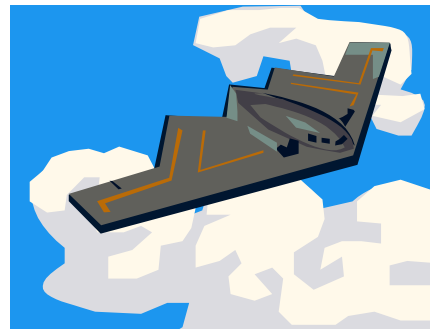
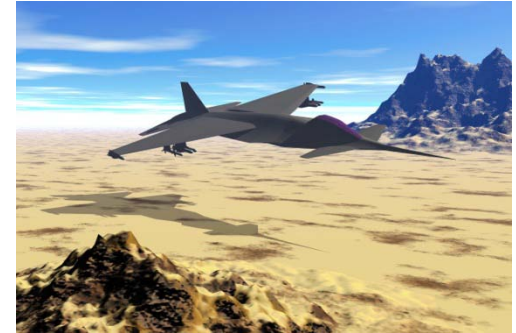

The Road Ahead for Unmanned Air Vehicles

INCOSE San Diego Mini-Conference, 30 October 2010

Mark Halverson

Presentation Contents

- Disclaimer
- Brief History of UAVs
- What is Going On Today?
- Future Opportunities and Future Roadblocks
- What is Being Done About It?
- Conclusions
- Questions?



Disclaimer

- I am ***not*** representing any company or organization.
- This presentation represents strictly my own opinions.
- This presentation contains no proprietary or classified information.

A Brief History of UAVs

- First, I want to narrow the discussion down to larger UAVs.
 - *Gross weight greater than 250 lbs.*
 - *Range greater than 50 miles*
 - *Autonomous capabilities; Responds to external stimuli*
- As soon as there were radios and aircraft, there were “unmanned aerial vehicles”. But these did not become “significant” and do useful things until technology advanced:
 - *Improved propulsion*
 - *Improved navigation*
 - *Improved communication (data links)*
 - *Computers that could manage the vehicle, be programmed to achieve some goal, and respond appropriately to external stimuli (first they were analog, and then digital)*

A Brief History of UAVs (cont.)

- In the 1950's, work started on air-to-air missiles.
 - *Quite primitive and short-ranged at first*
 - *Analog seekers and analog guidance computers*
- In the 1960's the air-to-air missiles improved, and the first “smart bombs” came into use
 - *Kill probability of the air-to-air missiles was miserable; needed adaptive intelligence to succeed.....didn't improve until the 1970's*
 - *In the Korean and Vietnam Wars, the military had great difficulty knocking out bridges and trestles*
 - *AGM-12 Bullpup (manually guided), and the AGM-62 Walleye (automatic TV guidance); both gravity bombs, no engine*
- In the 1960's/1970's various target drones were used as decoys and reconnaissance assets; primitive guidance and generally did not respond to stimuli; navigation problems

A Brief History of UAVs (cont.)

- In the 1970's the AGM-65 Maverick arrived, now in multiple types (TV, infrared, and laser guidance systems); high-speed powered flight.....modern versions in use today
- None of the above had the range, payload capability, navigation accuracy, or on-board intelligence to be taken all too seriously. But then in the 1970's a quiet revolution started with the development of the BGM-109, Tomahawk.
 - *Fired from a sub, then later aircraft and ground launchers*
 - *Range of about 1500 miles; autonomous (no need for a pilot)*
 - *Payload of a W80, or 1000 lbs conventional*
 - *There was a small company in Walled Lake, Michigan.....*
 - *Extremely accurate INS with TERCOM, later with GPS and/or scene matching*
 - *Digital computers for vehicle management and mission management*

A Brief History of UAVs (cont.)

- In the 1980's multiple intelligent unmanned vehicles went into development. By then we had the technology to do really cool stuff.
- But then we hit **the first roadblock**.
 - *Most Air Force and Navy brass were pilots; these were the “Right Stuff” guys. They gave strong push-back to the idea of unmanned aircraft*
 - *We could call them target drones or weapons, but when it came to “unmanned aircraft” their interest cooled rapidly*
 - *Even Ronald Reagan’s “Star Wars” push helped only slightly*
- Then in the 1990's, the value of unmanned vehicles could no longer be denied. Nevertheless, development programs were slow in coming about. Innovative companies pushed their own initiatives (almost in spite of the military).

A Brief History of UAVs (cont.)

- Today, the use of unmanned aerial vehicles is widespread and has captured the public's imagination
- But now further progress is being held up by **two additional roadblocks**. These create the following problems.
 - *To reduce costs and development time, production aircraft in quantity must be produced*
 - *To reduce costs and schedules for airworthiness certification, type certificates are needed for UAVs*
 - *To make operations quicker and more efficient, we need a “file-and-fly” system for UAV operations*
 - *For practical military operations, the UAVs must be able to fly in the National Airspace (NAS), and in the airspace belonging to foreign countries*
 - *Today, none of this is possible due to the **two roadblocks**.....*

What is Going On Today with UAVs?

