Key Opportunities in Aeronautics Enterprise

UC Berkeley

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Opportunities

- Future Aircraft
  - Environmental footprint
  - Aircraft development cycle
  - Aircraft production rate
  - Supply chain
- Airspace Operations
  - Efficiency
  - Disruptions
  - Safety
  - Human and Autonomy
  - Preparing for Future Operations
- Summary

Future Aircraft

More Electrified Aircraft for Reduced Emissions

Challenge: Battery for Aviation Needs

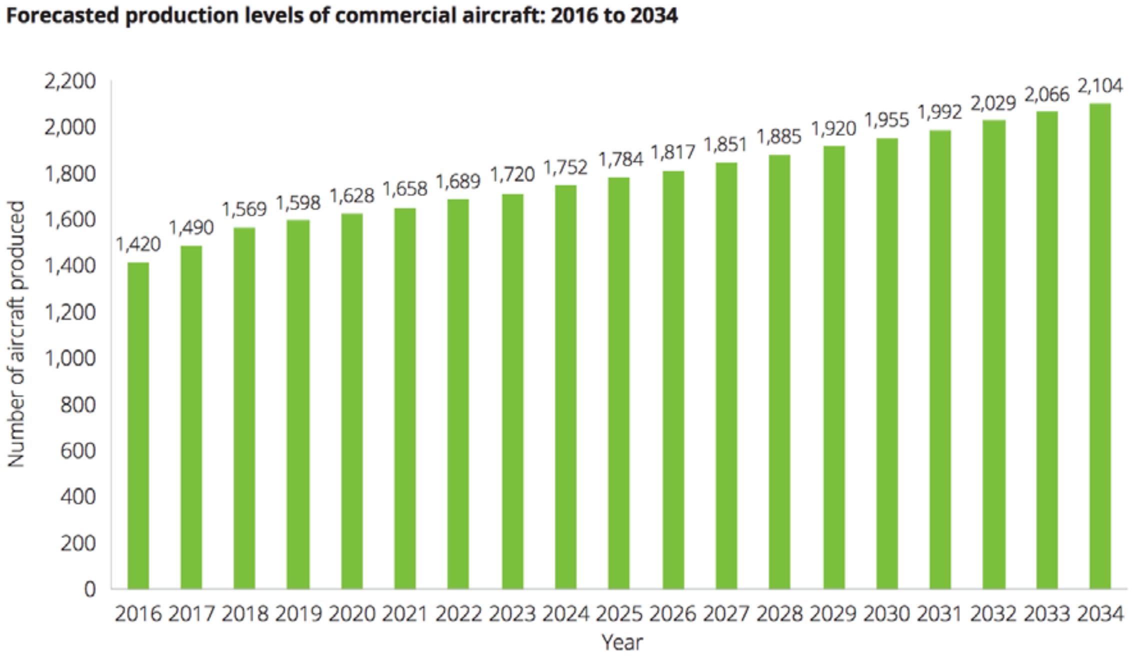
Reduce aircraft development cycle time

- Every modern aircraft was:
  - Delayed
  - Over budget
  - Heavier initially
- Design complexity:
  - A380-800 has about 100,000 wires, 470 km, 5700 kg of weight, and additional 30% weight for harness to hold wiring

Increase aircraft production rate

Current Situation ($800+B backlog)

- Boeing and Airbus have backorders (~5000+, with ~55/month rate)
  - Boeing delivered 806 aircraft and Airbus 800 in 2018
  - Airbus 863 (2019, 7% up)
  - In 2016, Boeing had 5715 undelivered orders and Airbus had 6874

