The Coming Convergence Between Manned and Unmanned Aviation

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Thanks to…

- Bruce Holmes
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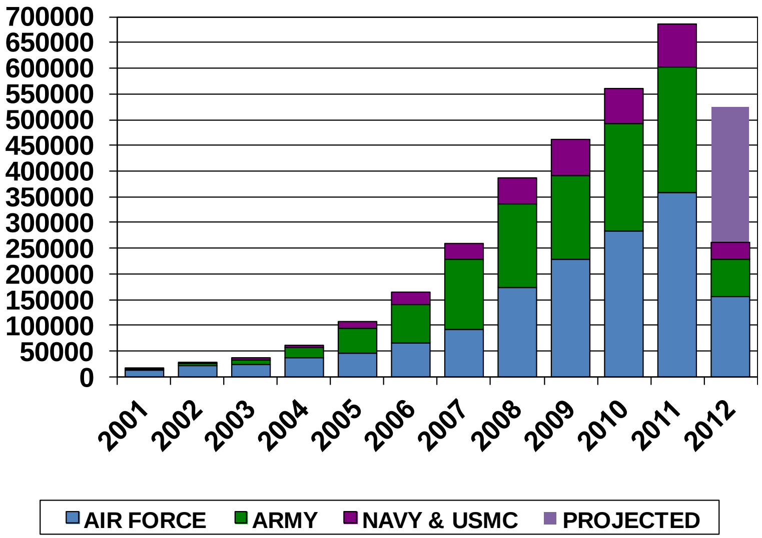
- Ella Atkins

A word about the UAV market…

- Some UAS markets are real:
  - ISR
  - Science
  - Small UAS
- But skeptical on whether today's paradigm really has broad applications within the NAS
- To do that, you must move to the next stage of the UAS revolution – towards UAS that carry passengers



UAS Uses evolve

Aurora FLIGHT SCIENCES

- Data collection and relay

- Air-to-ground weapons delivery

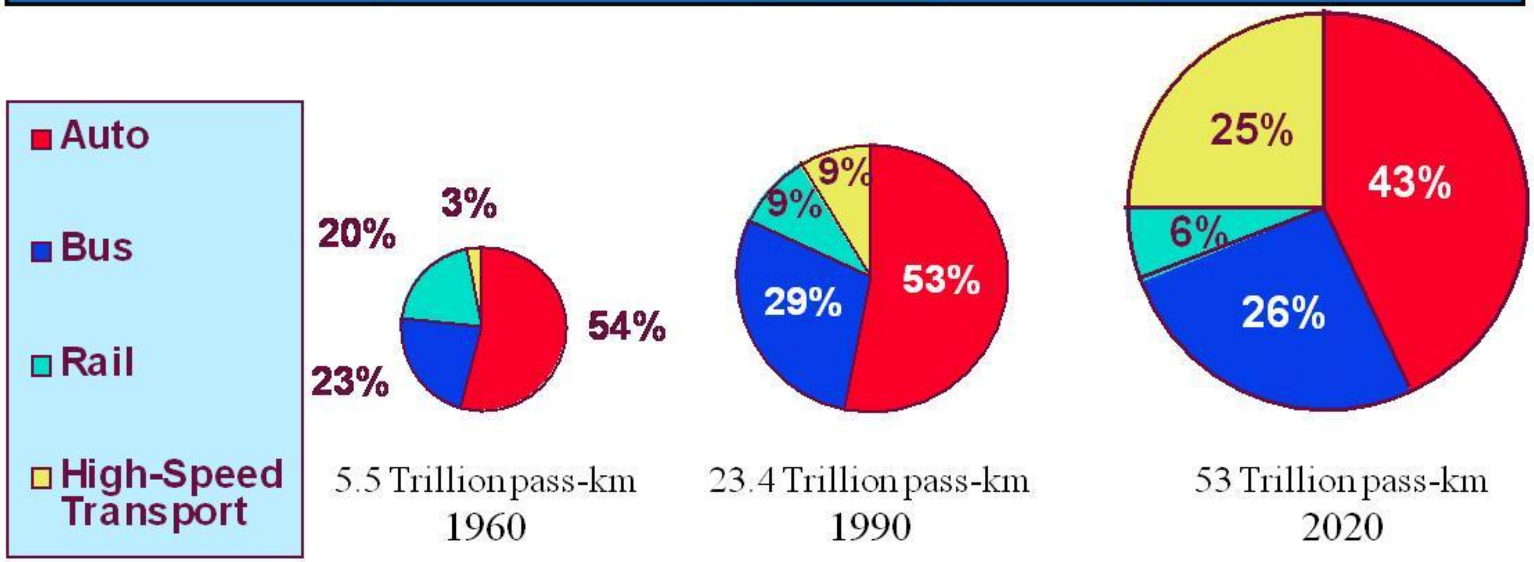
- Cargo delivery

- Air-to-air

- Passenger carriage
  - ➢ Casualty Extraction
  - ➢ Special Missions
  - ➢ General aviation

