Unmanned Aircraft Systems: Use & Regulation

Robert A.K. Mitchell

June 23, 2015

Government-University-Industry Research Roundtable

Evolution or Revolution?

Proposed FAA regulations:

The UAV

- 55lb or less
- 100mph or less
- Aircraft markings required
- Registration required but no FAA airworthiness certification

Maintaining the UAV

- Operator must maintain in condition for safe operation

Operator

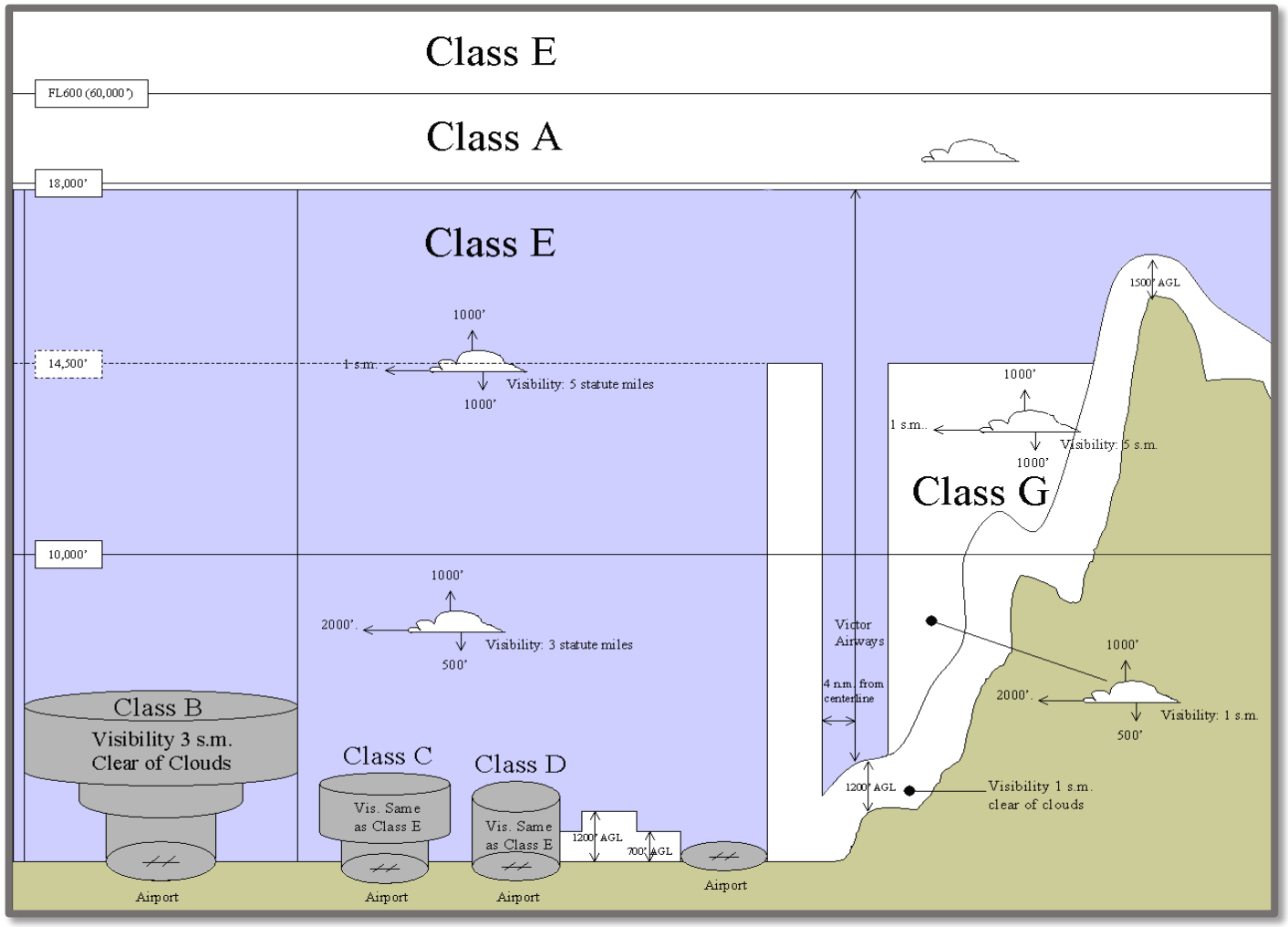
- ❑ 17+ years old
- ❑ Vet by the TSA
- ❑ Mentally and physically capable
- ❑ Pass an initial FAA aeronautical knowledge test, then every 2 years
- ❑ Obtain an unmanned aircraft operator certificate with a small UAS rating
- ❑ One person or VO per unmanned aircraft
- ❑ Nothing careless or reckless

Operation & Control

- ❑ Preflight inspection by the operator
- ❑ Visual Line Of Sight
- ❑ Close enough to the operator to see it
- ❑ At or below 500ft AGL
- ❑ No flights over (uninvolved) people
- ❑ Yield right-of-way to all other aircraft
- ❑ See-and-avoid

Airspace

- No operations are allowed in Class A
- Operations in Class G airspace OK
- Operations in Class B, C, D and E airspace OK with ATC permission
- Daylight
- 3 miles weather visibility

