Department of Aerospace Engineering Sciences
Senior Projects – ASEN 4018

Aerially Deployed Autonomously Monitored Surface Sensors
Project Definition Document (PDD)

Document History

Release	Date	Description	Name
Initial	9/13/07	Version 1.0	Ashleigh Bailey

Approval

Title	Name	Signature	Date
Customer			
Advisor #1			
Advisor #2			
CC			

Project Definition Document

Aerospace Senior Projects (ASEN 4018 & 4028)

1.0 Information

1.1 Aerially Deployed Autonomously Monitored Surface Sensors (ADAMSS)

1.2 Project Customers

Dr. Jim Maslanik Office: ECME 273 Phone: 303-492-8974 Email: James.Maslanik@colorado.edu	Dr. Brian Argrow Office: 429UCB Phone:303-492-5312 Email: brian.argrow@colorado.edu

1.3 Group Members

Ashleigh Bailey Ashleigh.bailey@colorado.edu 720-530-5128	Ryan Bell Ryan.bell@colorado.edu 303-917-680
Benjamin Brown BrownBt@colorado.edu 410-903-4892	Will DuBois duboisw@gmail.com 970-618-7753
Heather Gass Heather.Gass@colorado.edu 303-229-6079	Kurt Papathakis Kurt.Papathakis@colorado.edu 970-531-1096
Jaclyn Poteraj Jaclyn.Poteraj@colorado.edu 720-352-2584	Johnathan Sparks Jonathan.Sparks@Colorado.edu 303-810-4155
Marcus Wilkerson Marcus.Wilkerson@colorado.edu 303-520-9125	Tejendra Dhakal dhakal@colorado.edu 720-318-5040

2.0 Background and Context

Global warming is an important area of study in the scientific community. Many people are demanding a rigorous description and understanding of the causes and effects of global warming. Petroleum prices are on the rise, the ethics behind the use of petroleum are being debated, and the future of the global environment is being scrutinized. Though the validity of the concept is heavily debated, the potentially negative and universal effects of global warming will make it a major area of research for years to come. In the study of global warming, glaciers have proven to be invaluable tools for evaluating and monitoring changes in climate and temperature. The glaciers of the arctic and Antarctic regions represent the largest reservoir of fresh water on the planet. Entirely composed of solid, compressed ice, these glaciers are constantly flowing across the land due to seasonal melting and refreezing. The motion of these glaciers each season is extremely sensitive to the local climate and temperature, making each glacier a large-scale indicator of global climate change. By studying the motion of these glaciers during the spring and summer months, researchers may be able to make advances in the understanding of global warming.

In order to study the motion of glaciers, scientists often mount GPS receivers to their surface. The process for placing and monitoring these receivers is often difficult and costly because glaciers tend to be located in the arctic and antarctic regions of the planet. Researchers are typically required to trek out across the glacier to several locations and manually place the GPS equipment. Additionally, most of the equipment, once placed, is unable to remotely transmit data back to a nearby research station, requiring that the scientists return at regular intervals to retrieve the data. These procedures require the researchers to travel through hostile environments, placing themselves and the expensive equipment in danger. In response to these dangers, the Research and Engineering Center for Unmanned Vehicles (RECUV) has proposed a new technique that will provide a higher level of safety to the glacier researchers. In addition, the technique will save time and money. RECUV is sponsoring the development of a system that will allow GPS receivers to be placed and observed remotely via one or more unmanned air vehicles (UAVs), eliminating many of the hazards posed by current research methods. This system would allow scientists to remotely deploy and monitor glacier research equipment from the safety of a nearby research station.

The goal of the project described in this document is to design a system for the deployment of several low-cost sensor packages from a fixed wing UAV. The deployment package will be designed to attach to a variety of UAV models so that it can be adapted to many different scenarios. Each sensor package will be designed to be inexpensive and disposable, with very low environmental impact, eliminating the need for researchers to retrieve the equipment after a study. The system will improve over current research methods by decreasing cost and increasing versatility in a variety of environments. With this system, scientists will be able to cheaply and remotely monitor glacier behavior and conditions, providing greater opportunity for advances in the understanding of the impact of global warming.

3.0 Goal

Our goal is to improve on current methods for glacier study by reducing hazards to both personnel and equipment. We hope to develop a system for the remote placement and observation of sensors in Polar Regions by applying UAV technology. The sensors will be capable of measuring and transmitting global position and atmospheric temperature and pressure data to be used in the study of glacier movement due to global warming.