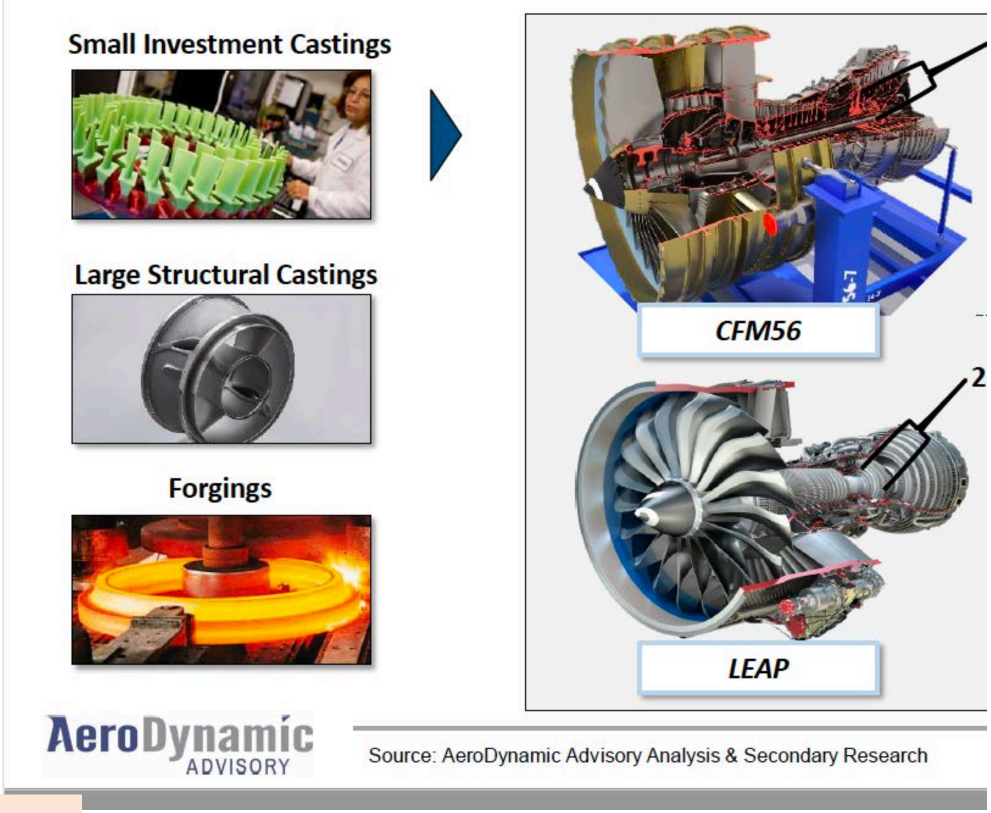


Source: Deloitte analysis, Airbus, Boeing

Set up supply chain and MRO for emerging eVTOLs

Challenges

- Casings and forging
- Composites
- Auxiliary Power Units
- Printed Circuit Boards
- Actuators
- Software
- High volume manufacturing and assembly methods
- Many others