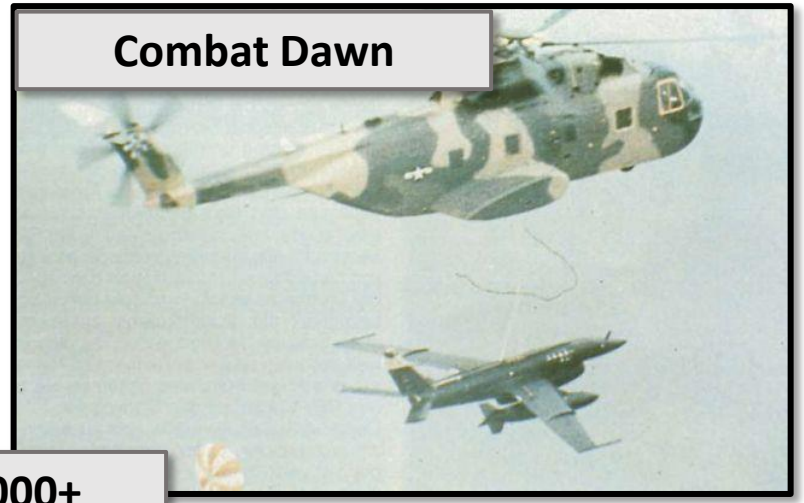


How did we get here?

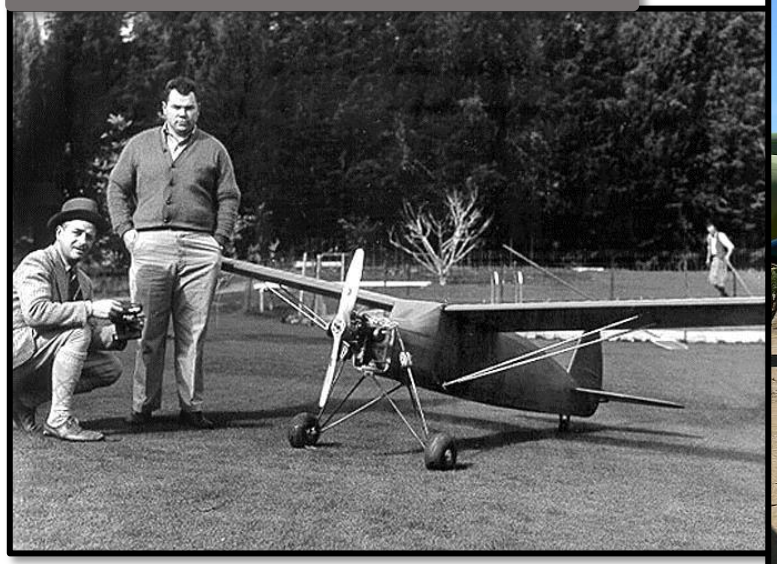
1849 – Venice revolt -- Austria attacked Venice with unmanned balloons full of explosives

'…In a favorable wind the balloons will be launched and directed as near to Venice as possible, …. being brought to vertical positions over the town, …. fired by electro magnetism with a long isolated copper wire with a large galvanic battery … on a building…..'

Combat Dawn



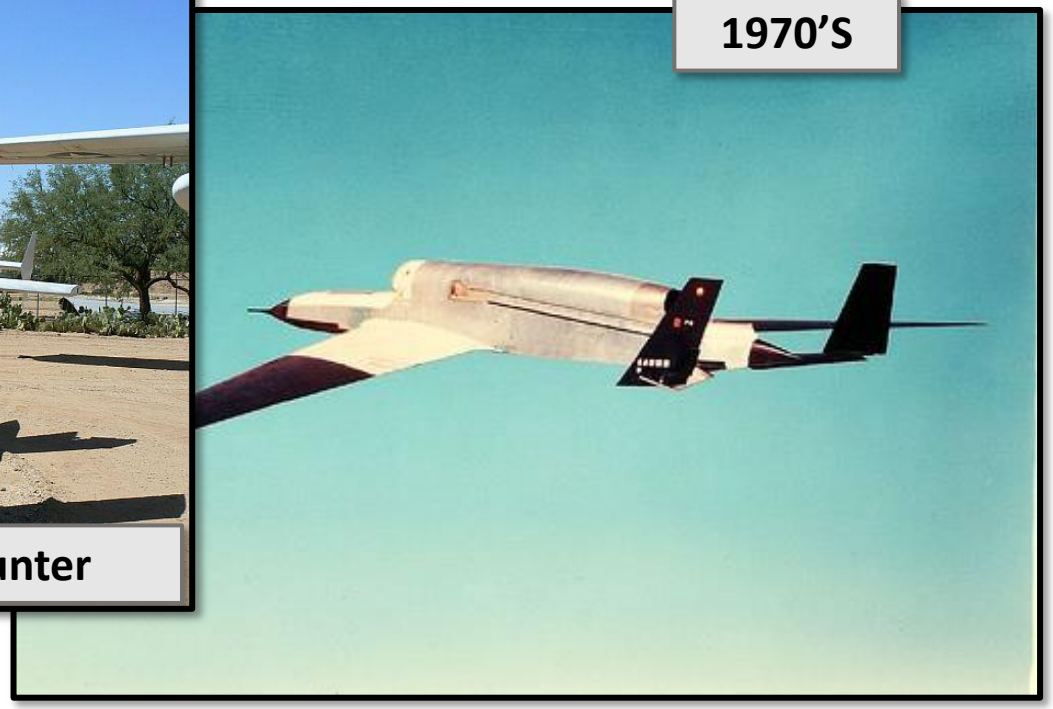
WW2 Radioplane – 15,000+



1960'S – 3,000+

Buffalo Hunter

1970'S




042015
U.S. AIR FORCE

Common UAV Issues

1. Political

- General acceptance & threat to other programs
- Legislative
- Exportability
- Airspace Integration
- Misuse