- Most of today's UAVs have designs that trace back to weapon systems, or are built on weapon systems concepts.
 - *Single or dual architectures for navigation and flight control*
 - *If 998 from 1000 don't crash or get lost, that's great! (2×10^{-3} crash rate)*
 - *Informal software development processes (garage shop SW)*
 - *Lack artificial intelligence to react to contingencies*
 - *Some even lack the autonomy to take-off and land by themselves*
- For the larger UAVs, regular operations require flight in public airspace, over populated areas, and over foreign countries.
 - *For some, that's the **only** way to get them into theater*
 - *Currently, all UAVs are flying (1) under highly restricted experimental certificates, (2) only in totally in restricted airspace, (3) with one-time Certificates of Waiver or Authorization (COAs, for public entities only), or (4) with diplomatic clearance.*

What is Going On Today with UAVs (cont)?

- Today's UAVs are flying further, carrying more, and doing more
 - *Intercontinental range; pilot in Nevada but operating over Iraq*
 - *Carrying and launching weapons (Predator, UCAS X47-B, others)*
 - *More sophisticated surveillance, reconnaissance, ELINT sensors*
- Now there is no doubt. The government and military will not be able to do without UAVs
 - *Manned aircraft and their operations are too expensive*
 - *Some missions are too dangerous, or too tiring, for human pilots on board*
 - *Some missions require a precision and diligence over time that humans can not perform reliably*

What is Going On Today with UAVs (cont.)?

- In an attempt to mitigate some of the airworthiness problems, some are “De-manning” today’s Manned Aircraft
 - *Replace co-pilots of FedEx cargo aircraft with computers and “ground pilots”.*
 - *Replace co-pilots of long-haul trans-Pacific passenger flights*
 - *“Unmanned technology is more reliable and more precise than human pilots.” The human pilot is there in case of emergencies; otherwise, he had better not touch anything!*
- **“Unmanning” of Today’s Manned Aircraft**

What is Going On Today with UAVs (cont.)?

- **Fire-X today.**



Future Opportunities and Roadblocks

- **Everyone seems to agree, the opportunities for UAVs in the future are unlimited!**

- **But, there are two major roadblocks:**
 1. *There is currently no regulatory basis for obtaining a type certificate for a UAV.*
 2. *No current UAV design architecture meets the FAA's standards for airworthiness (depending upon the situation, probability of catastrophic event less than 1×10^{-7} to 1×10^{-9} per flight hour). Also, no solution for "sense and avoid".*
 - People on the ground haven't raised their voices yet, but other pilots are becoming concerned!

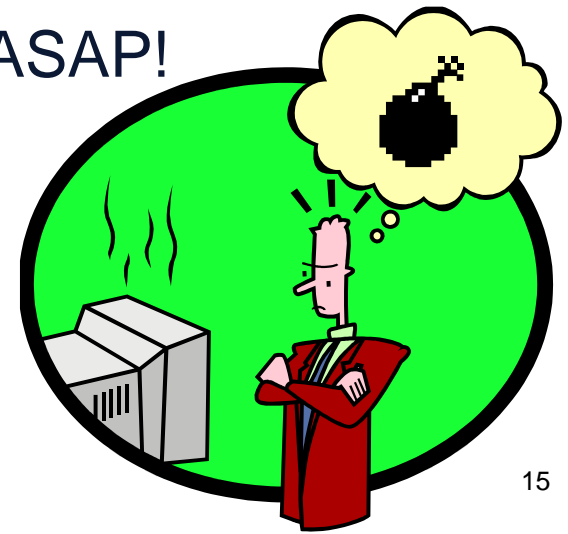
It's Not that the Concept of UAVs is Flawed.....

- It's just that (*unbelievably*) no one saw this airworthiness thing coming.
- But now, here we are.....



The Way Forward.....

- The UAV developers will have to start working to FAA recognized standards; civil certifications will be necessary
 - *Must have mutual recognition on the international level*
 - *RTCA/DO-178B for software*
 - *RTCA/DO-254 for complex hardware*
 - *14 CFR Parts 25/29 (the FARs) for technical airworthiness*
 - *ARP 4761 and ARP 4754 for system safety*
- Develop a regulatory basis for UAVs.....ASAP!



What is Being Done About It?