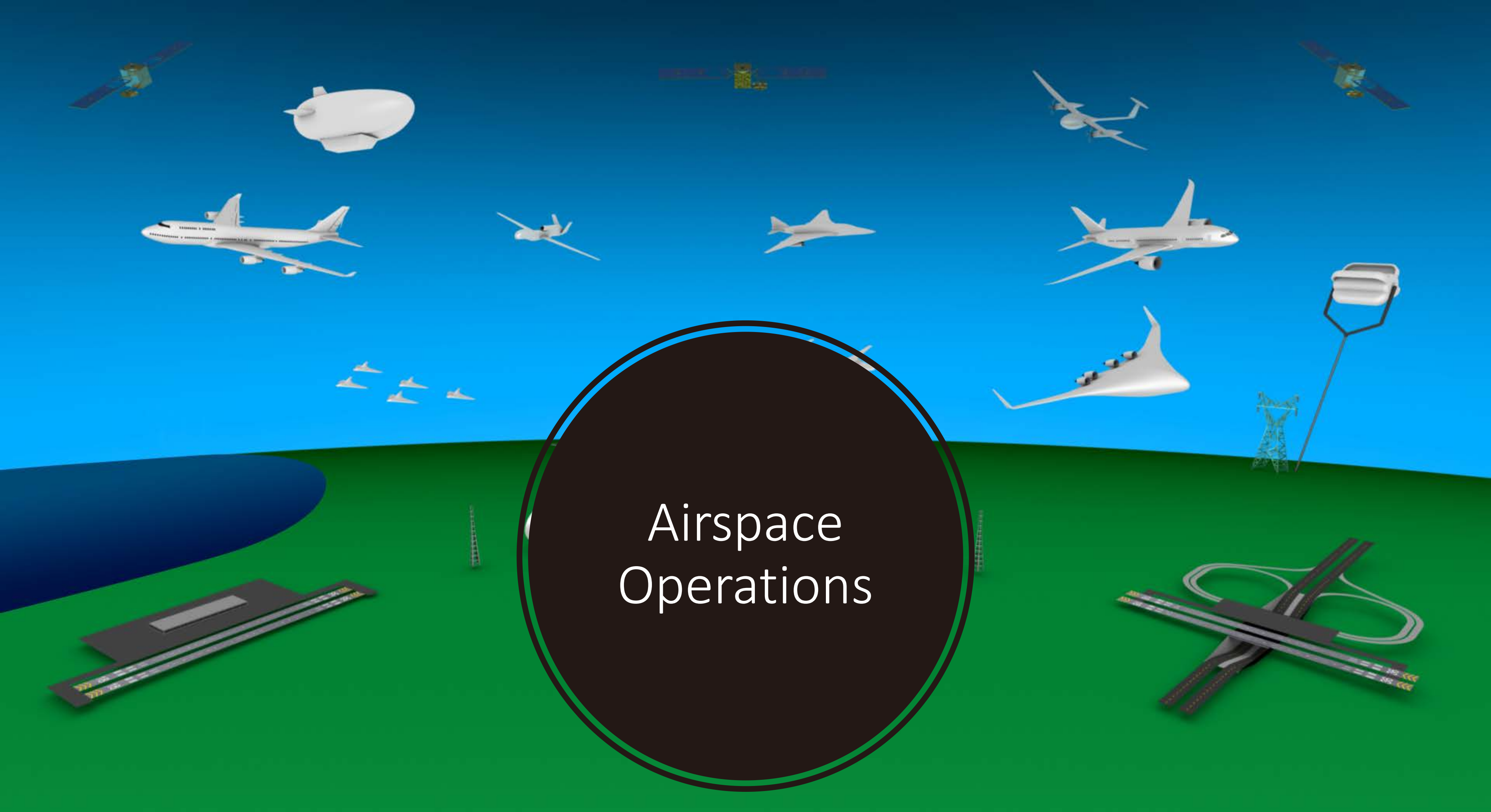


MRO: Maintenance, Repair, and Overhaul
eVTOLs: Electric Vertical Take-off and Landing Vehicles

Need sustainable supplier, manufacturer, and MRO network

Car companies are entering aero industry

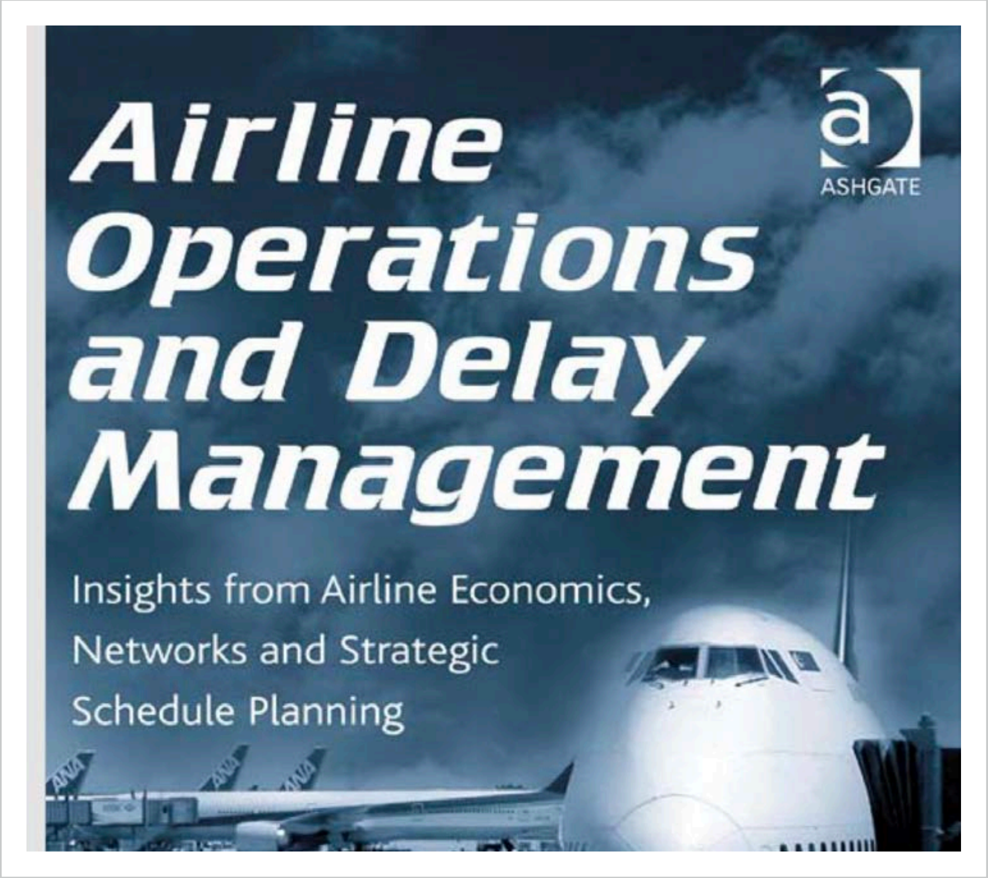
Need to understand the production certificate, and aviation grade manufacturing needs