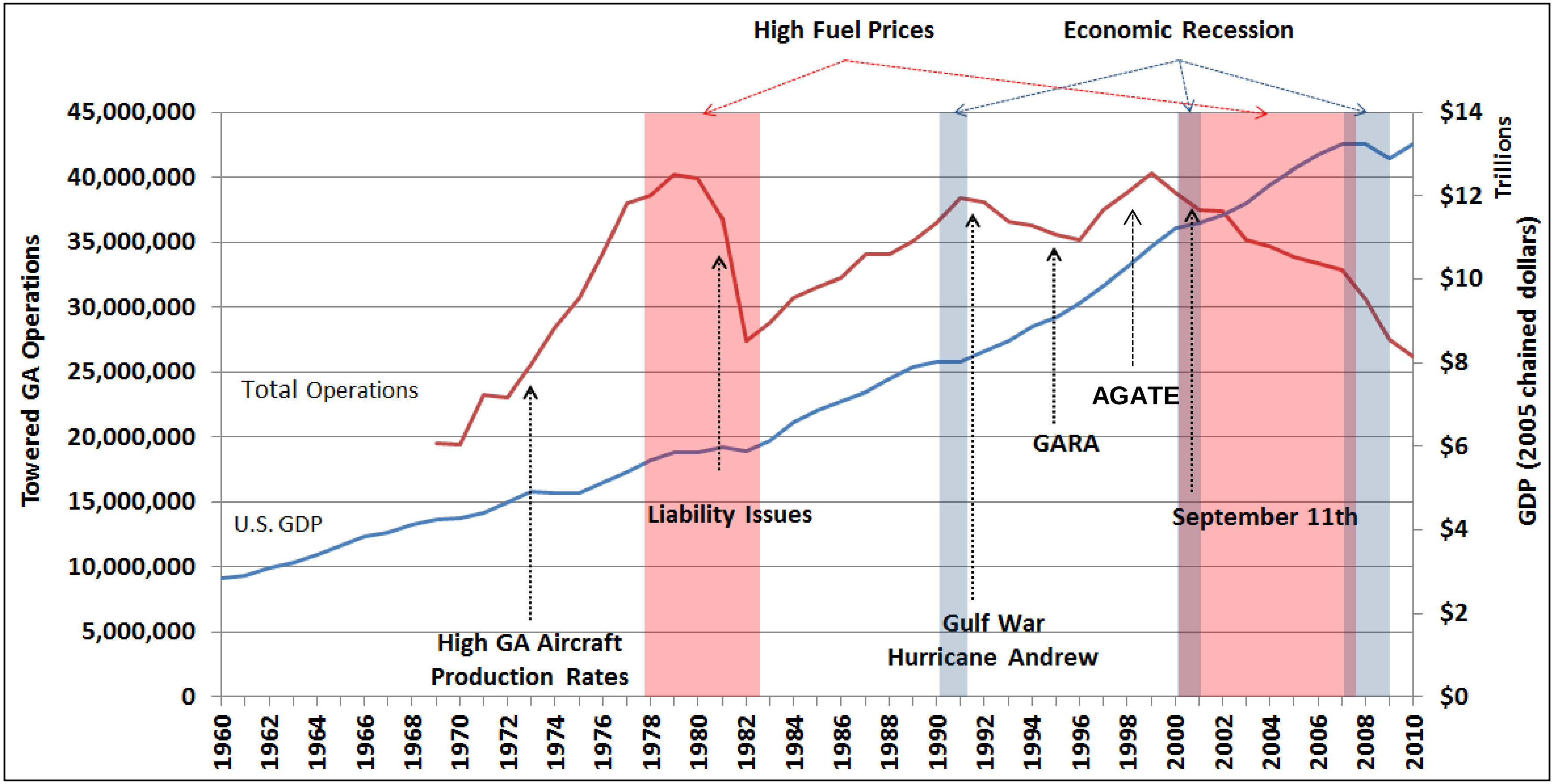
Evolution of Transportation Demand

As *per capita* income rises,
per capita annual travel rises,
personal daily travel time budgets remain constant,
and
high-speed modes gain market share
(Schafer and Victor, Sci. Amer., Oct. 1997)



