Technology Assessment of the Airworthiness of Unmanned Aerial Systems

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A Center of Excellence AMTAS Advanced Materials in Transport Aircraft Structures

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Motivation and Key Issues

- FAA traditional focus on flight safety extended to include national security
- Civil and commercial market for UASs inhibited by lack of access to the NAS
- Historically UAS's presented no conflict with manned aircraft
- UA community needs regulatory documents for operations in the NAS

Objectives

- Provide means of assessing airworthiness of operational UAS airframes relative to FAA certified manned aircraft
- Identify gaps that must be addressed prior to FAA certification

Approach

- Survey GA manufacturers to identify elements necessary for FAA certification
- Develop checklist of major steps in the certification process
- Probe UAS community to assess level of technology relative to GA community
- Analyze results of the assessment & establish level of UAS airworthiness
- Identify major gaps relative to FAA certification

FAA Sponsored Project Information

- Principal Investigators & Researchers
  - Walter Horn
  - Allison Crockett
- FAA Technical Monitor
  - Tong Vu
- Other FAA Personnel Involved
  - Xiaogong Lee
  - Curtis Davies

Initial Project Milestone Chart

1.	Literature review of FAA certification requirements	Nov. 1, 2006
2.	Identify specific segments of FAA regulations for initial focus	Nov.1, 2006
3.	Literature review of UAS products	Dec.1, 2006
4.	Identify contact points in general aviation companies	Dec. 1, 2006
5.	Create and distribute survey for GA airworthiness representatives	Feb. 1, 2007
6.	Analyze data of GA survey and draw conclusions	Mar. 1, 2007
7.	Create initial matrix of key certification steps	Mar. 1, 2007
8.	Identify contacts in key UAS companies	May 1, 2007
9.	Create survey for UAS company contact points	May 1, 2007
10.	Distribute survey to UAS contacts	May 1, 2007
11.	Analyze results of survey and create follow-up interview questions	Jun. 1, 2007
12.	Follow-up interviews with UAS company contact points	Aug. 1, 2007
13.	Analyze data and draw conclusions	Aug. 15, 2007
14.	Write final report	Aug. 15, 2007

Focus Category of UAS

- Compile information on all classes of UASs currently in production , but
- Concentrate on those UAS's that would likely fit, on the basis of mass and geometry, into the Part 23 category of aircraft.

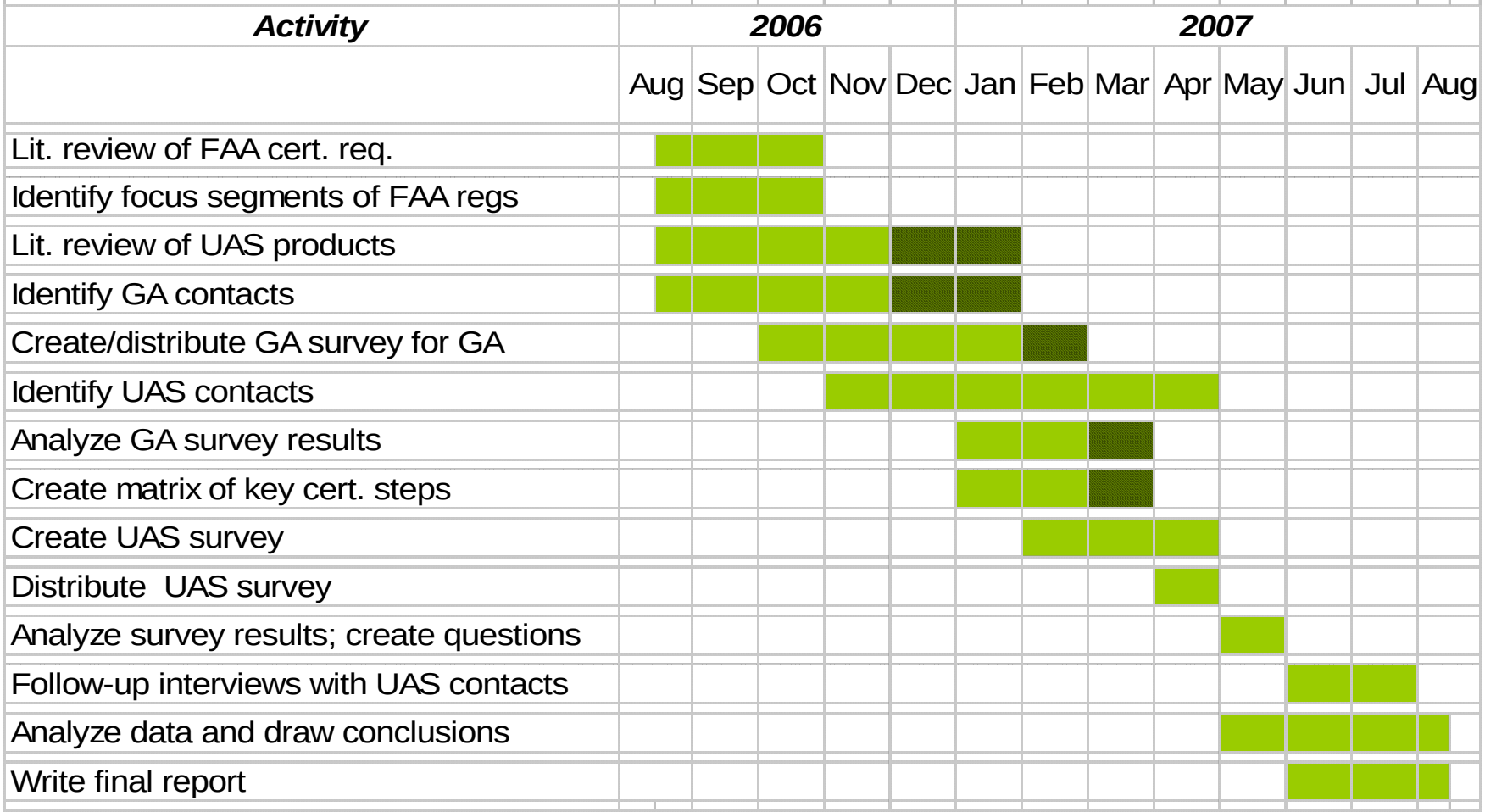
Focus Segment of Airworthiness Standards