- *An industry, military, and government partnership is working together in the RTCA working group: SC203*
 - *Defining use-cases and requirements for UAVs*
 - *Defining how air traffic controllers interact with UAVs*
 - *Defining requirements and evaluating technologies for “Sense and Avoid”, the UAV’s equivalent of “See and Avoid”*
 - *Formulating government regulations to be used for certifying the airworthiness of UAVs*
- **Also working with various foreign countries to build a consensus for mutual recognition of UAV airworthiness regulations**
 - *Now, are you ready for the kicker?*

What is Being Done About It (cont.)?

- *The FAA and RTCA do not expect a workable set of UAV regulations until 2020 at the soonest!*
- *Most people believe that this will require a proven “Sense and Avoid” technology, that today does not exist yet*
- *Until that time, no type certificate for a UAV will be possible*
- *Flight over populated areas will not be possible, and routine “file-and-fly” operations will be only a dream*

Conclusions

- The public will not accept UAVs designed to weapon system standards flying overhead. Neither will pilots sharing the same airspace. Proper FAA certification will be required.

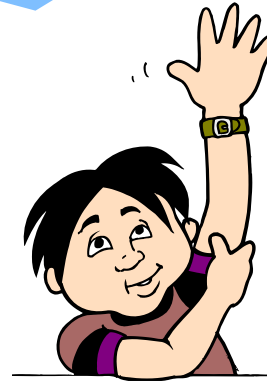
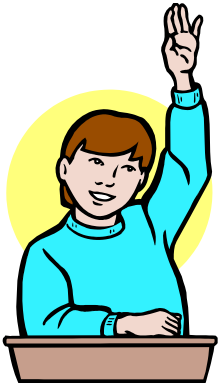
The FAA is tasked with protecting public safety. They take this job seriously, and they are quite good at it. However, this involves a large bureaucracy and a complicated public process.



Conclusions (cont.)

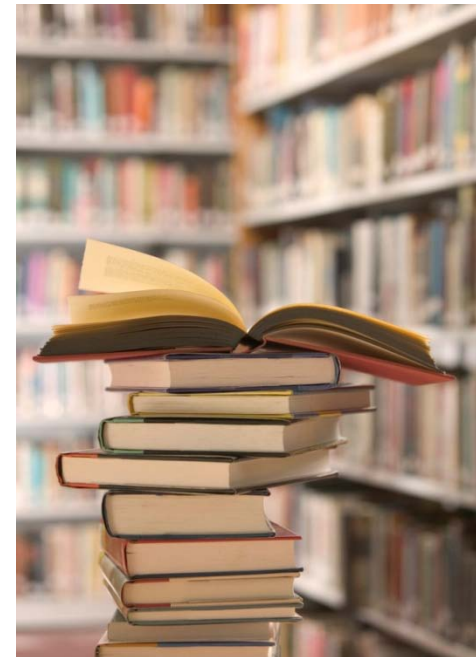
- The UAV developers will have to “up their game”, and start building and certifying the unmanned aircraft in a manner analogous to manned aircraft: ***FAA civil airworthiness certification.***
 - *The public and the pilots of the manned aircraft out there will accept no less.*
 - *International mutual recognition of UAV regulations will be necessary in order to support unrestricted flying (as today with manned aircraft)*
- Even in the best-case scenarios, all of this will not happen until 2020 at the earliest

Questions?



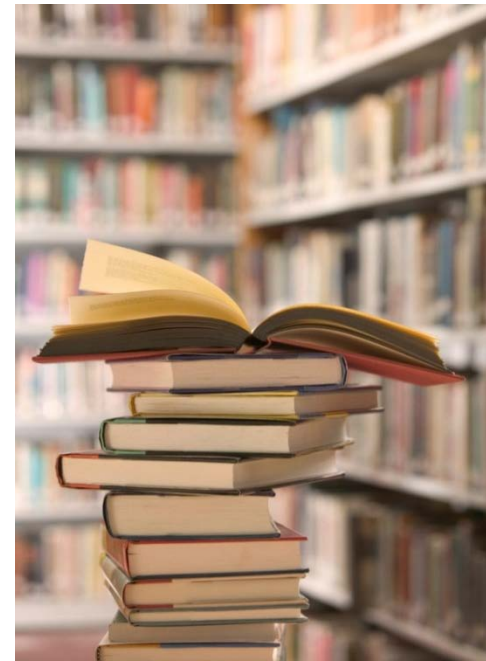
Bibliography

1. “Interim Operational Approval Guidance 08-01, Unmanned Aircraft Systems Operations in the U. S. National Airspace System”, Federal Aviation Administration, 2008
2. Source for Missile and Weapon Data: Wikipedia <http://en.wikipedia.org/>
3. “Trust: Greatest Obstacle to UAV Autonomy”, *Aviation Week Magazine*, August 2010



Bibliography (cont.)

4. “***Draft*** Minimum Aviation System Performance Standards (MASPS) for Unmanned Aircraft System (UAS) Operations in the National Airspace System”, RTCA Special Committee 203, March 2010



Back-Up Slides