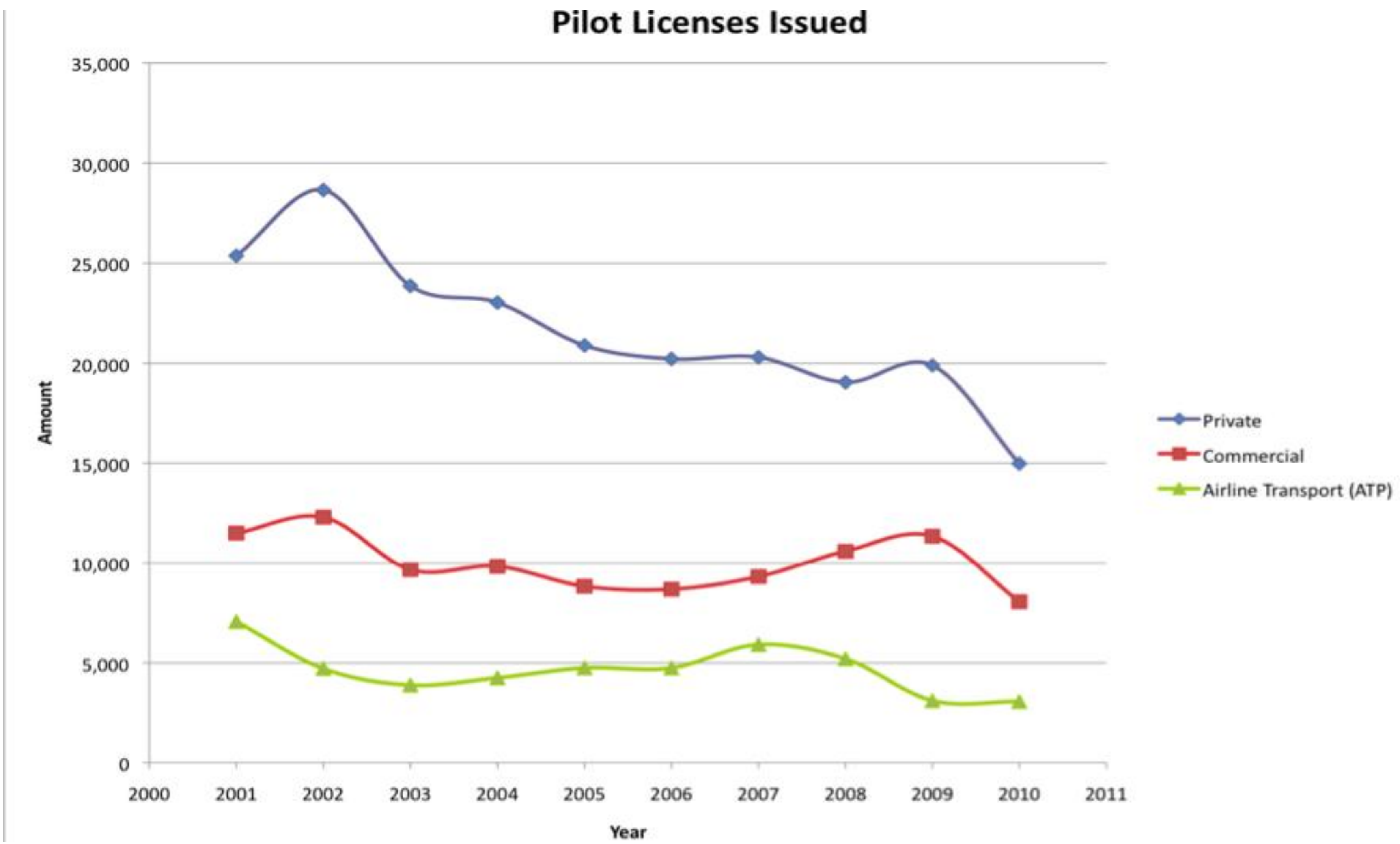
High-Speed Transport in 2020 – as large as all transport in 1960 and as all auto transport in 1990

General Aviation Not Growing With GDP Due to Poor Technology and Lack of Profitability



Data illustrate decoupling of demand from GDP, indicating that new strategies are required to move this market's needle.

….also fewer pilots



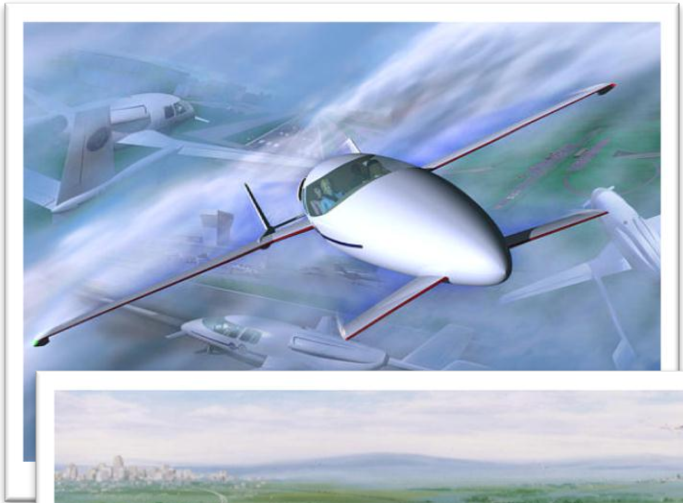
Why?