Airspace Operations

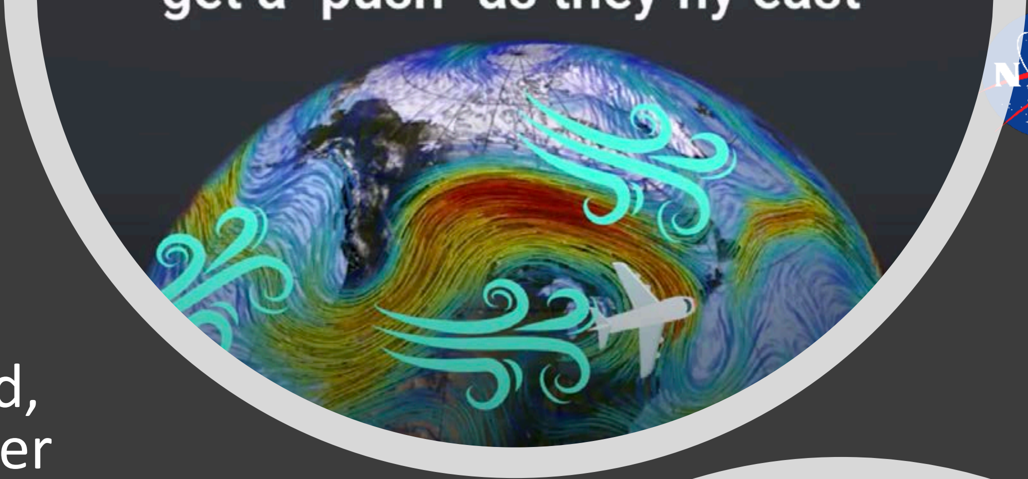
Increase efficiency of current airspace operations

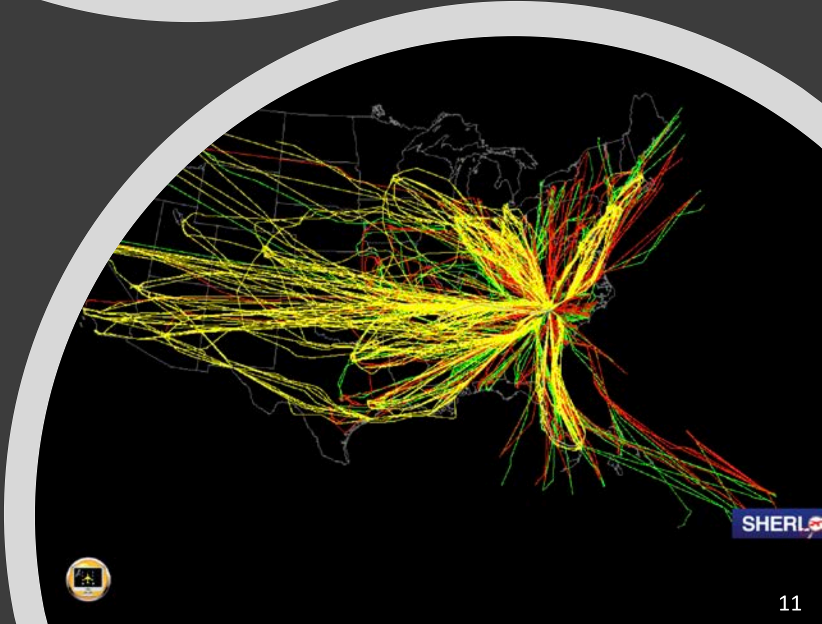
Use data to learn about inefficiencies



Better automation to reduce impact of disruptions

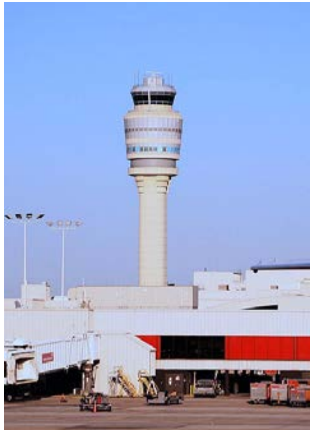
- 25% aircraft get delayed, ~70% are due to weather
- Major disruptions cause significant impact: volcanic ash, typhoons, etc.
- Deciphering avoidable and unavoidable delays (e.g., SFO marine stratus) and use better probabilistic models





Learn from Current Aviation Safety Data

- Aviation Safety Recording System (ASRS)
- Operational errors and deviations



"Every hour around here is 59 minutes of boredom and 1 of sheer terror."

DOT/FAA/AM-93/22

Office of Aviation Medicine
Washington, D.C. 20591

AD-A275 986

An Examination of the Operational Error Database for Air Route Traffic Control Centers

Mark D. Rodgers, Editor

Civil Aeromedical Institute
Federal Aviation Administration
Oklahoma City, Oklahoma 73125

December 1993

DTIC ELECTE FEB 24 1994 S B D

Final Report

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

Divergence of humans and technology

Regulations based on fatigue limit stage length of aircraft or increase cost by carrying additional crews

