NASA Multirole Atmospheric UAV

Introduction

The NASA Airborne Science Program (ASP) supports the Earth Science community by operating a wide range of aircraft. The type and flight envelopes of the vehicles in service with ASP varies drastically.

Currently 5 gaps in the capability of the ASP vehicles has been identified. Typically the gaps would be filled by 5 different aircraft as the requirements are so varied; however, Natilus believes that a single UAV platform can fill 4 of the 5 gaps currently identified by ASP.

ASP Capability Gaps

The current aircraft operating with ASP is shown below in Figure 1. The numbers indicate the different capability gaps that currently exist within the fleet.

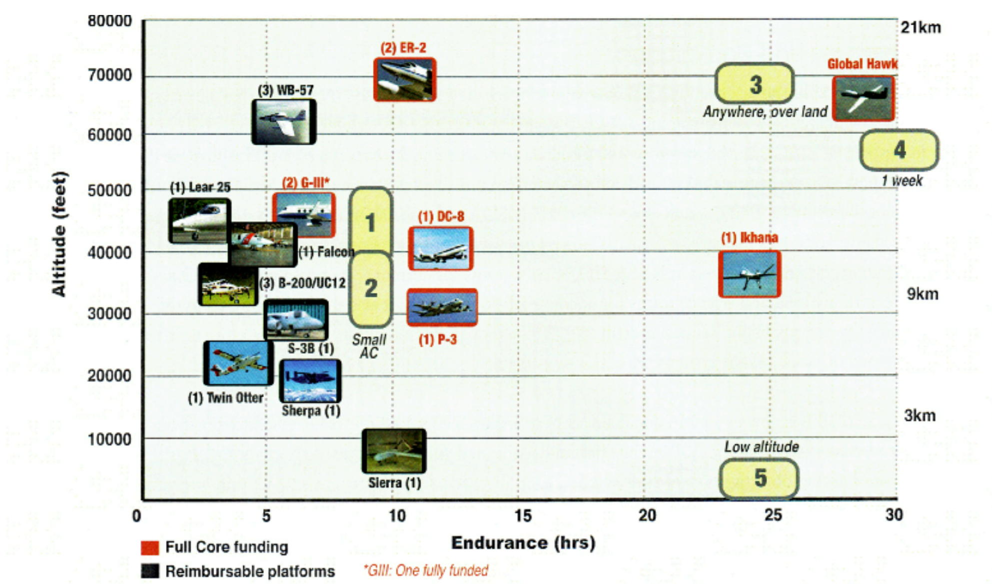

Figure 1: Summary of Aircraft Gaps as Identified by NASA Science Center Survey

	Gap	Performance Needed	Science Rationale
1	Flight altitude to 50kft, 8 hr duration, moderate payload	Similar to DC-8 Flight regime, including nadir ports, but something smaller and less expensive	Lidar systems for weather and terrain mapping but not full size laboratory
2	Flight altitude 25 to 35kft, 8 hr duration, small to moderate payload	Similar to King Air (B-200) but with longer duration	In situ sampling and ocean color both want 8 hrs, but flight characteristics and cost of B-200

	Gap	Performance Needed	Science Rationale
3	Very high altitude (65k+ft), long duration (24 hrs), fly anywhere	Similar flight regime as Global Hawk, ideally higher, not constrained to over ocean	Ability to see the evolution of atmospheric transport processes during a 24-hour period
4	Very long endurance (~week)	Above weather and traffic with ability to follow event	Ability to monitor or track fire or pollutant plume, storm development
5	Low altitude, long duration (or long range to target), where the target is remote or there are basing contraints	100-200 ft over water, stable flight; over land with autopilot	Radiation science over the ocean; carbon flux measurement; coral or ocean color imaging

Table 1: Explanation of Gaps Indicated in Figure 1

Vehicle Requirements

The gaps presented above have then been translated to vehicle requirements in Table 2 below.

Gap	Altitude Req (ft)	Endurance (hrs)	Speed Req (KTAS)	Payload Req (lbs)
1	0-50,000	8	459	2000
2	25-35,000	8	310	0-2000
3	65,000+	24	340	2000
4	60,000	168	~200	<500
5	100-200	8	~100	<500

Table 2: Derived Vehicle Requirements

Out of all the requirements, altitude and endurance drive vehicle design. Most fixed wing air vehicles right now can be designed with required altitude ranges and endurances up-to 24 hrs, however, endurance of greater than 1 week would require a complex and expensive vehicle; likely not a traditional fixed wing platform. As such, gap 4 requirements will not be considered for the design.