- Most important concerns of potential new GA buyer:
  - Safety (am I going to die if I fly in this?)
  - Safety (am I going to die if I try to fly it myself?)
  - Safety (will my family die if I take them along?)
- Cost & complexity to remain current in today's ATC environment
- Modern GA aircraft (Cirrus, Diamond, etc) have exploited composites, aerodynamics, propulsion, and glass cockpits
  - Without fundamental changes in safety record
  - Without reversal of general trend of decline

Hypothesis

- Reversing decline of General Aviation can come only by incorporating technologies currently emerging from “unmanned” aviation
- Not really a question of manned versus unmanned, but rather where on the spectrum of autonomy one falls…
  - Between no automation and full automation

Evolution of Aircraft, Airspace, and Surface Systems, and NASA-Industry-FAA Investments



AGATE Alliance
1994-2001

GAP Project
1995-2000

ERAST
1994-2002

SATS Project
2001-2005

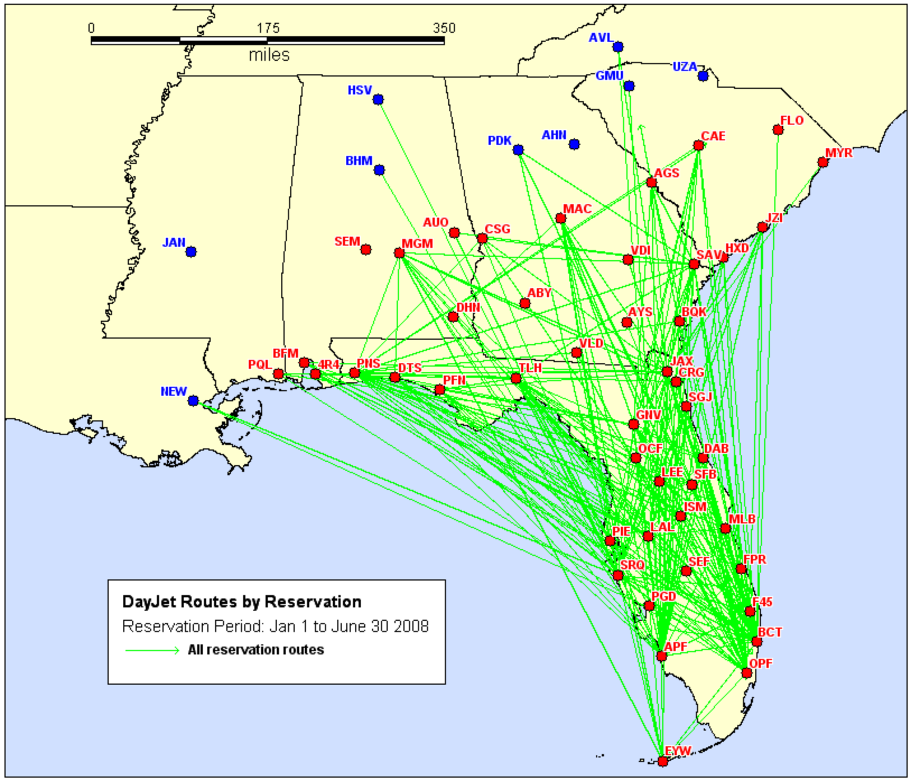
Outcome: Technology, Regulatory Policy, Infrastructure Investment supporting expanded use of community airports
and smaller aircraft
for public transportation; however,
<u>we did not go far enough</u>

UAS in the NAS
2011-2016

SATS Assessment

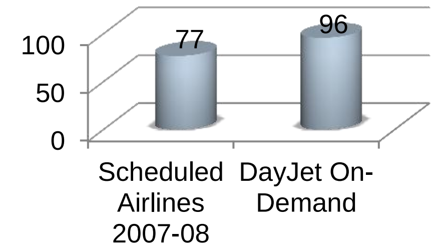
- Deployed new transportation system demand analytical modeling.
- Conducted Business Case studies for:
  - North Carolina
  - Ohio
  - Upper Great Plains
  - Virginia
  - Michigan
  - Northeast Corridor & the Southeast
- Result
  - At \$1.50 - \$2.00/seat-mile operators earn 20% profit
  - There is sufficient demand at those fares to support sizable fleets of aircraft
- However: Purpose-designed aircraft are needed to achieve fares ~< \$1/seat-mile

The DayJet Experience



Out of 400 million U.S. business trips/year, our ABM projected capturing between 1.5 – 2% with Dayjet business model, depending on regions and consumer behaviors. At 1.5% of market, 6 million legs flown requires 1500-2000 aircraft flying10 legs per day per aircraft.