4.0 Objectives

4.1 Overall Objective

- Develop a deployment system that is capable of deploying a network of small sensors from the air onto a specified glacier. The sensors are programmed before takeoff to receive and record the translation of glaciers over a specified period of time. After a set time the sensors shall be able to transmit data back to an overflying UAV.

4.2 Sensor Deployment System

- The team shall conceive, design, fabricate, integrate, test and verify a sensor deployment system that operates from an RC or autonomous aircraft, or as part of such aircraft.

- The deployment system shall be capable of operating on various RC aircrafts. A series of three sensors will be deployed from a specified aircraft for the purposes of proof of concept.

4.3 Data Acquisition

- The team shall develop a method for recovering data from the ground sensors. This should be operated remotely, so that members will only have to be within 10 km of the sensor.

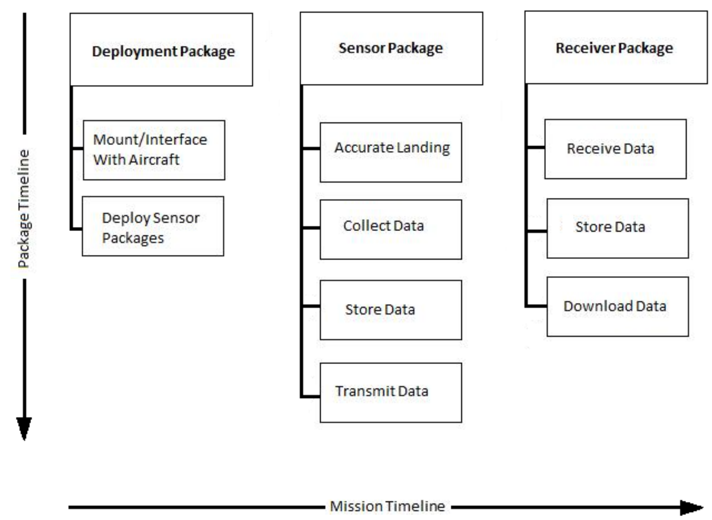
- It will be permissible, for testing, for a pilot to be within 300 yards of the sensor so that an aircraft may be piloted.

4.4 Sensor Packages

- The team shall design, build, integrate, and test three drop-sensors.

- One fully functional sensor needs to be produced for proof of concept. This sensor needs to be carried and deployed in order to demonstrate the ability to land the sensor within the desired target area, perform autonomously, record data, and have the ability to upload data remotely for retrieval.

5.0 Functional Block Diagram



6.0 System Operational Timeline (Concept of Operations)

6.1 Preflight Phase

6.1.1 Airfield and target location weather and foreign object and debris (FOD) check

6.1.2 Hardware

6.1.2.1 Mount deployment package to aircraft
6.1.2.2 Mount sensor packages onto deployment package
6.1.2.3 Confirm all batteries fully charged and loaded
6.1.2.4 Fill all fuel tanks to proper level
6.1.2.5 Perform a visual preflight inspection of the aircraft and components

6.1.3 Electronics

6.1.3.1 Sensor package equipment all turned on and operational
6.1.3.2 Uplink confirmed with sensors to test survivability
6.1.3.3 Test and confirm sensor deployment mechanism is operational
6.1.3.4 Test and confirm aircraft control mechanisms are operational

6.1.4 Preflight aircraft run-up, ensuring proper engine operation

6.1.5 Taxi to takeoff location on airfield

6.1.6 Final weather and FOD check

6.2 Initial Flight Phase

6.2.1 Perform takeoff

6.2.2 Enter airfield pattern and perform aircraft system check

6.2.2.1 If any systems are not in proper operation, commence landing
6.2.2.2 If all systems are operational, continue with mission

6.2.3 Climb to cruise altitude and heading

6.3 Sensor Deployment Phase

6.3.1 Cruise to target location

6.3.2 Confirm target location

6.3.2.1 If target location cannot be confirmed, skip to step 6.4
6.3.2.2 If target location is confirmed and area is determined clear, continue with mission

6.3.3 Deploy sensor package

6.3.3.1 Confirm altitude and velocity for drop trajectory
6.3.3.2 Commence sensor package deployment
6.3.3.3 Sensor package deploys drag device
6.3.3.4 Sensor package touchdown
6.3.3.5 Deploy ground interface equipment