Initial focus in the following sections of the CFR 14 Part 23 Airworthiness Standards:

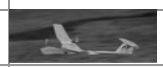
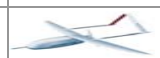
- Subpart C – Structures
  - 23.305 Strength and deformation
  - 23.307 Proof of Structure
  - 23.571 Metallic pressurized cabin structures
  - 23.572 Metallic wing, empennage, and associated structures
  - 23.573 Damage tolerance and fatigue evaluation of structure
- Subpart D – Design and Construction
  - 23.603 Materials and workmanship
  - 23.605 Fabrication methods
  - 23.613 Material strength properties and design values

Progress at Jan. 2007 Program Review Meeting

Schedule of Tasks for Technology Assessment of Airworthiness of UAS's



Small UAS – Under 50 lbs

Company	UAV Name	Photo	Avail.	Wt. (lbs) (w/o payload)	Payload wt. (lbs)	Length (ft)	Wing Span (ft)	Speed (knots)	Oper. Alt.(ft.)	Endurance	Mission/User
AV AeroVironment's	WASP Micro Air Vehicle			0.4	0.1	0.7	1.1	1.5	1,200	60 mins	Organic Squad level Reconnaissance & Surveillance, Light Infantry Millitary Operations on Urban Terrain
	SWIFT			6.1		3.0	3.8	2.6	100-500		Light Infantry Military, Dismounted Urban Warfare, Remote Recconnaissance and Surveillance, Force Protection and Convoy Security.
	PUMA			12.0		5.9	8.5	22.9	100-500		Extended Duration Surveillance, Light Infantry Millitary Operations on Urbanized Terrain, Dismounted Urban Warfare
	DRAGON EYE			4.5	1.0	2.4	3.8	19.0	1,000	40-60 mins	Over the Hill Reconnissance/Marine Corps
	Hornet			0.4	0.1	0.58	1.25				
	RAVEN RQ-11B			4.0	2.0	3.4	4.3	2.9	1,000	1.5 hrs	Over the Hill Reconnissance/ Army, Air Force, SOCOM
Rotomotion, LLC	SR100 VTOL SR20 Electric VTOL SR200 VTOL			18 10 50							
IAI Israel Aircraft Industries	Mosquito			1.1		1.0	1.1		300		
Lockheed Martin	FPASS			7.0	1.0	2.7	4.3		1,000	1 hr	Force Protection/Air Force
AV AeroVironment's	Pointer		No	10.0	2.0	6.0	9.0	2.3	3,000	1 hr	Special Operations /SOCOM/Air Force
Advanced Ceramics	Silver Fox			20.0	5.0	4.8	7.8		16,000	10 hrs	Special Operations/Navy
Insitu Group/BOEING	Scan Eagle			40	5-7	4	10		19,000	15 hrs	Force Protection/ USMC
Mission Technologies, Inc.	Buster			10	3	3.4	4.125		10,000	4+ hrs	
Aerosonde/ Lockheed Martin	Aerosonde		Yes	33	2.2	5.4	9.5	65-70	20,000	40 hrs	Navy
ARA	BATCAM			0.84	0.09	2	1.75		1,000	18 mins	SOCOM
Honeywell	MAV			15	5	1.25	1.1		10,500	40 mins	DARPA/Army

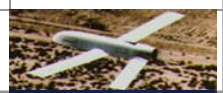
Medium UAS – Under 1,000 lbs.