Along with the numerical vehicle requirements presented in Table 2, the following functional requirements were derived:

- Low cost of acquisition and operation
- Unpressurized to lower the cost of analysis needed for instrument integration
- Unmanned (lower cost of operation and higher endurance)
- Flight termination system which allows the asset to be savaged in the event of failure
- Low tail to prevent instrument interference

NATILUS

Proposed Miltirole Atmospheric UAV

Given the vehicle requirements above, the Natilus engineering team designed a high altitude UAV with capability to function cost-effectively both at low and medium altitude conditions as well. The UAV configuration is of traditional high aspect ratio fixed wing design, similar to that of the U2/ER-2.

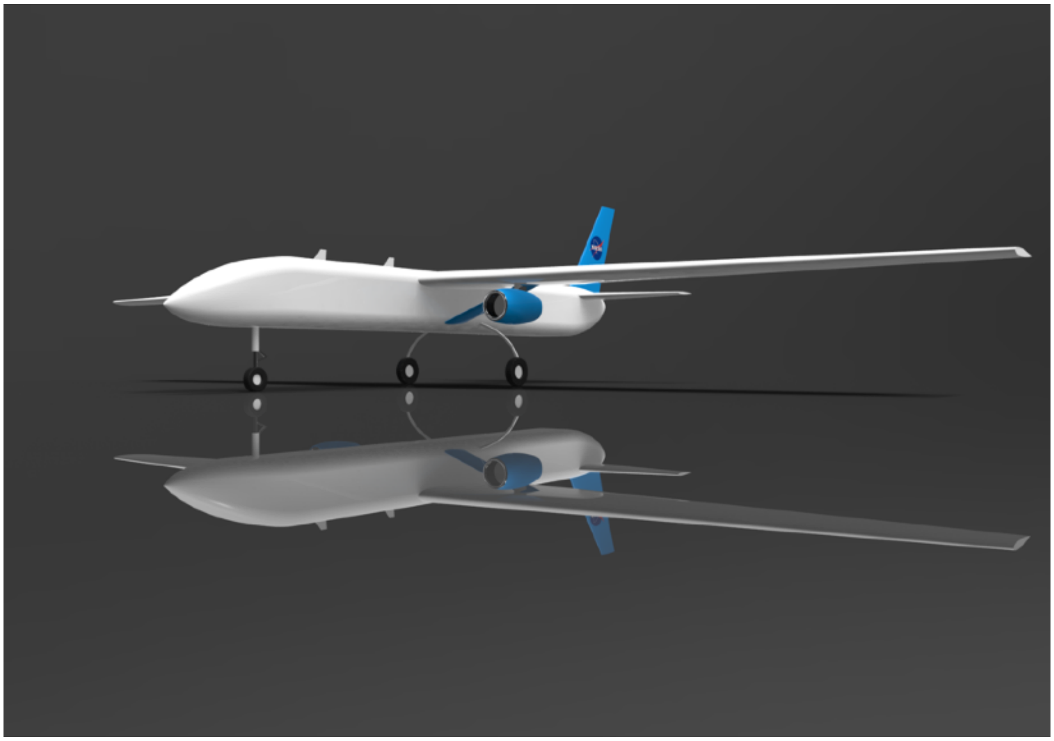

Figure 2: Multirole Atmospheric UAV

Max Gross Weight (MGW)	11,000 lbs	**Engine**	2x PW617F1-E
Max Empty Weight (MEW)	4400 lbs	**Thrust**	2x 1730 lbf
Fuel Weight	6600 lbs	**Fuel**	Jet A or Equivalent
Max Payload Weight	3000 lbs	**Service Ceiling**	80,000 ft
Wing Area	550 sq ft	**Endurance**	24 hrs @ 80,000 ft
Aspect Ratio	10		15 hrs @ 35,000 ft
Wing span	73 ft		8 hrs @ 0 ft
Length	45 ft	**Payload Volume**	480 cu ft
Ground Height	15 ft	**Range**	3000 NM
Autopilot	Natilus Proprietary	**Cruise Speed**	280 KTAS