2. Technical

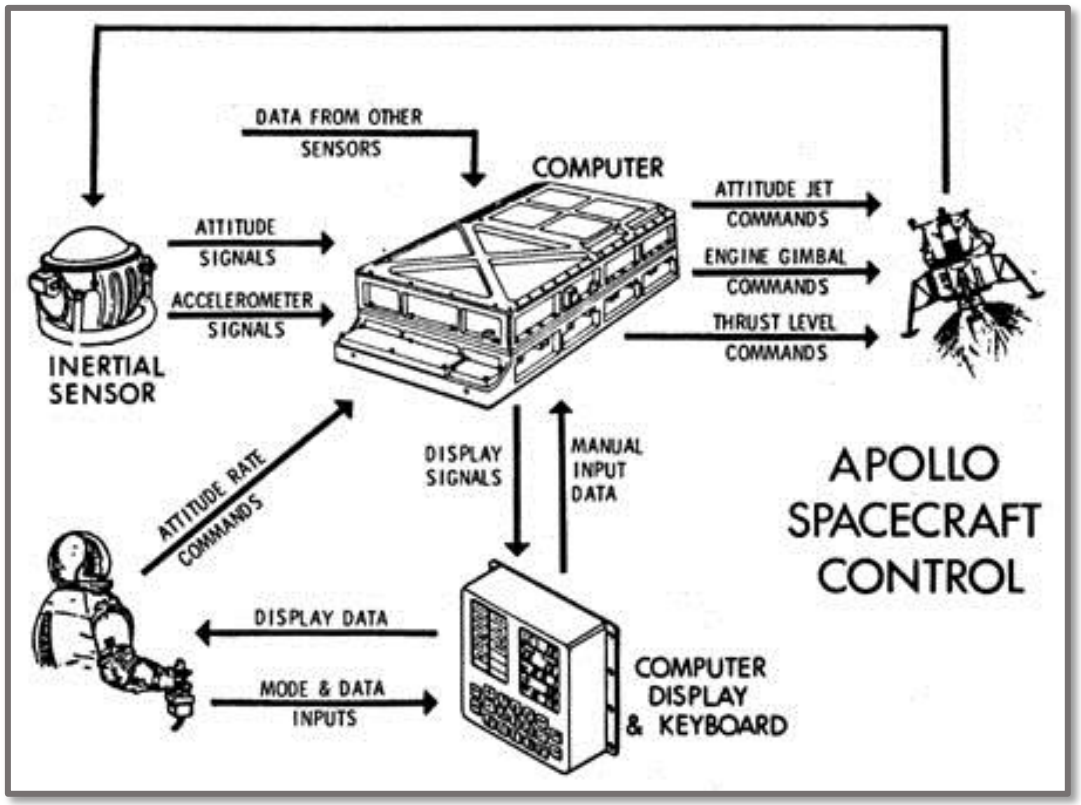
- SWAP growth
- Software integrity
- Communications integrity
- Cyber vulnerability

Software Integrity

Then

Apollo CM/LEM guidance computer

- 16 bit word
- 2048 words of RAM (magnetic core)
- 36,864 words of ROM (core rope memory)
- 2ft x 1ft x 6 in - weight 70lb, 55W
- De-bug via page & line



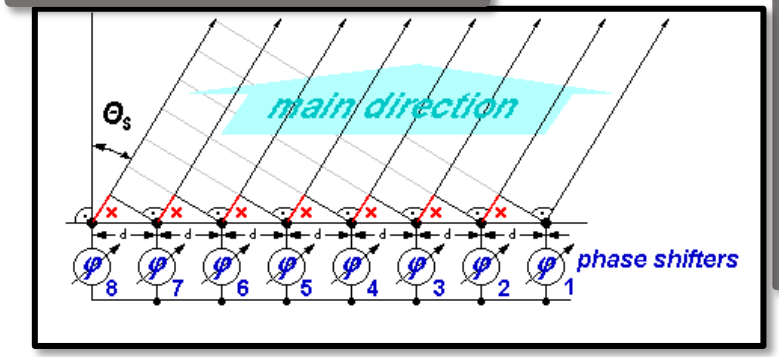
Now

- ❑ Multiple machines
- ❑ Virtually unlimited throughput & capacity
- ❑ SLOC count in the millions
- ❑ High potential for human error
- ❑ Cyber susceptibility