Summary of Flight and Duty Limits, for Unaugmented Operations

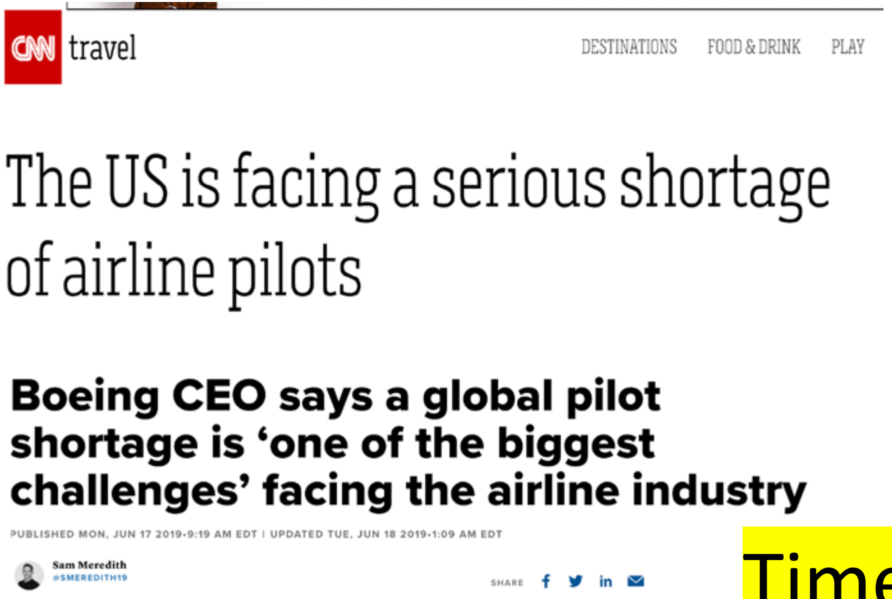
Maximum Flight Time Limits

Time of Report (Acclimated)	Maximum Flight Time (hours)
0000-0459	8
0500-1959	9
2000-2359	8

The World's Longest Non-stop Flights

From	To	Airlines	Time	Distance
Singapore	Newark	Singapore Airlines	18h 45m	16,700km
Auckland	Doha	Qatar Airways	18h 30m	14,534km
Houston	Sydney	United	17h 30m	13,800km
Perth	London-Heathrow	Qantas	17h 20m	14,499km
Los Angeles	Singapore	United	17h 20m	14,100km
Auckland	Dubai	Emirates	17h 15m	14,200km
San Francisco	Singapore	United, Singapore Airlines	17h 05m	13,593km
Los Angeles	Jeddah	Saudia	16h 55m	13,409km
Johannesburg	Atlanta	Delta	16h 40m	13,582km
Abu Dhabi	Los Angeles	Etihad	16h 30m	13,502km

Sources: News Reports, Flightmapper, World Economic Forum


CNN travel

DESTINATIONS FOOD & DRINK PLAY

The US is facing a serious shortage of airline pilots

Boeing CEO says a global pilot shortage is 'one of the biggest challenges' facing the airline industry

PUBLISHED MON, JUN 17 2019•9:19 AM EDT | UPDATED TUE, JUN 18 2019•1:09 AM EDT

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SHARE

Time for increased autonomy?

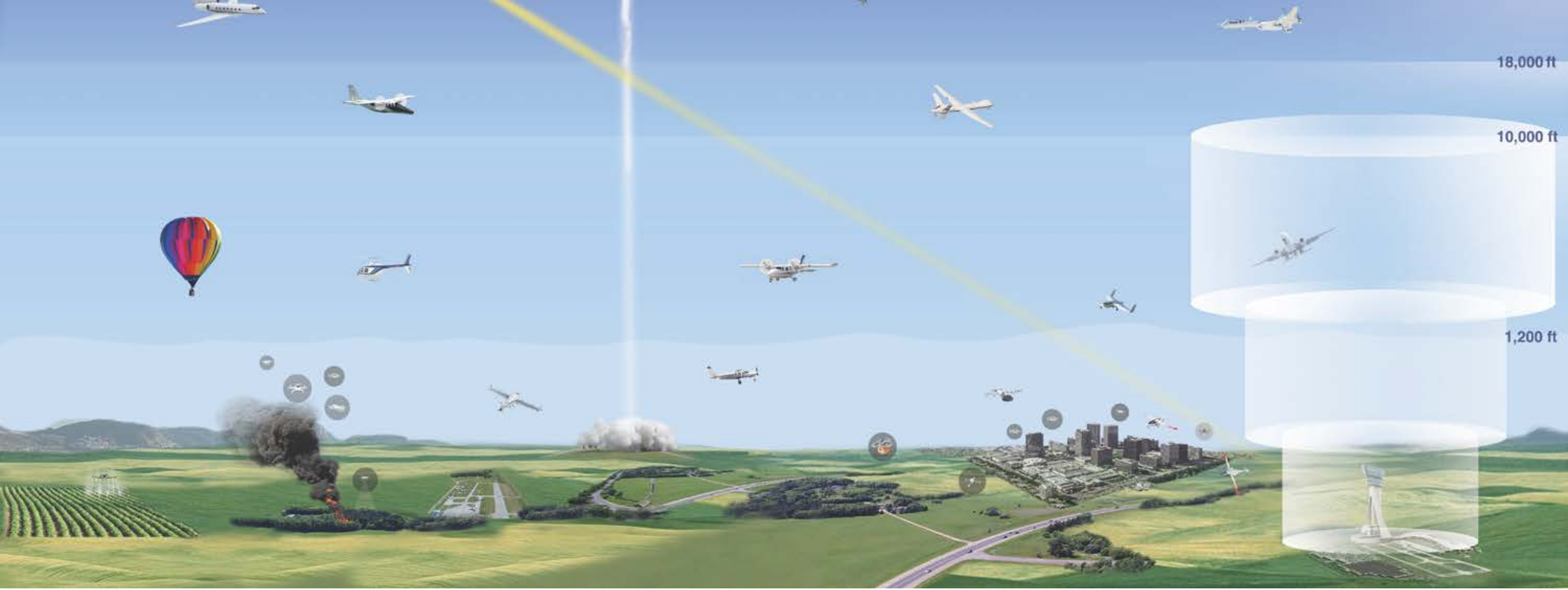
Reduce time to become aviation professional