On-Time Performance

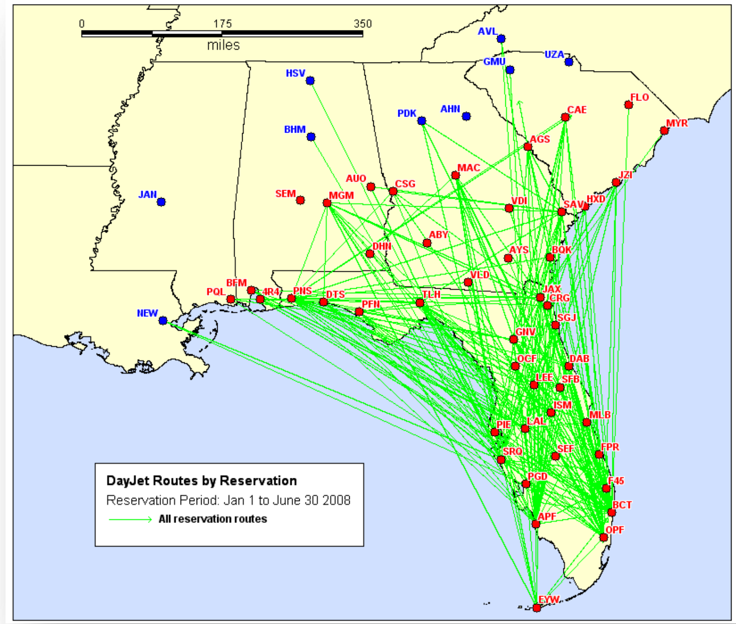


- Command Center Ops
  - ✓ 50% fewer dispatchers
  - ✓ Basis for automation/OPA
- ~ 1 year of revenue ops
- 28 aircraft
- 4.5 pilots/aircraft
- 61 DayPorts; 375 cities total
- Hard to model U.S. demand in 2007; now possible to do the nation
- FAA Kudos

A DayJet Lesson on Aircraft

11 months of revenue service

- Average Trip Length = 252 nm
- Shortest leg – 97 nm
- Longest leg – 450 nm
- Typical Altitude = FL 180-210
- $1.25/seat-mile < Fares < $4/s-m