Company	UAV Name	Photo	Avail.	Wt. (lbs) (w/o payload)	Payload wt. (lbs)	Length (ft)	Wing Span (ft)	Speed (knots)	Oper. Alt.(ft.)	Endur. (hrs)	Mission/User
Freewing Aerial Robotics LLC	SCORPION 60-25			75		6.8	12.2		5,000		
	SCORPION (1997 Joint & Maritime			253		11.8	16.1	150	15,000		
	SCORPION Model 100			319		11.8	16.1	120	15,000		
IAI Israel Aircraft Industries	SEARCHER Mk II			961		19.2	28		33,000		
	Ranger			617		15.1	18.7		18,000		
AAI Corporation	Shadow 200		Yes	215	50	9	12.75	150/84	15,000	4	
IAI Israel Aircraft Industries	Shadow (RQ-7A)			327	60	11.2	12.8	110/70	14,000	5	Brigade Level Recce/Army
	Shadow (RQ-7B)			375	60	11.2	14	105/60	15,000	7	Brigade Level Recce/Army
Pioneer UAV, Inc.	Pioneer (RQ-2B)		Yes	452	75	14	17	110/65	15,000	5	Surveillance Recce/Marine Corps
Dragonfly Pictures	DP-5X			475	75	11	10.5	100	10,000	5.5	Tacticcal Reconnaissance Surveillance and Target Acquisition/DARPA
DRS Unmanned Technologies	Neptune			80	20	6	7	84/60	8,000	4	Navy
BAI Aerosystems	XPV-1 Tern			130	25	9	11.4	87/50	10,000	2	SOCOM
NAVMAR Applied Sciences Corporation/BAI Aerosystems	XPV-2 Mako			130	30	9.11	12.8	75/50	10,000	8.5	SOCOM
	Finder/NRL/ACTD			59	13.5	5.25	8.6		15,000	10	
	LEWKS/SAIC/ACTD			800	200	10	15		15,000	8	
BAI Aerosystems, Inc.	Exdrone		Yes	89	25	5.3	8.2	115mph	10,000	2.5	

Large UAS – Operating Below 40,000 ft.

Company	UAV Name	Photo	Avail.	Wt. (lbs) (w/o payload)	Payload wt. (lbs)	Length (ft)	Wing Span (ft)	Speed (knots)	Oper. Alt.(ft.)	Endur. (hrs)	Mission/User
Northrop Grumman	Hunter (RQ-5A)			1620	200	22.6	29.2	106/89	15,000 ft	11.6	Division/Corps Level Recce/Army
Northrop Grumman	Hunter (MQ-5B)			1800	200	23	34.25	106/89	18,000 ft	18	Division/Corps Level Recce/Army
IAI Israel Aircraft Industries	Heron			2755		27.9	54.5		30,000 ft		
Exide Technologies Industrial Energy	IGNAT-ER Long Endurance			2259		28.5	57.7	108	30,511 ft		
General Atomics Aeronautical Systems	I-GNAT-ER			2300	450	27	49	120/70	25,000 ft	30	Division/Corps Level Recce/Army
General Atomics Aeronautical Systems	I-GNAT 750		Yes	1142	140	17.4	35.3	161/53	25,000 ft	48	
General Atomics Aeronautical Systems	PREDATOR A (RQ/MQ-1)		Yes	2250	Internal 450 lb, Wings 100 lb ea	28.7	49	118/70	25,000 ft	24	Armed Reconnaissance/Air Force
Northrop Grumman	Fire Scout (RQ-8B)			3150	600	22.9	27.5	125	20,000 ft	6 +	Support Littoral Combat Ship Class of Surface Vessels/ Army and Navy
BOEING	X-50 Dragonfly Canard Rotor/Wing			1485	none	17.7	12	220	20,000 ft	0.5	DARPA
BOEING/Frontier	A-160 Hummingbird			4300	300 + lb	35	36	140	28,000 ft	18	DARPA/Army/Navy
Lockheed Martin	Cormorant			9000	1000	19	16	0.8M	35,000 ft	3	DARPA
Bell Textron	Eagel Eye		No	2850	200-300	17	15.2	210/97	20,000 ft	5.5	Coast Guard
BOEING/ Frontier/ Robinson	Maverick			1370	400	28.8	25.2	118	10,800 ft	7	DARPA/Army/Navy
MMIST, Inc.	CQ-10A SnowGoose			1400	575	9.5	6.8	33	>18,000 ft	Up to 19 , 9-11 w/ 200 lb payload	USSOCOM, Army
General Atomics Aeronautical Systems	Altus2		Yes	2,150	330	23.6	55.3	70-80	65,000	24	