6.3.4 Uplink Confirmation Phase

6.3.4.1 Aircraft loiter over target location
6.3.4.2 Confirm uplink with deployed sensors in range
6.3.4.2.1 If confirmed, loop to step 6.3 and deploy the next sensor
6.3.4.2.2 If not confirmed, continue on with mission

6.3.5 Perform drop sequence (step 6.3) for all three sensors then continue to step 6.4

6.4 Final Flight Phase

6.4.1 Climb to cruise altitude and heading

6.4.2 Cruise to airfield location

6.4.3 Perform airfield weather and FOD check

6.4.4 Descend to landing pattern and commence landing sequence

6.4.5 Taxi to post-flight area

6.4.6 Perform inspection of equipment and aircraft

6.4.7 Turn off all electronics and place into storage

6.5 Data Acquisition Phase

6.5.1 Long term data acquisition over one day

6.6 Data Uplink Phase

6.6.1 Repeat steps 6.1 and 6.2

6.6.2 Cruise to target location

6.6.3 Obtain communication altitude and loiter over target location

6.6.4 Uplink and copy data from the deployed sensor

6.6.5 After data uplink commencement, repeat step 6.4

6.6.6 Retrieve data from aircraft into storage device

6.7 Final Equipment Check

6.7.1 Receive sensor package from test field

6.7.2 Perform inspection and analysis of all test equipment

7.0 Project Requirements – All following project requirements are defined by customer.

7.1 Overall Project Requirements

7.1.1 Operating Platform

- **Req:** The system shall be interfaced with and delivered by a fixed-wing aircraft.
- **Dsc:** Either R/C or UAV will be used to deploy sensors, depending on FAA restrictions. Fixed wing works best for delivery time and range.
- **Verify:** Demonstration

7.1.2 Operating Environment

- **Req:** The system shall be capable of operating as low as -10^{o}C (-14^{o}F).
- **Dsc:** Arctic & Antarctic temperatures in summer/spring.
- **Verify:** Cold testing in BioServe's lab, or suitable refrigeration unit. Delivery package and sensor package will have to be tested together (test).

7.1.3 Weight Limitation

- **Req:** The total mass of the sensors and the deployment package shall be no more than 5 kg.
- **Dsc:** Customer knows capacity of lift on test aircraft.
- **Verify:** Will need to verify by weighing (inspection).

7.1.4 RoHS

- **Req:** All devices, mechanisms, and deployables shall comply with environmental safety standards for electronics (RoHS).
- **Dsc:** All deployed components should be lead free, as they will be deployed into the environment and not be retrieved.
- **Verify:** Inspection

7.1.5 Data Retrieval

- **Req:** Data acquired by the ground-based sensor system shall be transmitted via radio at TBD frequency to an airborne fixed wing aerial platform.
- **Dsc:** TBD craft will be a R/C or UAV, possibly the same as deploy vehicle.
- **Verify:** Fixed wing will be flown over sensor location and data will be retrieved to be downloaded at a later time (Demonstration).

7.2 Interface Project Requirements

7.2.1 Aircraft Interface and Test

- **Req:** The system shall attach to and allow for flight of Telemaster R/C aircraft.
- **Dsc:** To demonstrate that the deployment system is modular enough to adapt to varying circumstances. This plane is cheap, effective, and most likely to be taken on science missions.
- **Verify:** Mechanism attaches to customer-supplied craft and is able to take off and satisfy other requirements (demonstration).

7.2.2 Additional Aircraft Interface

- **Req:** The system shall attach to a Velocity R/C aircraft
- **Dsc:** Do not need to fly, only verify docking capability.
- **Verify:** Successfully attach a loaded deployment package (demonstration).

7.2.3 Data Retrieval Interface Distance

- **Req:** Data communication shall be 100% efficient at an upper limit of 1km between the aircraft-mounted receiver and ground-based sensor.
- **Dsc:** If sensors are approximately within 200m of each other, then all 3 sensors should be accessible from one location instead of having to fly over each individually. This also gives sufficient altitude for the aircraft to fly without hitting anything.
- **Verify:** Will test line of sight data transmission from 1km away. Data will be transmitted and then compared to data received. Transmission will be tested to failure to see what upper limits are (test).

