Unmanned Aerial Vehicle Mission Planning to Kangerlussuaq, Greenland

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Abstract - The Center for Remote Sensing of Ice Sheets (CReSIS) is developing an Uncrewed Aerial Vehicle (UAV) for application as a sensor platform in Polar Regions. Existing certification and flight regulations in Greenland do not adequately address the aircraft's larger size, nor have vehicles of this type been previously operated in the area. This paper will address some of the preliminary efforts undertaken to coordinate and fly the *Meridian* UAV in Greenland, beginning in 2008.

INTRODUCTION

The mission of CReSIS is to develop technologies; conduct field investigations; compile and analyze data to characterize ongoing rapid changes in polar ice sheets and to develop models that explain and predict ice-sheet interactions with climate and sea level. The Center was established in 2005 and immediately set about identifying areas in both Greenland and Antarctica as targets for their field programs.

In Greenland, the Jakobshavn Glacier stands out as one of the more significant fast-flowing glaciers, responsible for approximately 7% of the ice sheet's discharge into the oceans. Rapid changes in this glacier's speed over the past

five to ten years have intensified scientific interest across the polar research community. Many portions of the glacier of interest to scientists cannot be reached by sensor-carrying ground vehicles.

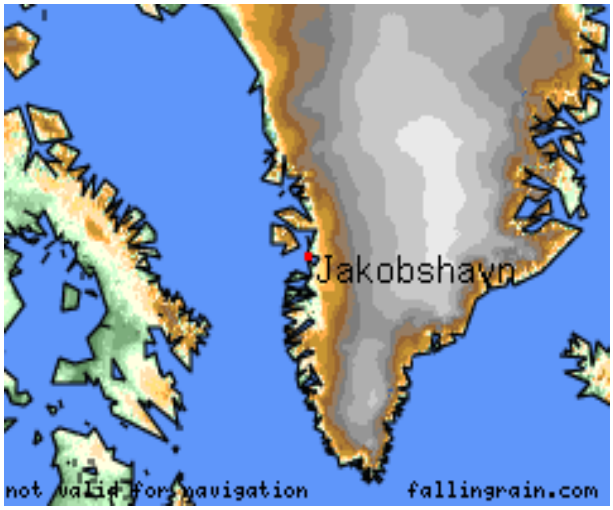


Figure 1. Jakobshavn Glacier

To address this need, CReSIS decided to begin development of an unmanned aerial vehicle (UAV) that could compliment existing polar research aircraft, but with less risk to pilots and smaller logistics support requirements. Engineers at the University of Kansas have recently completed a Detailed Design Review and began fabrication this summer.

Field plans call for deployment of *Meridian* to Greenland in late-spring 2008 for initial field trials and preliminary scientific missions. Coordination to allow this novel vehicle's employment has begun with regulatory agencies in both Greenland and Denmark.

AIRCRAFT DESCRIPTION

The *Meridian* UAV is the smallest turboprop-powered UAV in the world. The vehicle can be shipped in a standard 20' ISO container with wings disconnected. It is reassembled for flight with minimal tools. The vehicle is a single-engine autonomous aircraft with a range of approximately 1,750 kilometers. Takeoff and landing distances (with or without skis) are estimated at 1,500 feet. It is controlled by a fly-by-wire control system based around the Piccolo autopilot system produced by Cloud Cap Technologies.

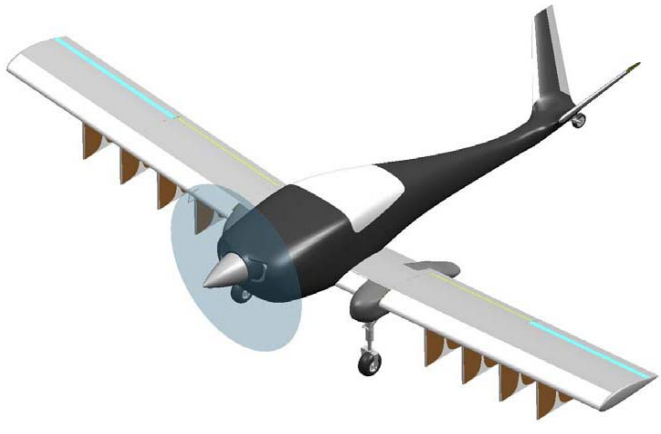
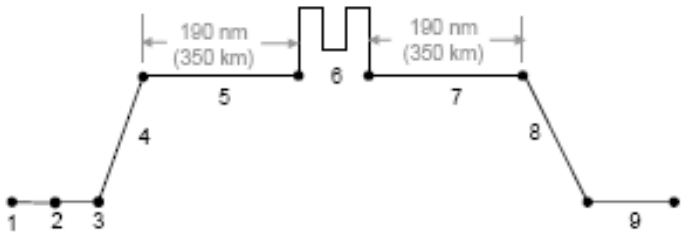