Impact of Evolution

Additive Manufacturing

AESAs



GPS Navigation

Multi-rotor UAVs

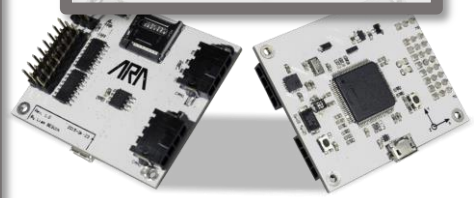
AHARS

- **Highly accurate Vehicle State**
- **Extremely small**
- **Very low cost**

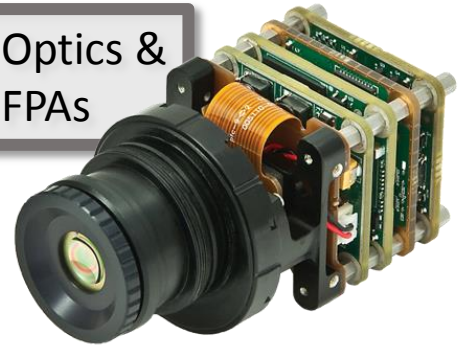
Synthetic Vision

Lightweight High capacity energy storage

Autopilot



Optics & FPAs



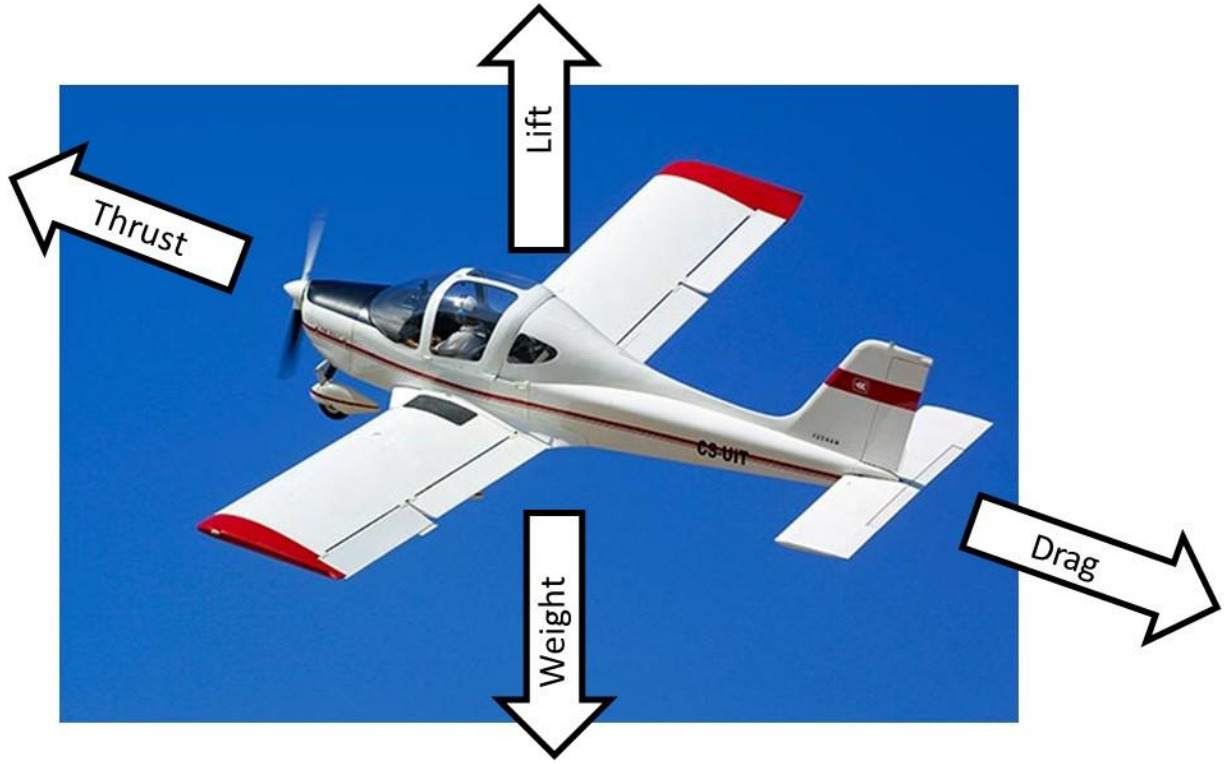
Nanocore module

The laws of Physics prevail and Aircraft design remains relatively unchanged:

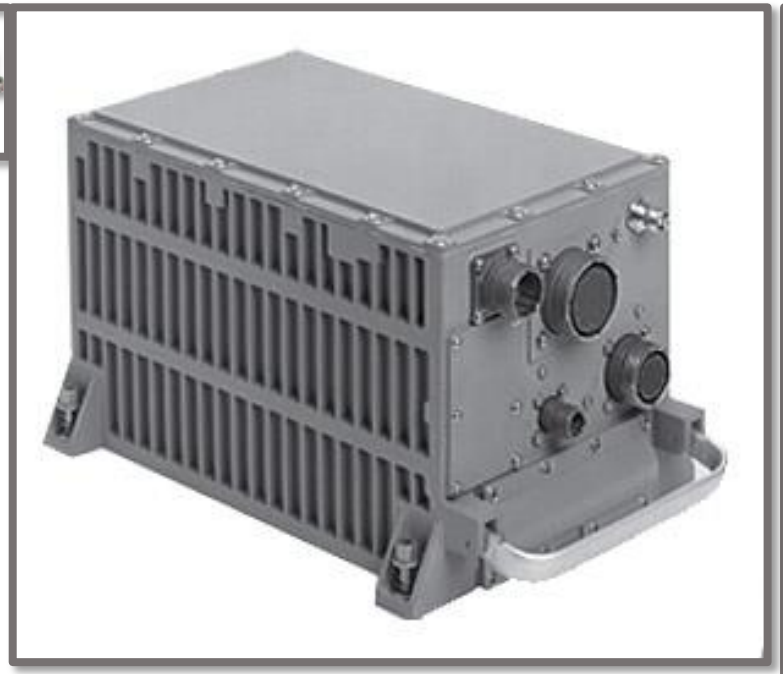
- Weather
- Aerodynamics and propulsion are unchanged
  - Bernoulli's equation
- Communications antennas size vs wavelength
- Apertures are still diffraction limited
- Lift/Drag
- Fuel fraction
- TSFC
- Aircraft fly the same way – 4 forces:
  - Lift vs Weight
  - Thrust vs drag
- …….