7.3 Science Project Requirements

7.3.1 Sensor Package Collection Rate

- **Req:** Sensor package shall collect data at a rate of no less than 1 measurement every 10 minutes for no less than 5 days.
- **Dsc:** Preferably will be GPS, but could also be temperature, and/or pressure.
- **Verify:** To be tested. Will also be tested in sub-zero conditions (test).

7.3.2 Drop Height

- **Req:** After a drop of 30 meters, the sensor package shall collect and store position data, and be able to transmit to the aircraft receiver.
- **Dsc:** Terrain will not be uniform and level. Flat surface will be the most punishing, but device should survive impact from all angles. Possible deployment mechanisms involve parachutes, streamers, impact ‘crumple zone’, controlled descent.
- **Verify:** Dropping from the top of the Physics building, or possibly the stadium. Allow to collect data, transmit data to receiver (test).

7.3.3 Deployment Package

- **Req:** The deployment package shall have the capacity to carry 3 sensors.
- **Dsc:** Three sensors are specified by the customer as the minimum number of sensors to be effective.
- **Verify:** One to two dummy sensor packages will be fit along with the live one in order to verify (demonstration).

7.3.4 Sensor Package Cost

- **Req:** An individual sensor package (1 unit) shall cost no more than $2000 US.
- **Dsc:** For science based missions, cost is critical. These devices will not be retrieved, so the cost for a single-use device needs to be quite low.
- **Verify:** All components to build and fabricate should come in under this cost (inspection).

7.4 Performance Project Requirements

7.4.1 Sensor Package Delivery

- **Req:** The system shall deliver 1 sensor to within a 100m of a customers specified location.
- **Dsc:** 3 sensors are requested, 1 sensor is sufficient for 'proof of concept' then others can be built at a later time. Dummy sensors will be used when three sensor packages are needed.
- **Verify:** 1 sensor shall be dropped from no less than 30m and retain its ability to collect, store, and transmit 100% position information to satisfy this requirement (demonstration).

7.4.2 System Operating Range

- **Req:** The system shall be capable of deploying sensors after traveling up to 10km from base station.
- **Dsc:** To be useful, the craft will need to deliver far from base camp.
- **Verify:** Time of flight is sufficient for satisfying this requirement. TBD source of greatest stress (temperature, aerodynamics, vibration, etc) (demonstration).

7.4.3 Sensor Spacing

- **Req:** The system shall be capable of deploying sensors no less than 200 meters apart.
- **Dsc:** This is needed in order to get measurements over the entire glacial surface.
- **Verify:** One sensor will deploy, and another greater than 200m away (demonstration).

8.0 System Requirements

8.1 Aerodynamics Systems

8.1.1 Deployment Package Shell

- **Req:** Deployment package shall not increase the coefficient of drag by more than TBD amount.
- **Dsc:** Fuselage lift is small compared to the wings, but drag is a concern. Too much drag will increase fuel consumption (either electrical or gas) and may compromise the vehicle's return (max of 20km). If deployment package is housed in fuselage, this might be able to be removed.
- **Parent:** 7.4.2 System Operating Range
- **Verify:** Analysis.

8.1.2 Deployment Package Location

- **Req:** Deployment package shall not cause the static margin of aircraft to change by a TBD amount.
- **Dsc:** Loaded mass might affect stability of aircraft. Location is important. It will be important to document this location as well in order to mount the system in the field.
- **Parent:** 7.4.2 System Operating Range
- **Verify:** Analysis.

8.2 Structures Systems

8.2.1 Sensor Package Seal

- **Req:** Moisture shall be prevented from getting inside the sensor package.
- **Dsc:** The sensor might land in a water puddle, or shallow drainage trough. System would need to be water tight in order to operate properly. Might be sealed through caulk, sealant, rubber gaskets, or hot glue. Should make sure material isn’t toxic or susceptible to cold temperatures.
- **Parent:** 7.3.1 Sensor Package Collection Rate
- **Verify:** Sensor shell will be submerged under water, and any leaks will be noted and corrected. Device just needs to be water tight, not impervious to water pressure (test).

8.2.2 Sensor Package Attitude

- **Req:** The sensor package’s antenna(e) shall maintain an up pointing direction (in East-North-Up coordinate system) after landing on the surface.
- **Dsc:** In order to get good GPS data and to ensure communication with fly-over aircraft later, this is a critical factor of the system. Omni-directional antenna is also a possibility, but power might limit this option.
- **Parent:** 7.2.3 Data Retrieval Interface Distance
- **Verify:** Varying orientations should allow for antenna to maintain upwards pointing (demonstration).