Figure 2. Meridian UAV Isometric

Key design characteristics and mission profile are outlined below in Tables 1 and 2.

Parameter	Value	Importance
Range	950 nm (~1750 km) w/ 1.5 hr Reserve	High
Endurance	> 9 hrs	Medium
Cruise Speed	100-120 kts (~180-220 km/hr)	Medium
Maximum Ceiling	15,000 ft (4,500 m)	Low
Rate of Climb	1,600 ft/min (490 m/min)	Low
Takeoff Distance	1,500 ft (~450 m)	High
Landing Distance	1,500 ft (~450 m)	High
Payload Volume	20" x 20" x 8" (~0.5 x 0.5 x 0.2 m)	High
Payload Weight	120 lbs (~55 kg)	High
Payload Integration	Wing Mounted Antennas	High
Payload Power	300 W	Medium
Stall Speed	58 kts (105 km/hr)	Medium
Stability and Control	FAR 23, where applicable	Low
Maneuvering Requirements	FAR 23, where applicable	Low
Aircraft Wingspan	Must fit in 20 ft Container	High
Aircraft Length	Must fit in 20 ft Container	High



1. Warmup
2. Taxi
3. Takeoff
4. Climb (No Range Credit)
5. Cruise Out (Optimum Alt. and Speed)
6. Data Acquisition (120 kts @ 5,000 ft AGL)
7. Cruise Return (Optimum Alt. and Speed)
8. Descent (No Range Credit)
9. Land/Taxi

Table 1. Design Mission Profile

Parameter	Units	Meridian
Geometry		
Wing		
Area	ft^2	69.6
Span	ft	26.4
Aspect Ratio	ft	10.0
Taper Ratio	~	1.0
Sweep (c/4)	deg	0
Airfoil	~	Clark Y
t/c	%	18
Dihedral	deg	5
V-Tail		
Area	ft^2	7.5
Span	ft	5.5
Aspect Ratio	ft	4
Taper Ratio	~	0.5
Sweep (c/4)	deg	26.3
Airfoil	~	NACA 0012
t/c	~	12
Dihedral	deg	50
Length Overall	ft	16.7
Height Overall	ft	6.6
Weights		
Takeoff Weight	lbs	1,085
Empty Weight	lbs	791
Payload Weight	lbs	165
Fuel Weight	lbs	119
Performance		
Range	nm	950
L/D_{Cr}	~	13.9
Powerplant		
Engine	~	TAE Centurion 2.0
Power	hp	135

Table 2. Meridian UAV Geometry and Weights Summary

A second vehicle under consideration as a risk-mitigation effort is the Yamaha RMAX. The RMAX is a model L15, unmanned helicopter with a Global Positioning System (GPS) and a communications modem. It has an endurance of approximately 1 hour and max speed of 60 miles per hour. The RMAX has a range of 25 miles and is obviously more suitable for short-range missions. It is far more payload constrained than *Meridian*. See appendix A for detailed RMAX aircraft information.

Figure 3. Yamaha RMAX Helicopter

AREAS OF OPERATION

The *Meridian* UAV is being developed for operation in both Greenland and Antarctica with more complicated mission planning associated with application in Greenland. The vehicle's first field deployment is scheduled for summer 2008. Operational basing is still under consideration, but LC-130 takeoff and landing capability plus cargo handling for the *Meridian*'s ISO container are driving potential locations.

Four bases that meet these two requirements have been identified:

- Kangerlussuaq Airport
- Summit Camp
- Thule Air Base
- Raven Camp (potential alternate)

Kangerlussuaq Airport- The Kangerlussuaq Airport is the largest airport in Greenland, with a runway length of 2810 x 60 meter runway. The approximate location of the asphalt paved runway is 67 01 01.09N 050 41 21.57W. The past operational purpose of the airport was to serve the United States Air Force. It undoubtedly has an adequate amount of runway space needed for operation of the Meridian UAV.

