Design, Development and Operation of UAVs for Remote Sensing

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Why fly UAVs?

- Fly where human flight is "too dangerous"
- Fly at a reduced expense w.r.t. crewed flight
- Fly more stealthily than crewed flight

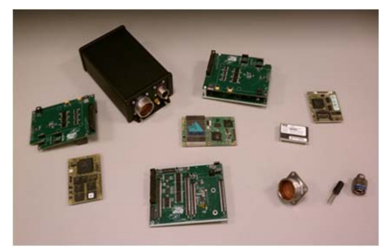
What can you do with UAVs?

- Remote sensing—military recon, crop/soil health, natural disaster damage, environmental change, spying (government, industry, individual)
- Airborne communications hub
- Delivery—weapons, fertilizers, fire suppressants, medical supplies, mail, NetFlix

KU UAS program: Core Competencies

- Mission-driven system development
  - Pick the right UAV for the mission
  - Design/Build custom airframe/avionics as needed
- UAV flight control
  - Upset-tolerant control algorithms
  - Obstacle/air traffic avoidance
    - Vision & Radar data integration
    - Cognitive algorithms for avoidance
  - Cooperative flight
- UAV Avionics development

Meridian UAV



Automated Flight System (AFS)

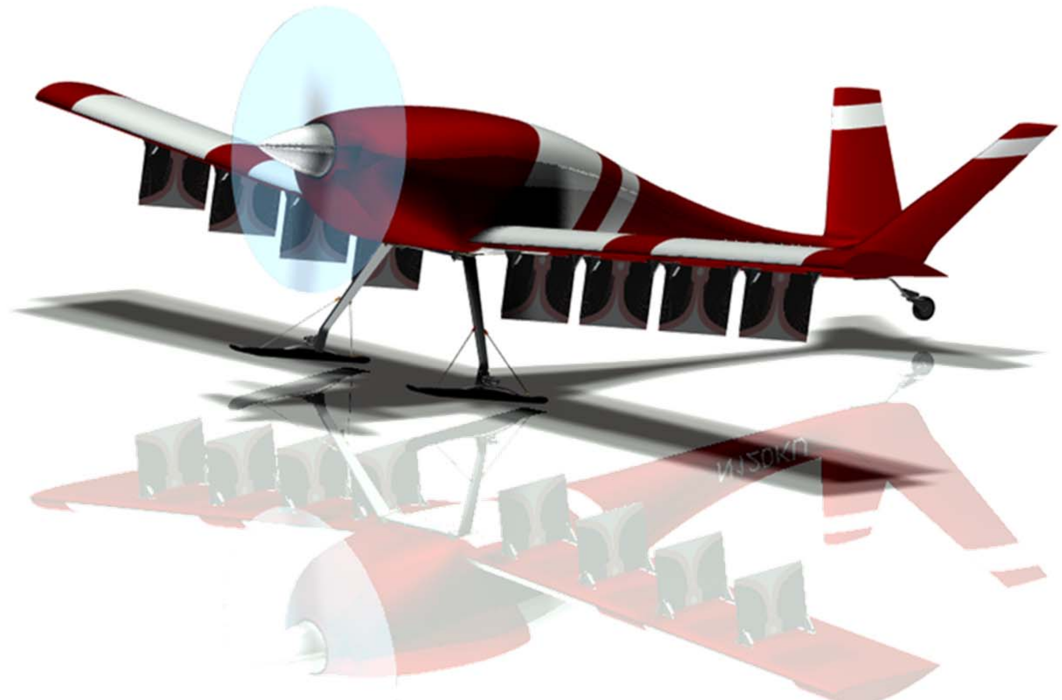
KU UAS Program: Facilities & UAVs

- Garrison Flight Research Center
  - 2500 sq ft fabrication space
  - Avionics development lab
  - Structural load frame
  - Mal Harned Propulsion Test Lab
  - ***AST 4000 fixed base simulator***
- Structural Composites Lab
  - Carbon fiber airframes
  - Glass fiber radar apertures
- RF Anechoic Chamber
  - Fits UAVs to 20-ft wingspan

- Meridian (NSF)
  - Unique design
  - Ice-sounding platform
  - Multiple arctic deployments
  - Custom ground station
- G1X
  - Modified kit UAV: extended wing
  - Ice-sounding radar
  - Dual-frequency radar
  - En route to Antarctica
- MSTs
  - Meridian surrogate trainers