8.2.3 Deployment Package

- **Req:** The deployment package shall have a release mechanism that will allow for the dispersal of a single sensor at a time.
- **Dsc:** Possible mechanisms include spring loaded, “Bomb bay doors”, simple holding mechanism. Will need to consider rear-mounted propellers on Velocity vehicle.
- **Parent:** 7.4.3 Sensor Spacing
- **Verify:** Completed mechanism should release a single sensor (demonstration).

8.2.4 Receiver Package

- **Req:** The transceiver shall attach to both customer specified aircrafts in a TBD fashion.
- **Dsc:** Telemaster and Velocity
- **Parent:** 7.2.1, 7.2.2 Aircraft Interface and Test
- **Verify:** Attach transceiver to aircraft (demonstration).

8.3 Electronics Systems

8.3.1 GPS

- **Req:** The sensor package shall collect and store GPS data
- **Dsc:** Primary data interest, with option of temperature and pressure.
- **Parent:** 7.3.1 Sensor Package Collection Rate
- **Verify:** Will collect data and store in memory (demonstration).

8.3.2 GPS Accuracy

- **Req:** Error of GPS measurements shall be no more than 2 meters.
- **Dsc:** This might be too large for slower moving glaciers. Greenland glaciers (which are subject of much interest to customer) move very fast, so attaining this requirement might be possible without DGPS.
- **Parent:** 7.3.1 Sensor Package Collection Rate
- **Verify:** Position testing of sensor device by taking device along measured path and determining error measured by GPS (test).

8.3.3 Materials of Electronics Construction

- **Req:** Electronic components of sensor shall comply with RoHS specifications
- **Dsc:** The sensors will end up in the oceans at some point
- **Parent:** 7.1.4 RoHS

- **Verify:** Use of lead-free solder and RoHS components in construction (inspection).

8.3.4 Power

- **Req:** The sensor package shall not consume more than TBD watts.
- **Dsc:** Sensor package will be quite stingy on power, as size and weight is a critical aspect of the design.
- **Parent:** 7.3.1 Sensor Package Collection Rate
- **Verify:** Will be verified through power budget and testing under full operation (test).

8.4 Communications and Control Systems

8.4.1 Communication Frequency

- **Req:** The transceiver shall communicate with ground-based sensor package at a frequency that is TBD.
- **Dsc:** Frequency yet to be determined between sensor and aircraft
- **Parent:** 7.1.5 Data Retrieval
- **Verify:** Confirm data transmission at distance specified in 1 km (test).

8.4.2 Release Mechanism Control

- **Req:** The release mechanism of the deployment package shall be controlled through a control on the ground.
- **Dsc:** Since this is not mounted on a UAV, the release mechanism will have to be triggered from the ground. It might be possible to develop logic for the mechanism to release given a set of longitude/latitude coordinates.
- **Parent:** 7.4.1 Sensor Package Delivery
- **Verify:** A push-button device should cause one cycle of the release mechanism to occur via RF (demonstration).

9.0 Minimum Requirements for Success

9.1 Flight

9.1.1 Aircraft shall be able to take off and fly with sensor package

9.1.2 Verified at system test

9.2 Sensor Release

9.2.1 Package shall deploy one sensor

9.2.2 Verified by observing deployment package separately and giving release command

9.3 Sensor Delivery

9.3.1 Sensor shall be delivered to a desired location within a 100m radius

9.3.2 Verified on with zip-line or at system test

9.4 Sensor Survival

9.4.1 Operational: able to measure and transmit vital data

9.5 Data Acquisition and Transmission

9.5.1 Sensors shall take GPS data at 1 hr intervals for 3 days

9.5.2 Verified pre-system test

9.5.3 Sensors shall transmit gathered data 1km

9.5.4 Verified pre-system test

10.0 Deliverables

10.1 Sensor Package- Quantity: 3 [1 required] (0.DEL.1)

10.1.1 Drag Mechanism: Capable of slowing fall of sensor package to a maximum of TBD speed at impact. Also orients sensor package for optimal communication.