Training humans, increase automation, create some other hybrid paradigm

?

Prepare for future airspace operations

Current system is technologically behind and won't scale

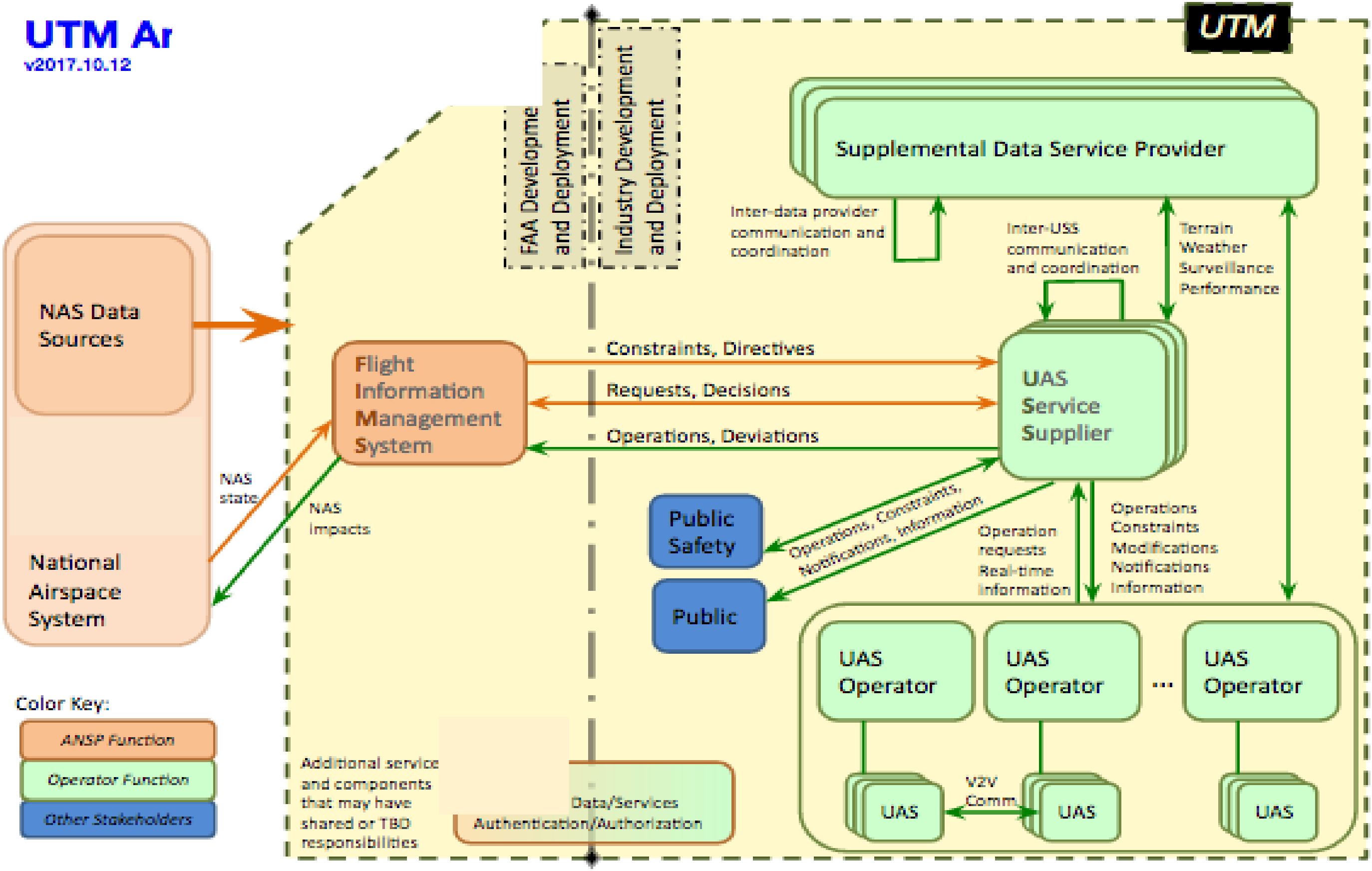


New Entrants need quicker and sustained airspace access

Airspace system needs to be ready when the vehicles are ready

SMALL UNMANNED AIRCRAFT SYSTEMS (UAS)