Extra Large USAs

Company	UAV Name	Photo	Avail.	Wt. (lbs) (w/o payload)	Payload wt. (lbs)	Length (ft)	Wing Span (ft)	Speed (knots)	Oper. Alt.(ft.)	Endur. (hrs)	Mission/User
BOEING	X-45C (L)			36,500	4,500	39	49	460	40,000	7	Air Force and Navy
	Manned/Unmanned Light Helicopter										
NORTHROP GRUMMAN	Global Hawk (RQ-4A)		Yes	26,700	1950	44.4	116.2	350/340	65,000	32	Persistent High Altitude Surveillance & Reconnaissance
	Global Hawk (RQ-4B)		Yes	32,250	3000	47	130.9	340/310	60,000	28	Persistent High Altitude Surveillance & Reconnaissance
	Fire Scout										
	Hunter										
	Killerbee										
	X-47B UCAS			46,000	4,500	38	62	460	40,000	9	Air Force and Navy
General Atomics Aeronautical Systems	ALTUS I					22	55		45,000		Ideal for Communications relay, cellular relay and commercial applications
	ALTUS II					22	55		65,000		Ideal for Communications relay, cellular relay and commercial applications
	PROWLER II		No	200	50	13.9	24	172/63	21,000	6	
	MARINER					36	86	240	52,000		Long-Endurance Navy and Homeland Security Applications
	PREDATOR B (MQ-9A)			10,500	750	36	66	220	50,000	30	Multi-Mission ISR/ Air Force
	ALTAIR					36	86	220	52,000		High-Altitude Scientific Research
	WARRIOR					36	48.7				

Information Sought With Original General Aviation Survey

- Identify company's last aircraft to receive FAA certification.
- Relative to that particular aircraft, provide the following information regarding company's process to demonstrate compliance with each of the focus sections of Part 23 regulations:
  - Identify major elements of procedure to demonstrate compliance (analytical validation procedures, test validation procedures, material selection and quality control procedures, manufacture quality and control procedures, system quality and reliability procedures, and other compliance procedures)
  - Identify major equipment necessary for compliance
  - Identify size and quality of workforce necessary for compliance
  - Estimate man-hours devoted to certification process

Mid-term Course Correction

- Felt that the general aviation community would not respond to the survey sufficiently
- Approach the GA community in a manner that would lead to the greatest amount of useful information.
- Two major elements of course corrections:
  - Modify the GA survey to concentrate on retrieving information relative to accommodation of new technology in the certification process - determine their approach for a certification situation where they use new technologies for airframe certification
  - Create a survey for the UA manufacturers that is independent of the GA survey. The major question to be addressed: "what technologies and procedures do you have in-place to establish your design goals, to verify your design, and to assure your customers of the structural integrity of your vehicle?"

Key Elements of Approach After Course Correction

1. Modified GA survey to retrieve information on how new technologies are incorporated in the airframe certification process.
2. Renew efforts to develop a thorough understanding of FAA regulations regarding airframe structures.
3. Explore avenues that might provide information that would lead to an understanding of existing UAS airframe technologies.
4. Use the results of steps 2 and 3 above to determine any gaps between current FAA regulations and the UAS airframe technologies.
5. Prepare the survey to be administered to the UAS manufacturers based on the outcomes of steps 2 and 3 above, with an emphasis on how to address the gaps identified in step 4 above.

Materials Submitted for April 4, 2007 Program Review

- Draft of the Revised General Aviation Survey
- Table of existing UAS systems with a summary of key details
- Table of US Airframe manufacturers segregated into type of flight vehicle manufactured
- Table of subsections of Airframe Structure and Material Sections of Volume 14 of the Code of Federal Regulations, Part 23 with initial judgment concerning the appropriateness of the subsection for UAS systems
- Listing of FAA Advisory Circulars that have been identified for examination to augment the regulatory materials of Volume 14 of the Code of Federal Regulations Part 23.