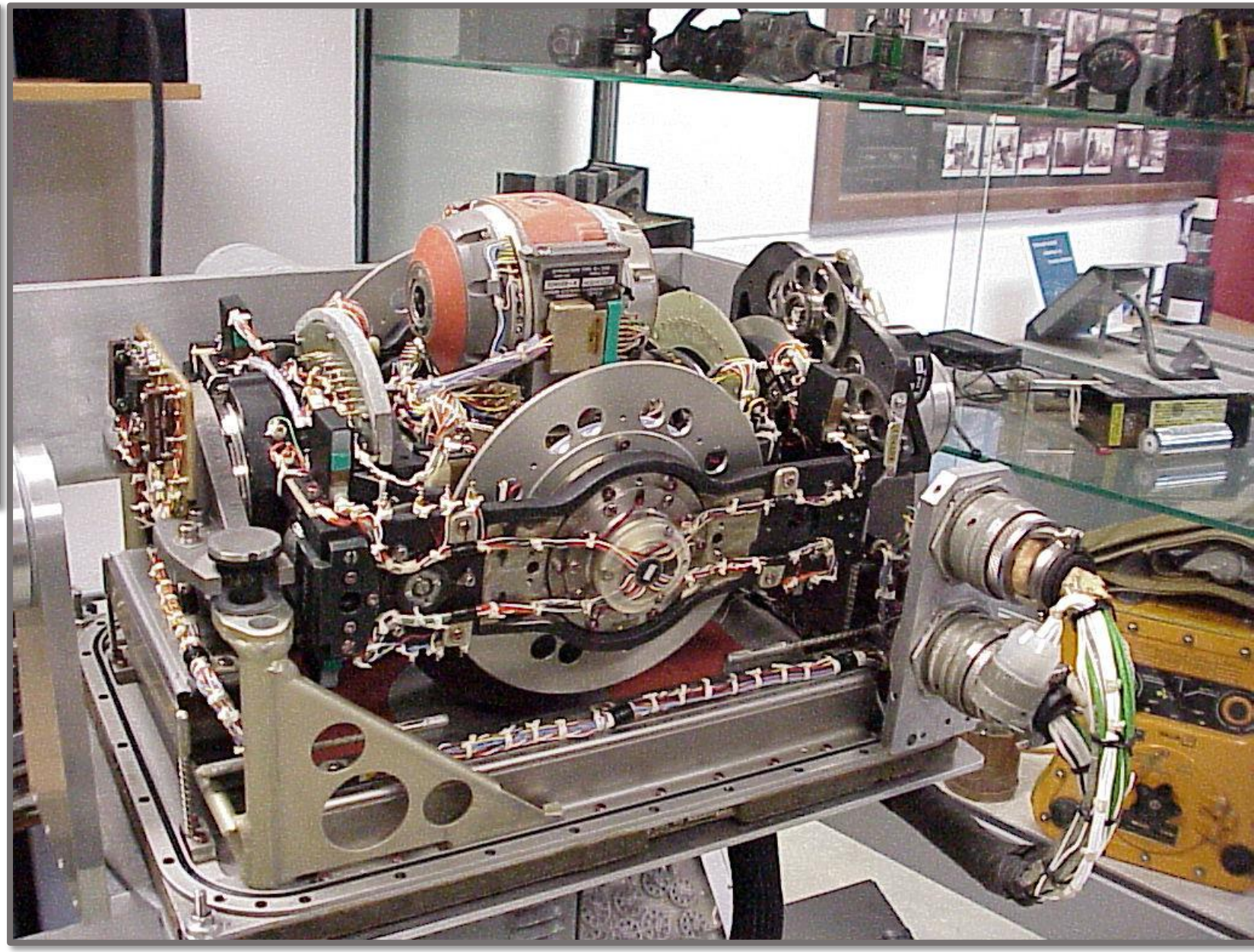
$$p + \frac{1}{2}\rho V^2 + \rho g h = constant$$

where p is the pressure, ρ is the density, V is the velocity, h is elevation, and g is the gravitational acceleration




SBG





Hypothesis – we have created a revolutionary capability with the potential for exponential growth

Technology is the enabler

- AHARS
- Additive manufacturing
- Electrical energy storage
- Highly sensitive focal plane arrays
- Highly sensitive communications links
- …….

Autonomous Systems

- Aircraft effectively flies itself
- G&C solution is transparent to the operator
- Operator provides outer loop control

Software & Mission Planning are Transportable

- Translation a mission plan to control inputs

True Open Architecture

- Access to 3rd party applications
- Innovation will be unlimited

Virtual Presence is feasible

- Synthetic vision
- Situational Awareness

Many Indicators:

In 2009, an Idaho farmer homebrewed his own drone, slapped a commercial digital camera on it, and began extracting data on soil patterns to help his business expand.

Law Enforcement

Communications

Agricultural

Mail

Deliveries

Deliveries

A *drone* with more *drugs* attached to it than it could *carry* has crashed near Mexico's border with the US, police say.

One example --- Law Enforcement

Tactical Operations
Fire Investigations & Assessments
Criminal Pursuit
Search & Rescue Operations
Crowd Control
Emergency Response
Traffic Investigations
Forensics
CBRNE - Chemical, Biological, Radioactive, Nuclear and Explosives
Border Patrol
Aerial Policeman
GPS & Mapping Applications
Accident Investigations
Traffic Management
SWAT Explosive Disposal Unit
SWAT Explosive Disposal Unit
Emergency Response Team
Hazardous Material Operations
Crime Scene Investigation
Gathering Evidence
Gunfire Rescue of Civilians
Conservation Enforcement
VIP Protection Training of Police Forces
Search and Rescue
Criminal Intelligence
Disaster Response
Prevention of Attacks
Surveillance Missions
Narcotics Investigations
Chemical Biological Agent Detection
Suspect and Vehicle Tracking

Hypothesis – we have created a revolutionary capability with the potential for exponential growth

Technology is the enabler

- AHARS
- Additive manufacturing
- Electrical energy storage
- Highly sensitive focal plane arrays
- Highly sensitive communications links
- …….