UAS Traffic Management Architecture



*Connections & communications are internet-based & built on industry standards & protocols

Global Impact

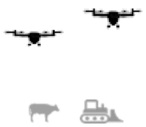
Scaled operations without burdening current air traffic system

Unmanned Aircraft System Traffic Management (UTM)

- Service-oriented architecture
- Cooperative
- Digital
- Intent-sharing
- Third-party services
- Managed by exception

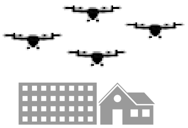
Technical Capability Levels (TCL)

Risk-based development and test approach along four distinct TCL



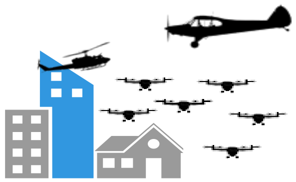
TCL1

- **Outcomes:** Validation of cloud-based service-oriented architecture



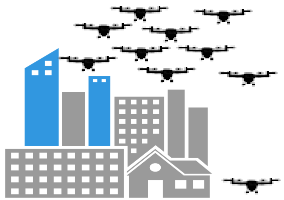
TCL 2

Outcomes: Information sharing between operators, and established federated 3rd party service model to enable BVLOS



TCL 3

Outcomes: Technologies for detect and avoid, comm. and nav., and data exchange between multiple suppliers in presence of manned aviation