US UAS Manufacturers

- AAI Corporation
- Accurate Automation Corporation
- Advanced Ceramics Research
- AeroCopter
- Aerosonde/ Lockheed Martin
- AeroVironment
- ARA
- Arcturus UAV
- Atair Aerospace
- Aurora Flight Sciences
- AV AeroVironment's
- BAE Systems
- BAI Aerosystems, Inc.
- Bell Textron
- Boeing Company
- Boeing/Frontier
- Carolina Unmanned Vehicles
- Composite Engineering
- Cyber Defense Systems Inc.
- Dara Aviation
- Dragonfly Pictures
- DRS Unmanned Technologies
- D-Star(AurAayan Aerospace)
- Exide Technologies Industrial Energy
- Freewing Aerial Robotics LLC
- Freewing Flight Technologies
- Freewing Unmanned Systems LLC (U.S.A.)
- General Atomics Aeronautical Systems
- Geneva Aerospace
- GeoData Systems
- Honeywell
- Insitu Group
- IntelliTech Microsystems
- Iron Bay
- Kaman Aerospace Corporation
- Kaman Aviation
- L-3 BAI Aerosystems
- Lew - Aerospace
- Lockheed Martin
- Mission Technologies, Inc.
- MLB
- MMIST, Inc.
- NAVMAR Applied Sciences Corp/BAI Aerosystems
- Neural Robotics Inc. (NRI)
- Northrop Grumman Integrated Systems
- NRL
- Pioneer UAV Inc. (PUI)
- Proxy Aviation System
- Pusher Development (Prescott)
- Raytheon
- RotoMotion, LLC
- SAIC/ American Sportcopter
- Schweizer Aircraft Corporation (Sikorsky)
- Tactical Aerospace Groiup (TAG
- Teledyne Brown Engineering
- Theiss Aviation
- Thorpe SeeOp
- Trek Aerospace, Inc.
- VeraTech Aero
- Victory Systems

May 31, 2007, Course Correction

- Meeting with Project Monitor, Tong Vu to discuss plans for remaining period of the project
- Agreement that GA community will have no incentive to respond to the survey; thus will probably half-heartedly repond, or fail to respond altogether
- Try a new approach to surveying the UAS community, that does not depend on the results of the GA survey
- This approach requires our distilling the requirements of Part 23 to a much smaller set of distinct requirements that we can use to examine the airframe airworthiness capability of the UAS manufacturing community.

New Direction of Project

- Distill Subparts C and D of the CFR 14 Part 23 to a set of key requirements
- Contact UAS contacts to get information on their compliance with the key requirements of Sub-Parts C and D
- Construct a matrix to summarize the results
- Procedure should include a mechanism to identify miscellaneous issues that fall outside the set of key requirements of the regulations
- Try to compare the technology issues of DoD aircraft specifications with corresponding FAA regulations

Table Summarizing Level of Compliance with Key Requirements of Regulations

Point Company	1	2	3	4	5	6	7	8	9	10	11	12
A	✓	✓	✓	10%	✓	80%	80%		✓	✓	✓	✓
B	✓	✓	✓	✓	✓	✓	✓	✓			10%	
C	✓	✓	✓	✓	✓	✓	✓	✓	20%			
D	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
E	✓	✓	✓	✓	✓	✓	✓	✓	80%	✓	✓	✓
F	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
G	✓	✓	✓	✓	✓	✓	✓	✓	20%	✓	✓	✓
H	10%	✓	✓	✓	✓		10%	✓	✓	✓	80%	
I	70%	80%		✓	✓	✓	✓	✓	✓			20%
J	20%	✓	✓	✓	✓		20%	✓	✓	✓	80%	
Total	80%	98%	90%	91%	100%	78%	81%	90%	52%	70%	675	52%

A Look Forward – Benefit of Current Research to Aviation

Benefit to Aviation

- Results of this study will provide a necessary initial step towards the creation of regulations to assure the airworthiness of UAS airframes.
- These regulations will provide the foundation for UASs to operate in the NAS in a manner similar to that for manned vehicles.
- Ready access to the NAS will invigorate the civil and commercial UAS market, prompt investment in UAS commercialization, and allow users to obtain cost-effective UAS services.

A Look Forward – Future Need

Future need

Thorough examination of Part 23 (Subpart C - Structures and Subpart D - Design and Construction) to determine specific subsections that are relevant to the airworthiness of both manned aircraft and unmanned aircraft systems, subsections that are not relevant to UAS airworthiness, and create additional subsections of the regulations that are necessary for unmanned aircraft, but are not germane for manned aircraft.