Meridian UAS on final approach NEEM Camp, Greenland ice sheet

Meridian UAS Overview



weights		
	takeoff weight	1082 lb
	empty weight	753 lb
	payload weight	165 lb
	fuel weight	164 lb
performance		
	cruise speed	110 kts
	range	600 nm
	endurance	12 hrs
	L/D (cruise)	12.5
powerplant		
	engine	TAE Centurion 2.0
	power	160 hp

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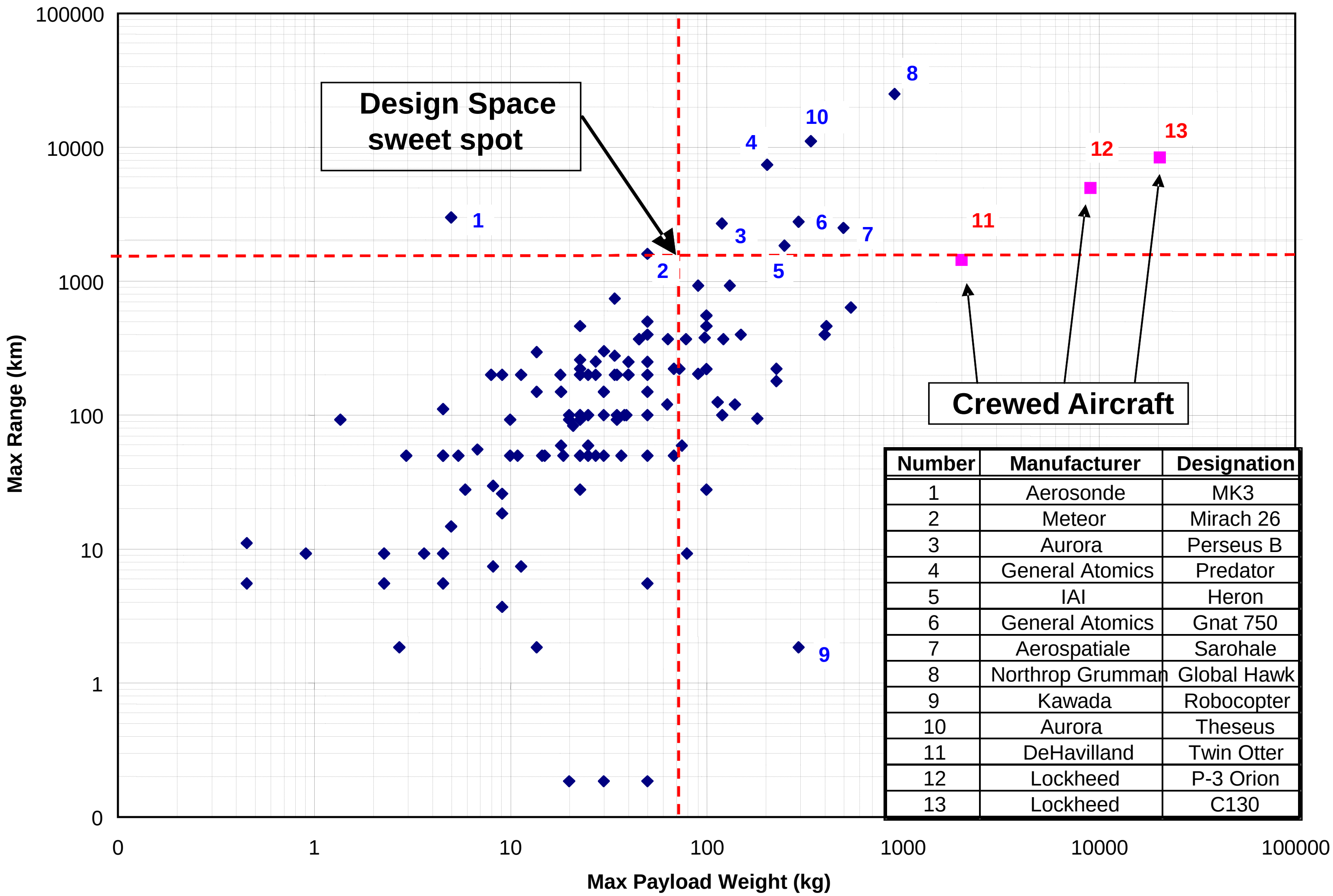
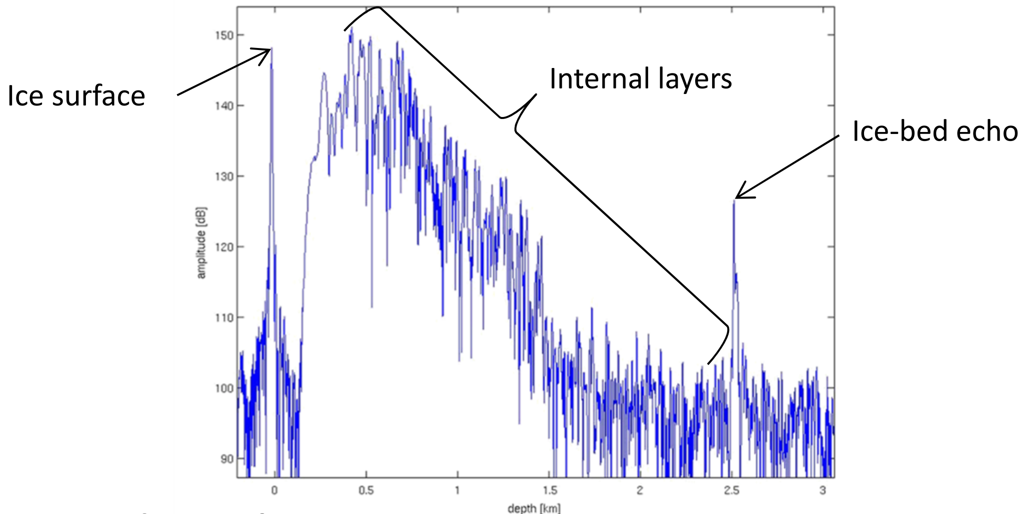
The desired, “mission-driven” spot in design space