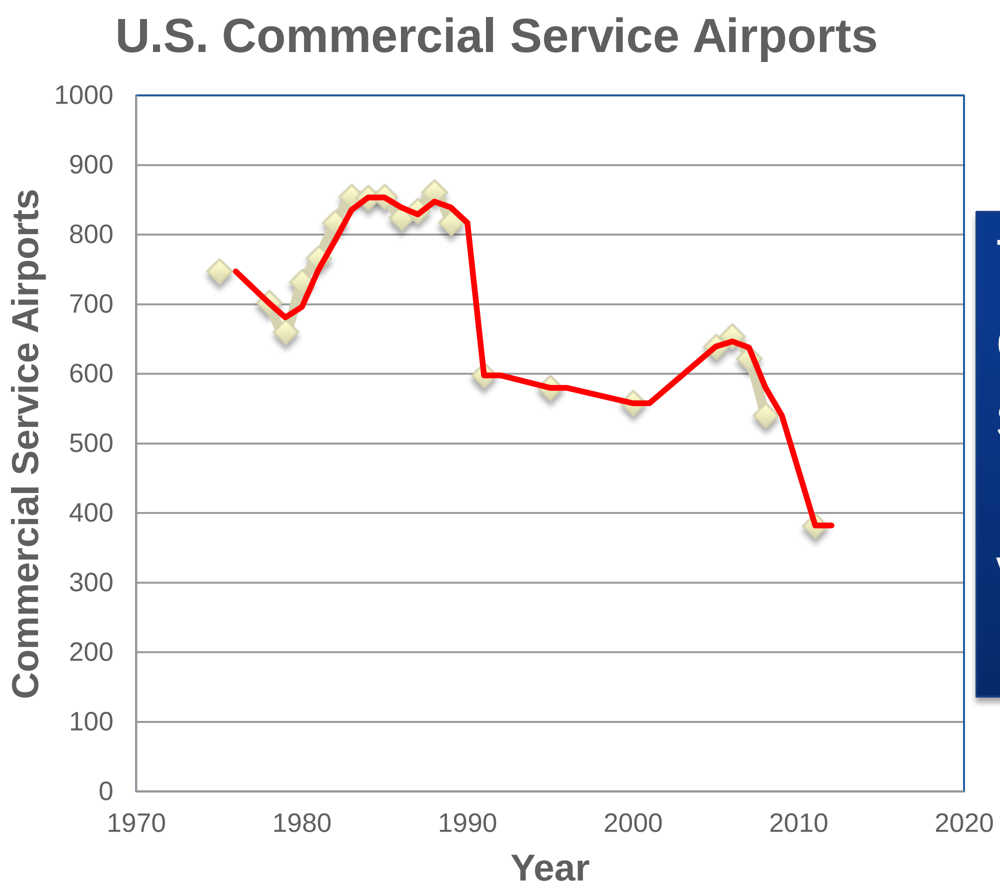


Eclipse 500

- Max Range = 1100 nm
- Optimum Cruise Altitudes – FL 350-410

SATSAir Story Very Similar (Cirrus SR 22, 4 years service)

Medium Term Market Driver: Scheduled Air Service Contraction



The continuing contraction of the scheduled air carrier industry creates a market vacuum as communities lose service

Based on data from the US Department of Transportation, Bureau of Transportation Statistics..

Enablers for Innovation in On-Demand Air Carrier Service

The "Right" Airplane

Real-time Logistics

Small World Networks

OPA and NextGen

OPA reduces crew costs by half (~15% of op. ex.)

NextGen reduces fuel costs by 5 – 15% (estimates during FAA Test Bed project)

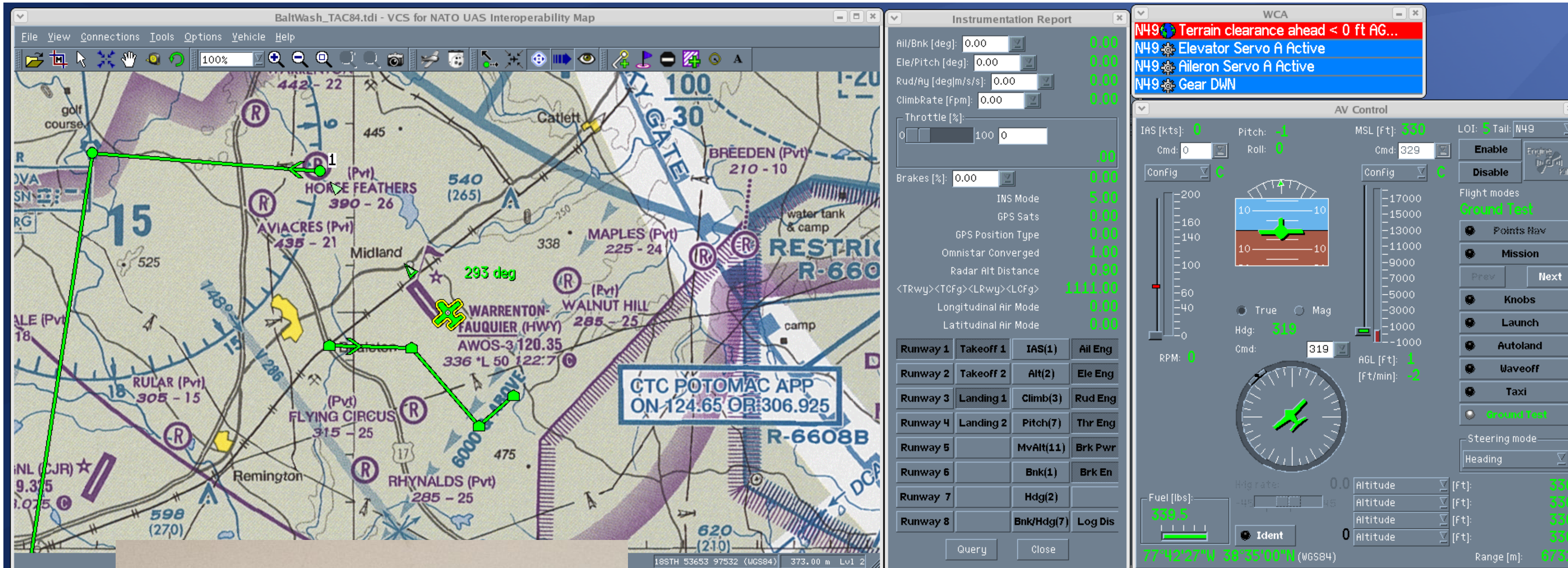
The regulatory, technical, and operational needs converge for UAS and On-Demand air service and OPA accelerates the opportunity

