td>
<td>1</td>
<td>$400.00</td>
</tr>
<tr>
<td>ECE Miscellaneous</td>
<td>1</td>
<td>$200.00</td>
</tr>
<tr>
<td>Servos</td>
<td>4</td>
<td>$200.00</td>
</tr>
<tr>
<td>Software</td>
<td>2</td>
<td>$250.00</td>
</tr>
<tr>
<td>MAE Miscellaneous</td>
<td>1</td>
<td>$150.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$2025.00</strong></td>
</tr>
</tbody>
</table>

Table 3: Budget breakdown

Since this is a multi-departmental project, we are able to get a little more money than the usual ECE only teams. After combining the funds of the AE and ECE teams, we are guaranteed $500. The team will need to do extensive fund-raising to complete the project. The VERTIGO² project leader, Luke Alexander, will be managing the team’s budget. He is in the process of obtaining more funds and possible sponsors. The team hopes to gain approximately $3000 for the project.
Schedule

The VERTIGO² team was created recently. Unlike other project teams that were formed in junior design, we did not have the extra semester to plan, gain funds, or work on preliminary documents. The team will spend most of the fall semester working on brainstorming the specifications for the control system, gaining more funding, and completing required documentation. The spring semester will be devoted to building the control system, integrating the control system with the aircraft, testing, and completing final documentation. Luke Alexander and Mimi Phan will be working together to form a schedule for the project.

Team Capabilities/Responsibilities

Luke Alexander is the CEO (Chief Executive Officer) of the VERTIGO² team. Luke has already earned his bachelor degree in Mechanical Engineering, and is currently planning to earn his bachelors in Aerospace Engineering. He has expertise in flight mechanics, stability, and control. He was the Structural Analyst from the original VERTIGO team. With his knowledge and experience from working on the project the previous year, Luke is ideal for the position of lead for the team.

Mimi Phan, ECE Coordinator, is a senior majoring in Computer Engineering. She will be leading the ECE project group in design of the control system. She will be acting as a Programming Specialist as well as substitute Webmaster. She’s had previous experience doing aero research at an Acoustics Research Laboratory. She has a couple of years of experience with writing technical documentation such as user manuals for new software and root cause analysis (analysis documents on problem software). At Florida Tech, she has taken classes like Computer Design and Microcomputer Systems where you build or program boards in assembly to classes like Software Hardware Design/Integration to Network Programming where you program in C++. She also knows XHTML, Javascript, and Photoshop for web development.

Kevin Boyce is a senior majoring in Electrical Engineering. He is VERTIGO² Circuitry Specialist. He has knowledge in circuit design and implementation including having built the Intel 8031 micro-controller. He knows how to build and test circuits. He has experience with programming in C++ and assembly. With his knowledge in circuits, he will be an asset to the team.

Ryan Strauss is a senior majoring in Computer Engineering. He has three positions. He will be working as one of our Circuitry Specialist as well as a Programming Specialist. He will also help with the team’s website. He has knowledge in circuit design and theory. He’s also programmed in C++, assembly, XHTML, XML, and XSL. Ryan will be using his knowledge/skills to assist the team in all aspects of the project.

Tebo Leburu, a senior majoring in Computer Engineering, is one of our Circuit Specialists. She has knowledge in circuit design and implementation including having
built the Intel 8031 micro-controller. He has experience with programming in C++ and assembly.

Duro Taylor, another Computer Engineering major, is one of the Programming Specialists. She has experience programming in C++ and assembly as well as doing HTML. She also works on circuit boards in class and during her free time. Duro will be using her knowledge in programming as part of the VERTIGO² team’s programming group.

Prateek Mohan is a senior in Computer Engineering. He also holds three positions in the team. He is working as one of our Circuit Specialist and Programming Specialist. He will also be working on the team website. Prateek has knowledge in circuit design and implementation including having built the Intel 8031 micro-controller. He has experience with programming in C++ and assembly. He also specializes in PHP and XHTML for web development. Prateek will be using his skills to assist the team in all aspects of the project.

Calvin Turzillo is a senior majoring in Electrical Engineering. He is the Communications Specialist as well as a Circuit Specialist. He has experience in soldering, integration of various types of systems, and RF. With his extensive knowledge in circuitry/communication systems, he will play a major role in the team.

Jeff Laub is an Electrical Engineering major. He is one of the teams Communications Specialists. He has programming experience in C++, assembly, and HTML. He also has knowledge of circuit design including the Intel 8031 microcontroller. He’s also good at soldering.

Chris Fernando is a graduate student majoring in Software Engineering. He has a wide variety of programming experience. He knows how to programming in C/C++, Java, XML, PHP, CSS, and assembly. He will be an asset to the team as well as being of great assistance to the programming team.
The circuitry group will be involved with the electrical design of the controller. They will work with the programming group to make a controller that will have the capability of communicating with the VERTIGO² prototype.
VERTIGO² Communications Team Organization

The communications group will be involved with integrating video/sound components with the VERTIGO² prototype/aircraft.

VERTIGO² Web Team Organization

The Web group will work on all aspects of the VERTIGO² website such as layout design, releasing the latest information, and uploading current team documentation.
The programming group will be involved with the creating code that will have the microcontroller communicating with the aircraft.
REFERENCES

http://www.findarticles.com/p/articles/mi_m1511/is_n11_v17/ai_18762283