10.1.2 Housing: Capable of withstanding impact with glacier surface, cushioning and sheltering electronics.

10.1.3 Sensors: Capable of taking data once every 10 minutes in temperatures ranging from -20^{o}C to 5^{o}C.

10.1.3.1 GPS Receiver: Capable of measuring global position with a TBD amount of accuracy.
10.1.3.2 Atmospheric Temperature: Capable of measuring atmospheric temperature within an accuracy that is TBD.
10.1.3.3 Atmospheric Pressure: Capable of measuring atmospheric pressure within an accuracy that is TBD.

10.1.4 Memory: Capable of storing at least 5 days of data when data is recorded once every 10 minutes

10.1.5 Relay System

10.1.5.1 Directional Antenna: Capable of communicating with ground station or receiver package from 1km away.

10.1.5.2 Software Package: Capable of successfully communicating stored data in at most TBD seconds.

10.1.6 Power System

10.1.6.1 Chemical/Rechargeable Battery: Capable of supplying sufficient power to Sensor Package for at least five days.

10.1.6.2 Solar Array (if necessary): Capable of recharging battery during daylight hours.

10.2 Deployment Package -Quantity: 1 [1 required] (0.DEL.2)

10.2.5 Housing: Capable of holding 3 sensor packages at a time. Shelters sensor packages and attaches mechanism to aircraft while having minimal effect on the flying capability on the plane.

10.2.6 Deployment Mechanism (Door): Capable of releasing one sensor package every t** minutes.

10.3 Receiver Package (0.DEL.3)

10.3.5 Housing: Capable of holding receiver equipments. Shelters equipment and attaches mechanism (both physical and electrical interface) to aircraft while having minimal effect on the flying capability on the plane.

10.3.6 Memory: Capable of storing at least three days of sensor data (from 3 sensors) for duration of flight.

10.3.7 Relay System

10.3.7.1 Directional Antenna: Capable of communicating with an individual sensor package from TBD meters.

10.3.7.2 Software Package: Capable of successfully receiving sensor package data in at most TBD seconds (per sensor).

10.3.8 Power System: Battery will be capable of supplying sufficient power to receiver equipment for duration of flight.

10.4 Storage Device (0.DEL.4)

10.4.5 Capable of safely storing and transporting the Deployment Package, three Sensor Packages, and Receiver Package to the final destination.

10.2 Risk #2 (0.RSK.2) Sensor Package Damage on Impact

10.2.1 The sensor package contains multiple electronic units, all of which are pivotal to success of the mission. These packages are being deployed from at least 30 m AGL which provides a large impact force when sensors reach their target and the sensors may break from these forces.

10.2.2 An aerial drag device will be equipped to the sensor package unit in order to provide a steady, controlled fall which will enable the package to land with a low enough force to not cause electronic malfunction. An additional softening device may also be used to decrease the landing force. Product Information will be gathered and tests will be done on the electronics to ensure the maximum acceleration is not exceeded in the drop.

11.0 Technical Risk

11.1 Risk #1 (0.RSK.1) Electronic Temperature Performance

11.1.1 The equipment will be operating at extremely low temperatures in the Arctic and Antarctic, therefore there is a risk involved with the electronics malfunctioning in the extremely cold temperatures of this region

11.1.2 Equipment will be bought/ manufactured with the explicit understanding that it is designed to work in these conditions. Tests will be done in temperature controlled environments with equipment prior to final production process.

11.2 Risk #2 (0.RSK.2) Sensor Package Damage on Impact

11.2.1 The sensor package contains multiple electronic units, all of which are pivotal to success of the mission. These packages are being deployed from at least 30 m AGL which provides a large impact force when sensors reach their target and the sensors may break from these forces.

11.2.2 An aerial drag device will be equipped to the sensor package unit in order to provide a steady, controlled fall which will enable the package to land with a low enough force to not cause electronic malfunction. An additional softening device may also be used to decrease the landing force. Product Information will be gathered and tests will be done on the electronics to ensure the maximum acceleration is not exceeded in the drop.

11.3 Risk #3 (0.RSK.3) GPS Sensor Movement

11.3.1 The GPS sensor is using accurate measurements to track the movement of the glaciers over five days. These glaciers have severe conditions of high winds, hard ice, deep snow etc. that can provide many ways of moving the sensor package over the five day period on the glacier. This will result in inaccurate data of the movement of the glacier.

11.3.2 In order to combat the severe glacier conditions there will be an anchoring device attached to the sensor package. This device will take into account the type of surface conditions of the ice, wind velocities, and snow levels up to 10 cm. The device will be designed to anchor properly in all these conditions and remain anchored for the duration of the five day test.