Table 3: Multirole Atmospheric UAV Specification

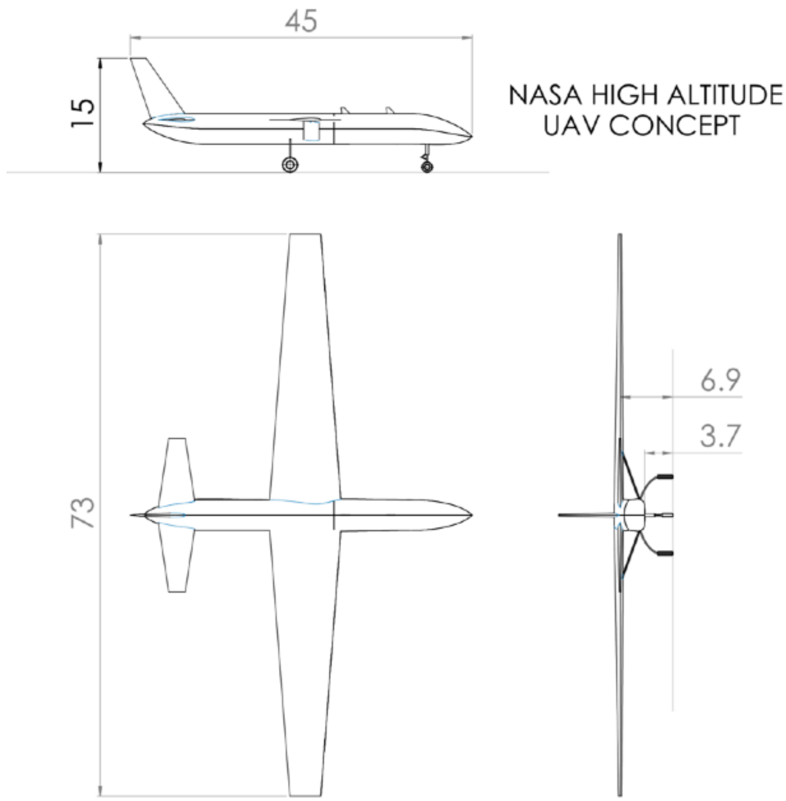

Figure 3: Multirole Atmospheric UAV 3-View (All dimensions in Feet)

To help reduce acquisition and operation cost, the vehicle is designed with simplicity in-mind while still providing and exceeding required functionality.

Structure and Assembly
The airplane is designed with an almost constant square fuselage which allows 70% of the fuselage to be built using one single tool using composites or with sheet metal. The horizontal tails use symmetric airfoils which allow the same tool to be used for both tails as well.

To help reduce complexity in the wing structure, wing braces extend to the fuselage, drastically reducing the loads that a typical cantilevered wing will need to be designed to handle.

The entire structure will be assembled using low temperature cure composites and low cost (out of autoclave) tooling. Most of the assembly techniques will mimic low production volume prototype techniques pioneered by military and the experimental aircraft circles.

Systems
To reduce the cost and complexity of the systems, off the shelf 'high-volume' production parts are used where possible:

- Actuators from industrial/manufacturing applications - not aerospace
- No hydraulic system
- Fixed landing gear
- Fuel system from automotive sector

Propulsion
The chosen Pratt and Whitney Canada (PWC) turbofan engine is a certified production engine meant for the Very Light Jet (VLJ) market. The specific chosen thrust class is already flying on the Embraer Phenom 100. Analysis has already been done and has shown that the engine has adequate thermal limits to be able to provide thrust up-to 80,000 ft.

Autopilot and Sensors
The proposed Natilus proprietary autopilot has been developed in-house over the last two years. It's architecture (both software and hardware) are designed with FAA certification in-mind.

The sensor integration into the autopilot is a combination of low cost components from the experimental General Aviation (GA) sector along with the ever-changing small hobby drone industry.

Command and Control
The vehicle is capable of operating through a Radio Control (RC) interface but primarily through an Intelsat communication link. The Natilus autopilot has been designed to reduce the amount of required personnel for operation - currently one operator is needed for an entire mission.

Flight Recovery
To allow for BVLOS operations and over populated areas, the UAV features a ballistic flight recovery system from the GA sector. In the event of a flight critical or Guidance/Navigation failure, both the autopilot and operator are capable of deploying the ballistic parachute which will lower the vehicle safety onto the ground with minimal damage.

Flight Instrument integration
To help ease science instrument integration into the airframe, two design features are present within the airframe:
- An almost constant square fuselage cross section, which 4 ft by 4 ft
- 4 panels will be completely removable on the top and bottom of the fuselage. The panel to fuselage interfaces allow for instruments to be integrated into the removable panels and therefore to the airframe via screw in operations; by-passing the need to cut out any skins as is currently common.

Ample 12 and 24V power will be available on-board the UAV for payload integration.

Typical Operating Cost

The following is the projected hourly cost of the UAV:
- Typical fuel burns at mid-altitude show hourly fuel costs of $570/hr
- Single operator cost per hour are expected to be $120/hr
- Insurance costs per hour estimate $50/hr
- Landing / navigation fees $80
- Engine and airframe maintenance per hour $200/hr

Total Direct Operating Cost (DOC) per hour = $1000/hr.

Vehicle Development and Acquisition Costs

Current estimates show that a vehicle could be built for 6MM and 1.5 yrs to a prototype first flight. The assumption is that the vehicle will not be certified and flight testing facilities/ approval provided by NASA.

Subsequent production vehicles are projected to cost 5MM.

Reference: "Update on NASA Airborne Science Program (ASP) Requirements", NASA 2015.