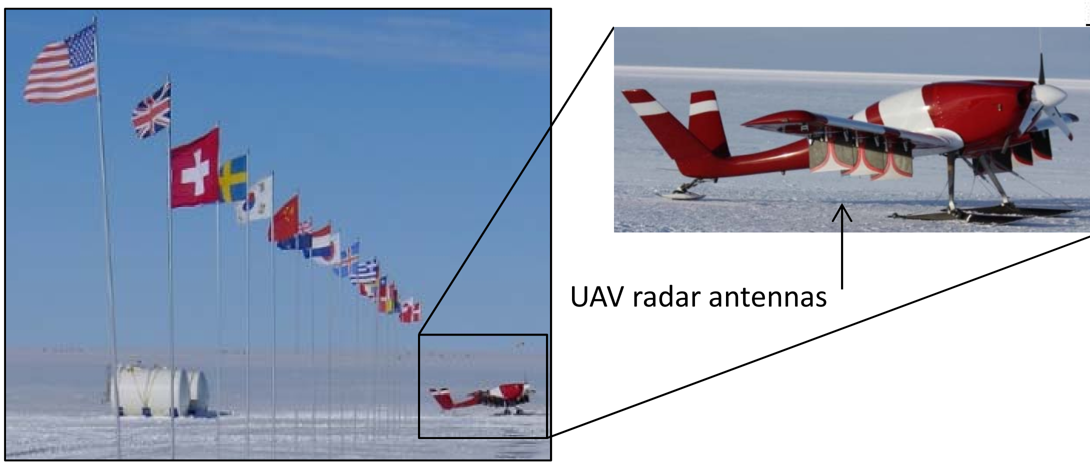
Number	Manufacturer	Designation
1	Aerosonde	MK3
2	Meteor	Mirach 26
3	Aurora	Perseus B
4	General Atomics	Predator
5	IAI	Heron
6	General Atomics	Gnat 750
7	Aerospatiale	Sarohale
8	Northrop Grumman	Global Hawk
9	Kawada	Robocopter
10	Aurora	Theseus
11	DeHavilland	Twin Otter
12	Lockheed	P-3 Orion
13	Lockheed	C130