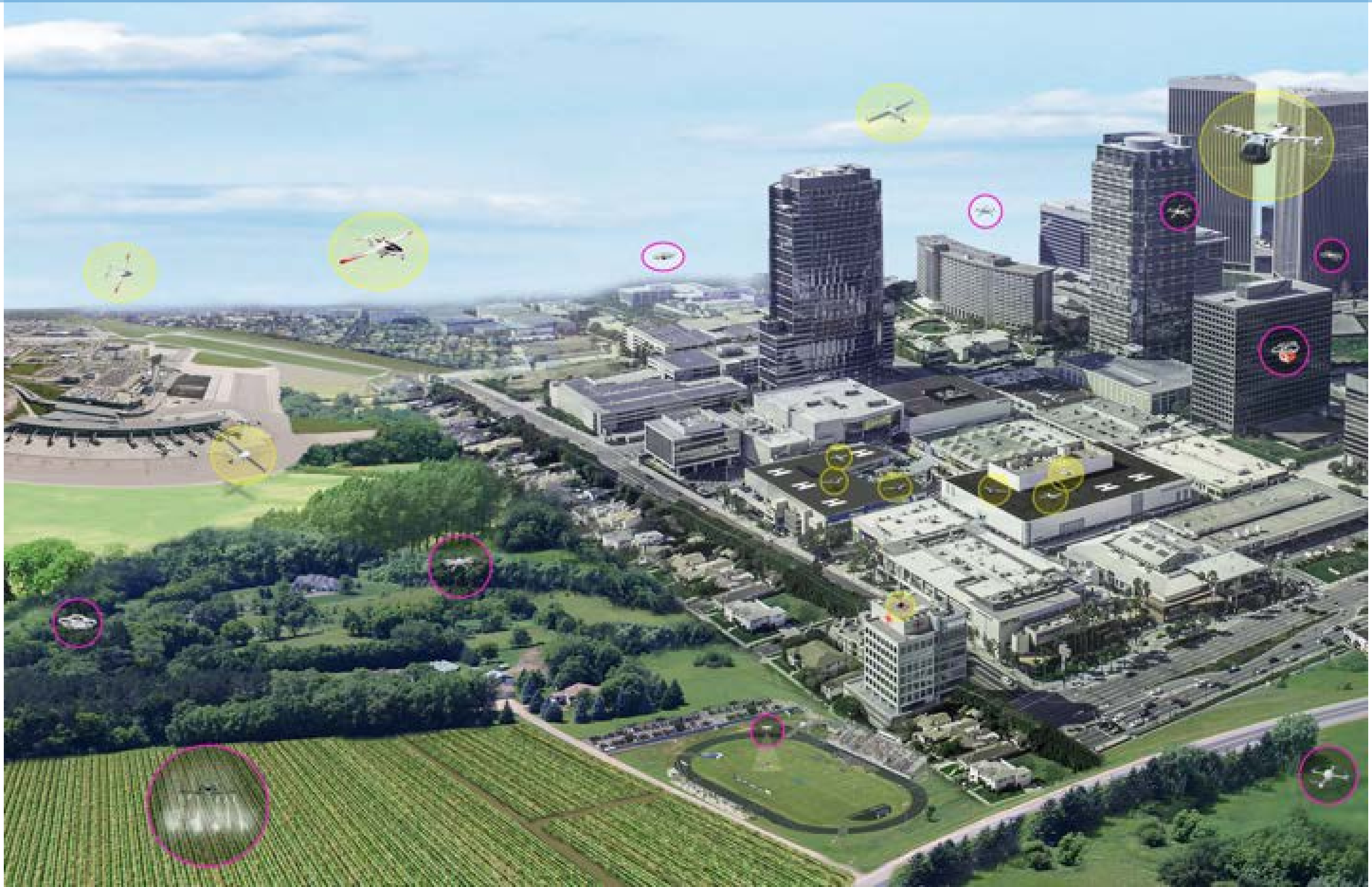
TCL 4

Outcomes: Operational concept, vehicle technologies, and data exchanges for operations near large structures and in highly populated areas

Transformation – Urban Air Mobility

Increasingly autonomous – focused on access, safety and scalability

URBAN AIR MOBILITY: SMALL DRONES TO LARGER PASSENGER CARRYING VTOLS



UTM-LIKE-ATM AIRSPACE OPERATIONS ENVIRONMENT

- Cooperative
- Intent-sharing
- Digital: data exchanges among operators
- Standardized application protocol interfaces
- Air/ground integrated
- Service-oriented architecture
- Role for third parties

Space Traffic Management

High Altitude UTM (upper E)

Conventional Manned Aviation (Class A, B, C, D, E)

Urban Air Mobility

Low-altitude small UAS

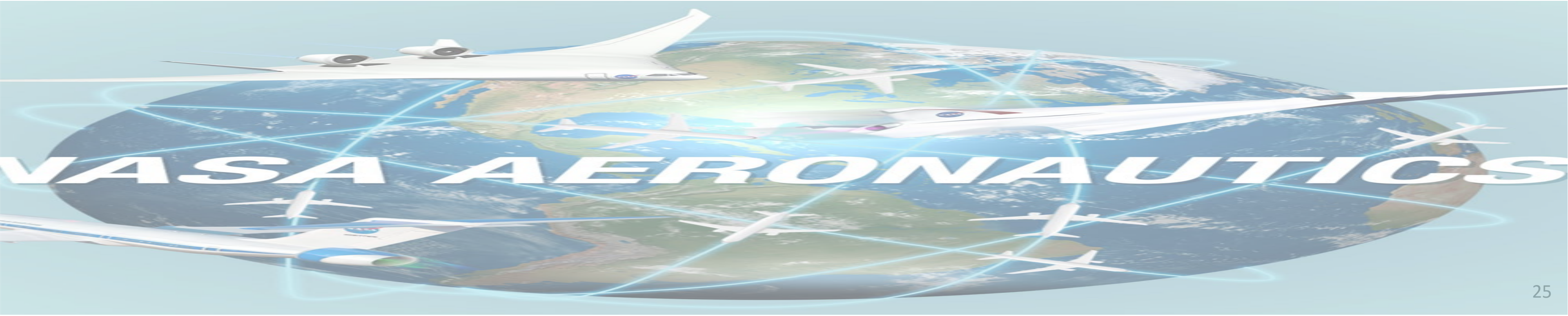
Access, Efficiency, Safety, Scalability, Security, Equity, and many other goals

Transition to UTM-inspired Airspace Traffic Management

Current ATM	UTM-inspired-ATM
All services are provided by FAA	Services are provided FAA and third-parties
Human address off-nominal situations to ensure safety	Automation for off-nominal situations to ensure scalability and safety
Little interaction among users and third parties	Users collaborate for efficiency, preferences for flights into constraints resources
• Human is information integrator • Every data for every vehicle moves through FAA systems • Management by clearances	• Automation is information integrator • New paradigm: Digital, connected ecosystems, outside applications • Movement towards management by exceptions

Research: Architecture, data exchanges, roles/responsibilities, performance requirements for aircraft and airspace system technologies, automation for contingency management and disruption handling, machine learning environment and algorithms for improvements, safety assurance, certification, acceptance approaches

Many opportunities for research and development



Public Service Annoucements

- Internships
  - Intern.nasa.gov
  - Search “Short-term Drone for Search and Rescue”

- Urban Air Mobility Working Groups
  - https://nari.arc.nasa.gov/aam

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embracing innovation in aviation while respecting its safety tradition