Autonomous Capabilities

- Aircraft effectively flies itself
- G&C solution is transparent to the operator
- Operator provides outer loop control

Software & Mission Planning are Transportable

- Translation a mission plan to control inputs

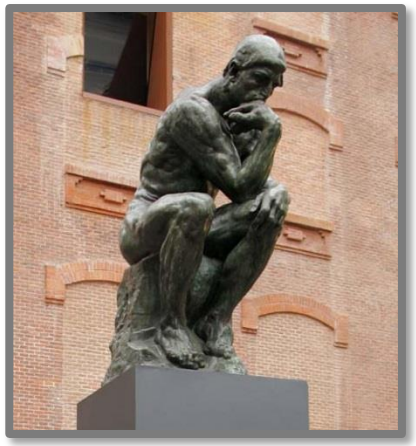
True Open Architecture

- Access to 3rd party applications
- Innovation will be unlimited

Virtual Presence

- Synthetic vision
- Situational Awareness

The UAS capability is available to everyone There is no limit to human ingenuity



Commercial Competition will yield Quality, Affordability and Unlimited new applications

Number of Pilots & Airplanes

2014 - US Population 318 million

2013 - 617,128 pilots in the US

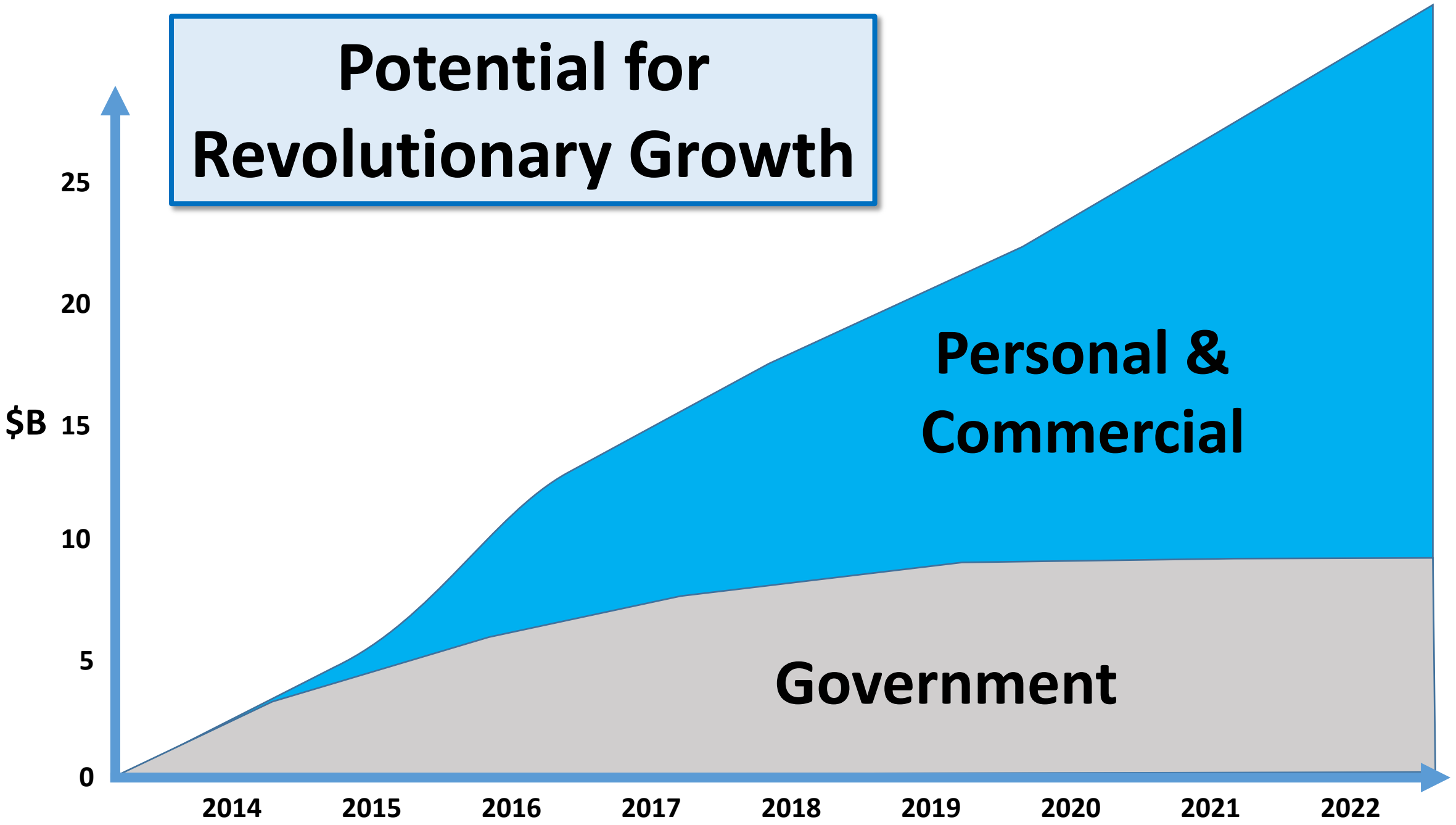
2011 - 224,475 general aviation aircraft

Potential # of UAVs and operators

1 in 500 => 636,000

1 in 100 => 3,180,000

Can the proposed FAA Rules be enforced?