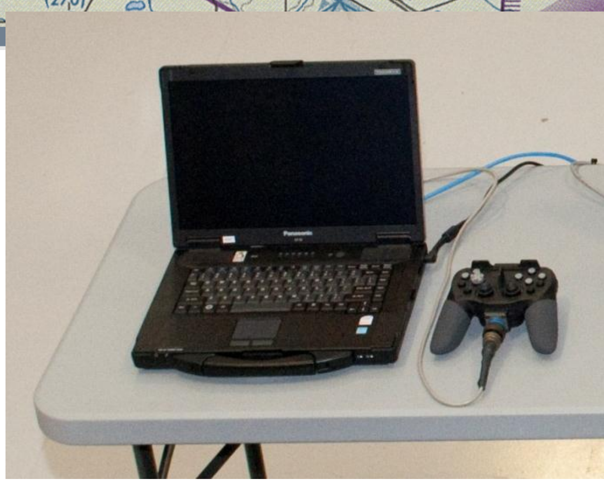
Hence the "Optionally Piloted Aircraft"

- Essentially, a UAV with a human onboard as the "see and avoid" sensor

- Affordable
- Quiet
- Flexible
  - Manned
  - Unmanned
  - Hybrid
- High Performance

How Centaur works today

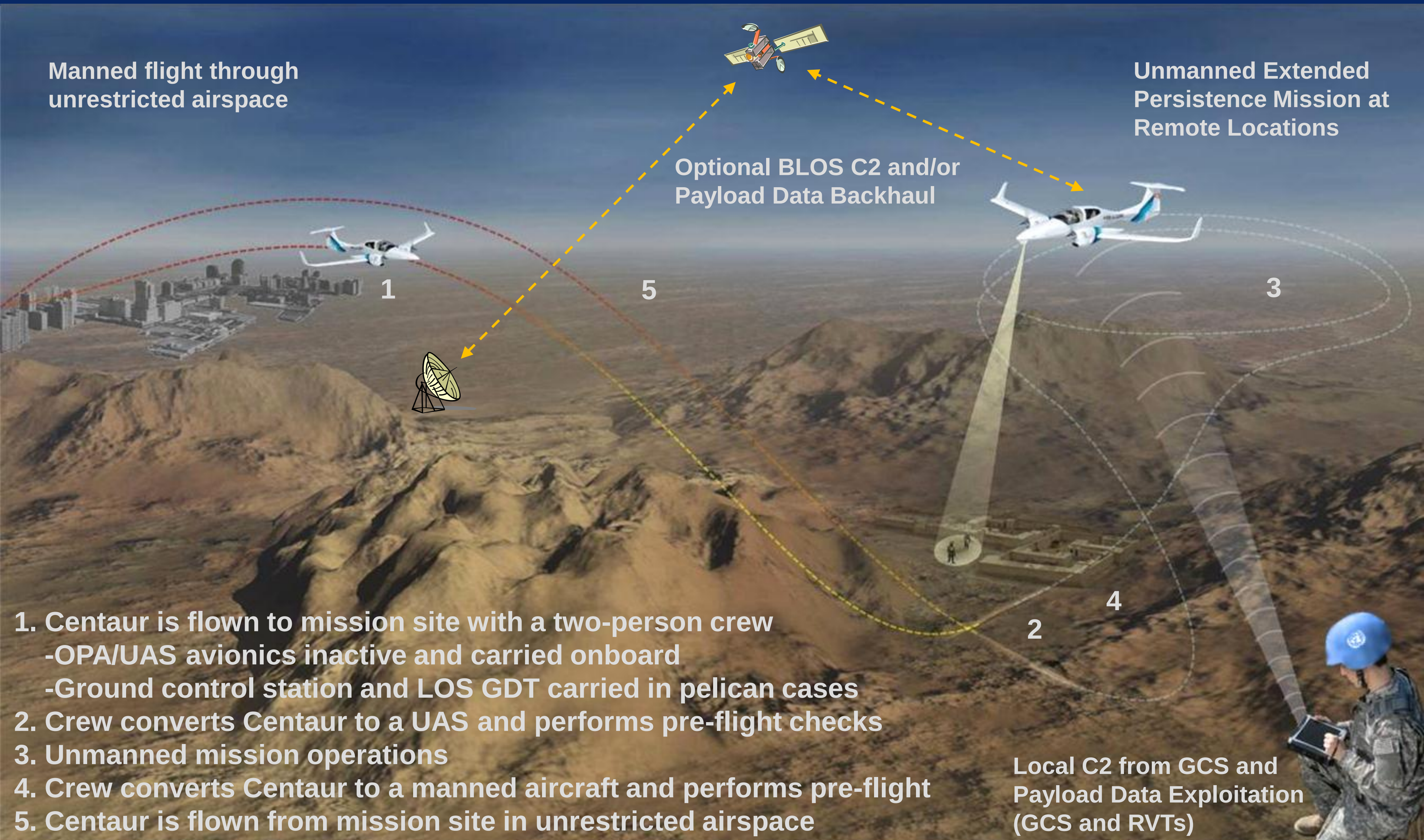




STANAG 4586

The controls

Centaur OPA Concept of Employment



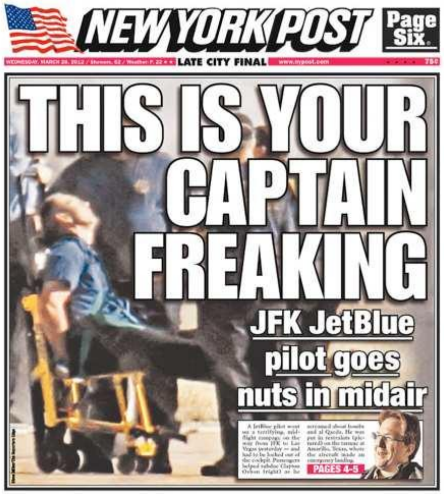
1. Centaur is flown to mission site with a two-person crew
   -OPA/UAS avionics inactive and carried onboard
   -Ground control station and LOS GDT carried in pelican cases
2. Crew converts Centaur to a UAS and performs pre-flight checks
3. Unmanned mission operations
4. Crew converts Centaur to a manned aircraft and performs pre-flight
5. Centaur is flown from mission site in unrestricted airspace

Roadmap

Version	Market	Market Size	Certification	Network/C^3
Centaur I *TODAY*	• ISR & Com Relay • Science Research • Airspace R&D	Tens-hundreds (10^1-10^2)	Certified in manned mode	Dedicated GCS
Centaur II *3-5 years*	• Cargo delivery • Air taxi	Hundreds-thousands (10^2-10^3)	Certified for single-pilot ops w/ PX & UAV flight in NAS w/o PX	Fleet dispatch center