Summit Camp-The Summit camp is located at the peak of the Greenland ice cap. The Summit station is located atop 3200 meters of ice and is nearly 400km from the nearest point of land. The length of the runway is 200' x 15,000' and has latitude of 72-36-23.9N and a longitude of 38-23-18.1W.

Thule Air Base-The Thule Air Base is located on the northwest coast of Greenland (76° 32′ 0″N 68° 50′ 0″ W), 700 miles north of the Arctic Circle and approximately 946 miles from the North Pole. The closest town to the base is Qaanaaq, and it is 75 miles northwest of the base with a population of about 600. Summer temperatures range from 30 to 44 degrees and there is constant sunlight from May to August.

Raven Camp-The Raven Camp area has a runway that is 6000ft x 200ft. The runway's coordinates range from 66 30'00.7"N 4 18'28.9"W to 66 29'15.2"N 46 16'45.8W. The Raven Camp is only a few hundred meters southwest of the Kangerlussuaq airport. See Appendix B for detailed runway information.

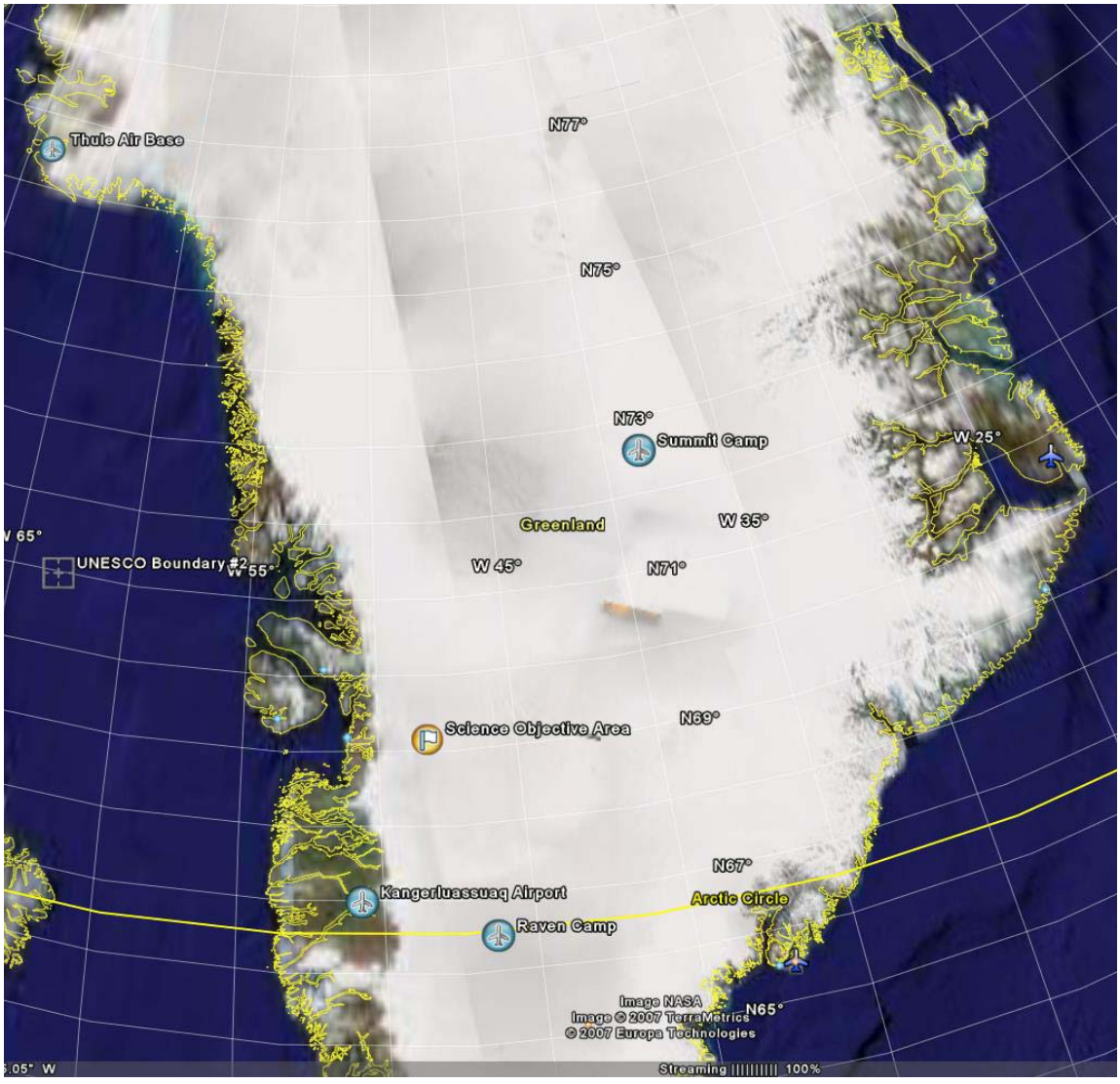


Figure 4. Potential Meridian Base Locations and Science Objective Area

Science Objective Area – Proposed field work for summer 2008 will occur in an area upstream of the Jakobshavn Glacier (69 10' 50" N, 48 11' 50" W). This site is approximately 262 kilometers to Kangerlussuaq and is reflected by the yellow flag in Figure 4 above. See Appendix C for detailed information on the Jakobshavn and its surrounding cities and population.

Among these 4 base areas Kangerlussuaq's airport provides the most reliable forms of UAV Maintenance, but its air operations are relatively heavy in trafficking in the mornings and around dinnertime. The airport provides tools, mechanics that are willing to assist CReSIS, and office space available. Summit Camp is a camp that most pilots try to avoid, because of its lack of maintenance support and its great distance from other maintenance supported areas. The researcher and pilot that land in this camp area must provide their own tools, maintenance, and other resources that may be needed. The runway is composed of snow and ice, it is over 300 kilometer away from the science mission, and the area doesn't appear to be populated. The Thule Air Base is a United States Air base that is more than 500 kilometers away from the science mission. The Raven Camp does not appear to be very far from the science area of study, but its runway is also composed of snow and ice, and it doesn't appear to contain a large population.

DIRECTED MISSION PLANNING TASKS

As part of the *Meridian* mission planning team, this effort was directed to researching the following issues:

- Study the Yamaha RMAX helicopter and capabilities
- Study the *Meridian* UAV and its capabilities
- Locate airports or camps to land and operate the Meridian
- Determine the geography and weather of potential operational bases

Yamaha RMAX Considerations – The RMAX aircraft has a short range, of 25 miles, and would have to operate inside the science area and not go farther than its range.

Meridian Considerations – The Meridian would have to be in an area where its 20' ISO container could be taken apart to construct it, enough runway space is available, and an area where autonomous vehicles may operate.

Geography and Weather at Potential Bases – Weather information for the potential bases are available in Appendix D.

CONCLUSION

Following the aerospace systems design phases: initial planning, conceptual design, preliminary design, detailed design, prototype construction, pre-production, and production are completed the mission to Jakoshavn, Greenland is fully prepared. The design phases used aid in the process of improving the structure of the Meridian based upon the weather, range, and effectiveness to accurately collect the data needed. The researcher's identification of the regulations enables the pilots and researcher of knowing where they pilot can and can't land the Meridian. The past challenges of the mission were resolved as a result, but further investigations can be done in the future to improve this mission.

Recommendations

Based upon what I've learned about the potential operational bases, I recommend that CReSIS operate out of Kangerlussuaq. The runway is not on ice, versus the other potential bases, and it is longer than needed. The mechanics are willing to aid in helping repair the vehicle and they provide tools. Currently there are no existing documents in Kangerlussuaq that express the requirements for operating UAVs heavier than 25 kilograms. CReSIS should take advantage of not having any vehicle requirements and work towards meeting the application information. This information includes:

- Operator of the UAV.
- Where – area. Eg. Bounded by coordinates (Restricted Area)
- Who will be operating the UAV.
- Purpose of the operations – science, sport etc.
- An FAA permit for the UAV.
- List of Equipment on board for ATC/ATS purposes. Transponder.
- Is it possible to track the flight VHF/SAT.

The help and support Kangerlussuaq offers exceeds that of the other potential operation bases and should be preceded for operation as soon as possible.

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