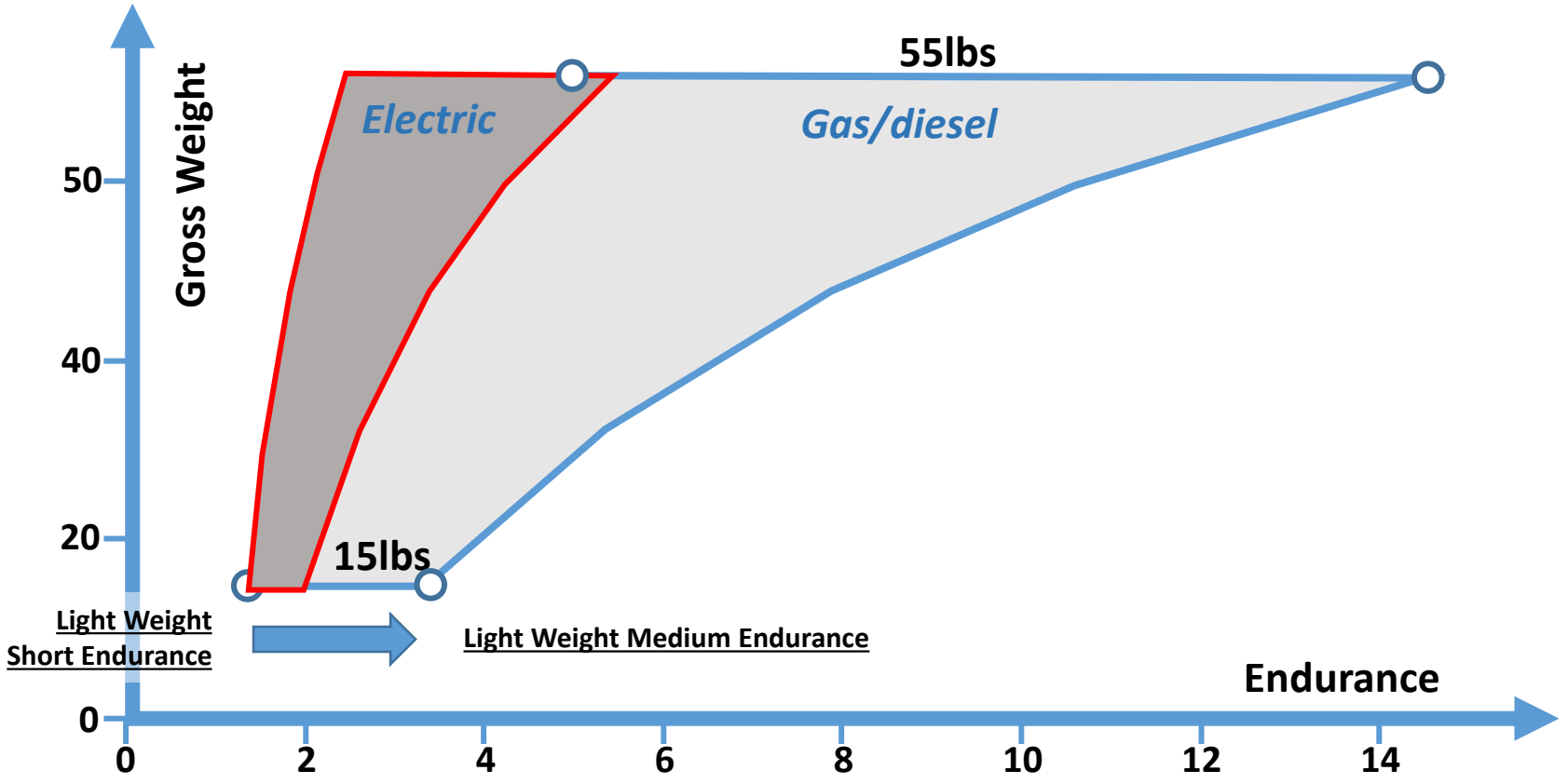

Potential for Revolutionary Growth
$B
25
20
15
10
5
0
Personal & Commercial
Government
2014
2015
2016
2017
2018
2019
2020
2021
2022

High Speed

- Fuel Fraction ~ 40% = 22lb
- Airframe + payload 33lb
- Typical TSFC ~0.5
- High speed L/D = 5
- Average thrust = 9lbf => 4.5lb/hr fuel
- Endurance ~4-5 hr

Long Endurance

- Fuel Fraction ~ 40% = 22#
- Airframe + payload 33#
- Typical TSFC ~0.5
- High speed L/D = 15
- Average thrust = 3lbf => 1.5lb/hr fuel
- Endurance ~15 hr



Operation & Control

- Visual Line Of Sight
- Close enough to the operator to see it
- At or below 500ft AGL
- No flights over (uninvolved) people
- Yield right-of-way to all other aircraft
- See-and-avoid

- Highly subjective
- Can’t control uninvolved people
- See & avoid implies visual contact with other aircraft
- Yield will depend on the other aircraft actions

Proposed FAA Rules

Proposed FAA Rules tend to emulate general aviation rules

- ❑ Pilot in the cockpit versus operator/visual observer
- ❑ Vehicle weight/speed and altitude restrictions
- ❑ Airspace restrictions

Objectives

- ❑ Providing access to this new class of aircraft
- ❑ Safety – people and property
- ❑ Maintaining control
- ❑ Maintaining full situational awareness

Will the proposed FAA Rules address the real core need?