11.4 Risk #4 (0.RSK.4) GPS and Data Uplink Block

11.4.1 There are many crevices on the glaciers. If the sensor package falls into one of these crevices the sensors may not be able to obtain the GPS satellites and/or will not be able to send the collected data through the uplink with the mother ship.

11.4.2 The sensor package will be designed to either naturally combat these conditions or to deploy a mechanism to avoid falling into a specified average crevice size. Also, the target location for the sensor package should be visually inspected using satellite imaging or GPS prior to deployment of the sensor device.

11.5 Risk #5 (0.RSK.5) Deployment Condition Replication

11.5.1 The customer for this project has not specified an exact aircraft which this system will be attached to, therefore the deployment specifics may be difficult to replicate for the sensor package. This can result in a loss in target accuracy, weight conditions, deployment airspeed and landing force.

11.5.2 The sensor package will be designed to fit two different types of RC aircraft with the idea that it will a versatile system that can be equipped on many other aircraft if need be with little modifications. The airspeed and weight requirements will be determined from the two specified aircraft as well as standard specifications for other aircraft in that field with the specific area of expertise.

11.6 Risk #6 (0.RSK.6) Sensor Moisture Saturation

11.6.1 Since the sensor package will be deployed in a wide range of conditions on the glacier, there is a chance that the sensor package may land in a small pool of water. This water could get into the sensor electronics and damage the sensors or other electronics

11.6.2 In order to prevent moisture saturation to the sensor electronics, water-proofing techniques will be used in order to protect all the electronics of the sensor system in the chance that they are submerged under up to 10 cm of water.

11.7 Risk #7 (0.RSK.7) Flight Test Laws and Regulations

11.7.1 New rules have been put into effect by the FAA governing the use of small RC and UAV aircraft. These rules may pertain to our testing and could make performing flight tests extremely hard or impossible.

11.7.2 The group is already looking for specifics on the FAA regulations and will get in touch with the FAA to get flight approvals soon early before the flights take place. Additionally, in the chance that a flight is still not permitted, we have a backup plan of using a zip-line system to simulate aircraft flight in order to perform the tests, with the idea that the equipment is designed to work with aircraft as well.

12.0 Anticipated Engineering Expertise

Technical Area	How Applied / Indicate Team Member Responsible
Communications Uplink/downlink	Complete link budget.
Digital logic, power, electrical hardware	Choose processor, battery, and PCB layout.
Sensors	Choose sensors.
Signal processing/conditioning and measurements	Integrate sensors, logic, and power.
Release mechanism	Mechanical design.

Impact analysis	FEM analysis.
Aircraft modification	Draw and analyze aircraft aerodynamic modifications.
Dart freefall aerodynamics	Model freefall aerodynamics, design parachute.
Dart thermal analysis and heater	Design heater if needed, model the thermal balance.
Payload package and thermal analysis	Model the thermal balance of the aircraft modification, design heater if necessary.

13.0 Resources

13.1 Facilities

- The project shall make use of both the Aerospace and ITLL machine shops.
- The project shall have limited access to the Table Mountain radio quiet zone, with approval of the site director.
- The project shall need access to a composite manufacturing facility.
- The project shall have access to an electronics manufacturing facility.

13.2 Additional Advisors

Additional advisors will be added as the project matures and their expertise is needed. To date, the project advisory board and the customers are the only additional advisors involved.

13.3 Funds

The project shall have the $4000 provided by the Aerospace Engineering Department for the senior design project seminar. An additional $500 will be provided by the customer. Depending on project options chosen, the customer may be able to supply one R/C type aircraft for project use. Proposals are currently being written for Undergraduate Research Opportunities Fund (UROP) and Engineering Excellence Fund (EEF) grants.

14.0 Acknowledgements

14.1 Customer contacts

Dr. Jim Maslanik has provided the group with the customer requirements as well as two aircrafts that will be used for the project.

14.2 Faculty members

Dr Dennis Akos
Dr. Jim Maslanik
Dr. Jean Koster
Dr. Lakshmi Kantha
Dr. Donna Gerren
Dr. Hanspeter Schaub
Dr. Ryan Starkey

14.3 Graduate Students

Matt Edwards

14.4 Undergraduate Students

Undergraduate students will be utilized in the event that they are interested and the appropriate work has arisen.

14.5 Others

There are no additional recourses until project matures.