Meridian UAV Ice-sounding: NEEM Drill Site, Greenland

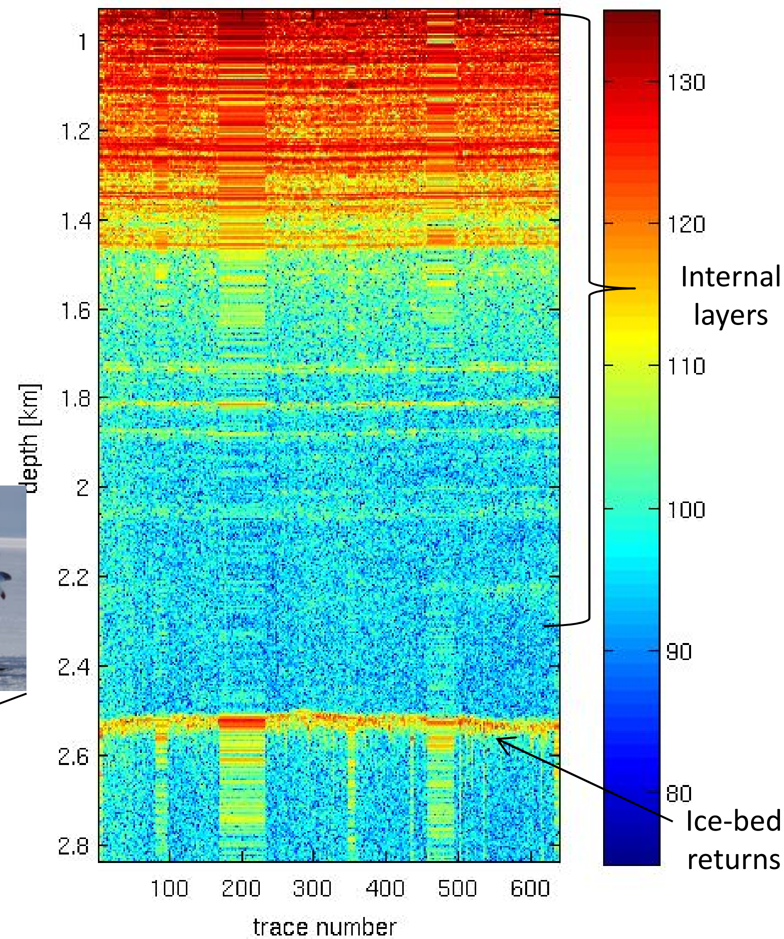
Radar Returns (time domain)



Meridian at the NEEM Camp



Echo-gram thru Greenland ice sheet: note the bedrock at ~2.5 km down



Meridian Ground Station and Health Monitoring System GUIs

Meridian Training System (33% scale YAK 54) on final approach at Pegasus Field, Antarctica

G1X UAS Overview

weights	
takeoff weight	85 lb
empty weight	65 lb
payload weight	10 lb
fuel weight	10 lb
performance	
cruise speed	70 kts
range	57 nm
endurance	1 hr
L/D (cruise)	13
powerplant	
engine	DA 100
power	9.8 hp

G1X during installation of 14MHZ and 35MHz sounding antennas in the Structural Composites Laboratory

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KU UAS Program: People

- Faculty
  - Shawn Keshmiri—control law development
  - Rick Hale—airframe & radar aperture design/build
  - Dongkyu Choi—artificial intelligence, situational awareness
  - Haiyang Chao—cooperative flight, vision systems
  - Chris Allen—radar for obstacle/traffic identification
  - Mark Ewing—avionics development

- Staff
  - Andy Pritchard—A&P mechanic
  - Wes Ellison—electronics technician, avionics development
  - George Blake—electronics technician, comm systems

KU UAS Program: Partners

- NSF/Center for Remote Sensing of Ice Sheets (CReSIS)
  - 10-year, $20M grant
  - Underwrote Meridian, G1X and AFS autopilot development
- NASA Langley
  - Aircraft/UAV aerodynamic upset conditions identification
- NASA Ames
  - UAV dynamics & control
  - Cooperative/formation flight
- DARPA
  - Cognitive algorithms for control
- Ft Riley
  - Access to Ft. Riley restricted airspace
- Kansas State University
  - Access to Smoky Hills restricted airspace

KU UAS Program: Current Priorities

- Making flight in the NAS safer
  - Non-linear control laws for low, slow UAVs
    - Upset-proof
    - Precision trajectories
  - See/sense/avoid technology
    - Integration of vision and radar data
    - Cognitive architectures to insure avoidance
  - Spin-off technology to GA community (workload reduction)
- Remote sensing…*in Kansas if airspace is cleared*
  - Precision flight line technology—spinoff from ice-sounding
  - Robust systems meeting emerging certification standards
  - Formation flight, creating synthetic apertures
- Re-purposing existing UASs to new partners/customers