Virtual Presence

If we have a solid communications link

If we know where we are

If we have an accurate view of the terrain visually and synthetically

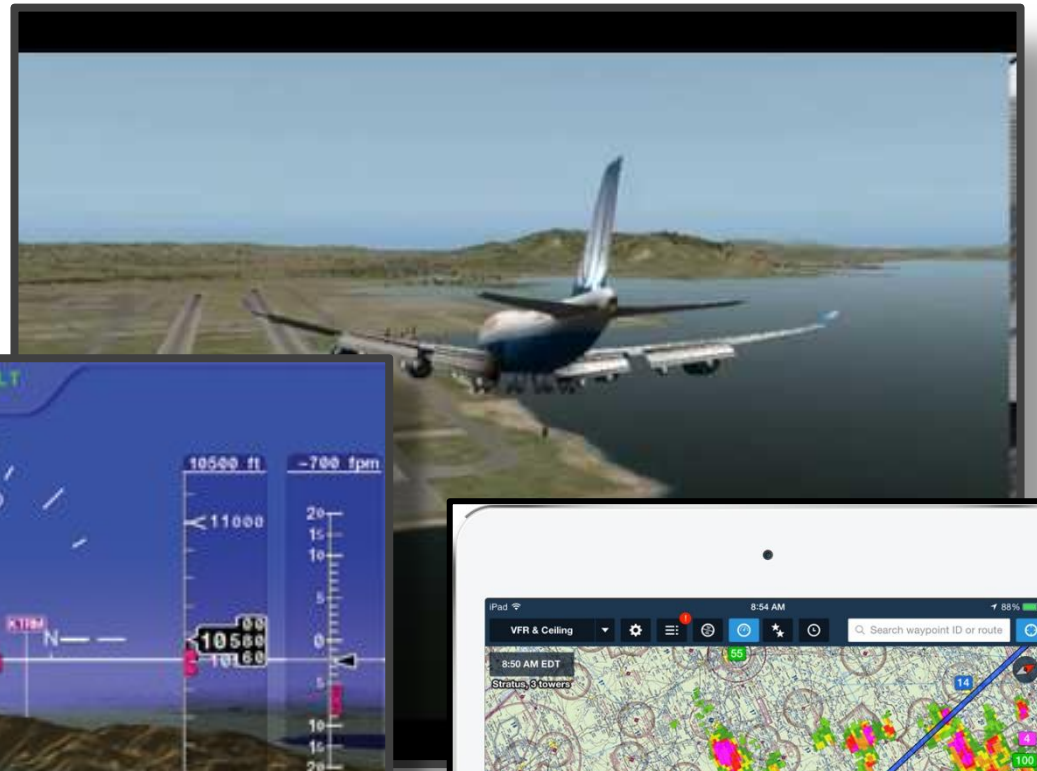
If we know where all the other aircraft are

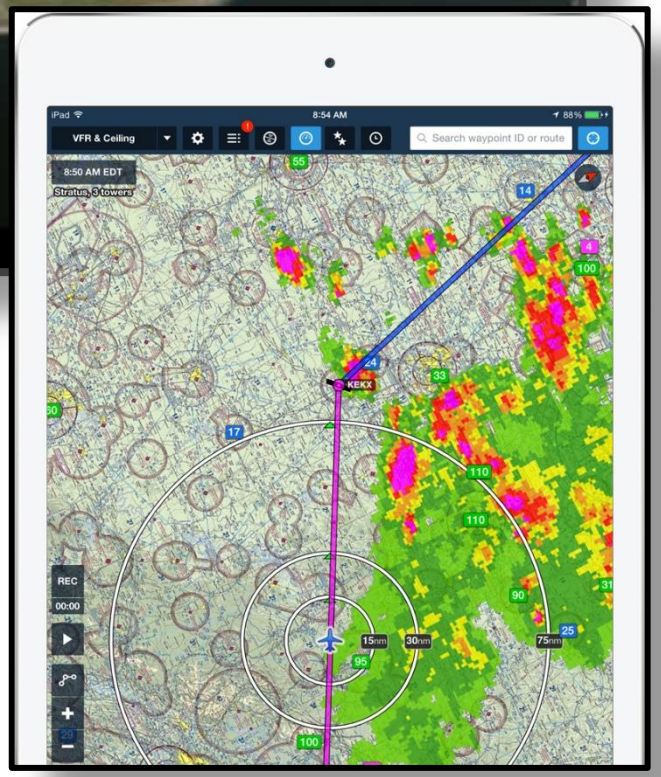
If we are fully aware of the weather & the vehicle health

If the vehicle can recover autonomously

That would be equivalent to being in the aircraft

Virtual Presence





Alternative

Virtual Presence

- ❑ 360 degree camera coverage
- ❑ Synthetic vision in the control station
  - Cockpit view
  - Stand-off views
- ❑ Vehicle health
- ❑ ADS-B equivalent (micro-version to be developed)
- ❑ XM-weather
- ❑ Hi-reliability secure communications
- ❑ Autonomous recovery

Benefits

- ❑ Achieves the real objectives of the proposed rules
- ❑ Creative solution
- ❑ Leverages existing technology
- ❑ Forces new technology
- ❑ Higher utility
- ❑ Maintains US leadership
- ❑ Spin-off to manned aviation

The US has an opportunity to lead the world:

- Technology
- Experience
- Mission understanding
- Innovation

If we are smart with the legislation, we will enable and benefit from an exponentially growing industry