Centaur III *7-10 years*	• Personal transportation	Thousands-tens of thousands (10^3-10^4)	Certified for UAV flight in NAS with passengers	Network operations center

Fundamental question: who is charge?

Nominal	Emergency	Example
Human	Human	JB191
Computer	Human	AF447
Human	Computer	US1549/Atkins
Computer	Computer	



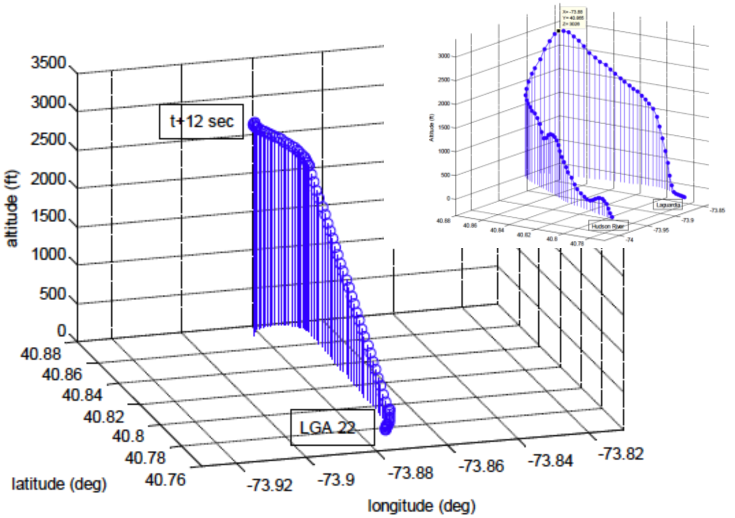


Figure 16: AFP Landing Trajectory to LGA 22 (3D): Loss-of-thrust detection + 12 seconds

Summary

- Decline of General Aviation cannot be reversed without major injection of technology to mask complexity and improve the user experience
- This technology is emerging from a variety of sources
  - NEXTGEN
  - NASA Systems Programs
  - UAS
- Winners in this market will be those who successfully integrate these trends
- *Not an issue of “manned” versus “unmanned” but where on the spectrum of automation you fall*

Where should the government focus?

- Certification issues – how will new systems be certified?
- Human-machine interface
  - ➢ What reversionary modes should exist?
  - ➢ Nominal and emergency conditions
- Network issues
  - ➢ I can build the iPhone, but who will build the network?
  - ➢ Need secure, digital data links for command and control
  - ➢ ADS-B for system-wide traffic separation & collision avoidance