NASA Aeronautics
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Global Growth in Aviation
Opportunities and Challenges

2017
4 BILLION
PASSENGER TRIPS

41,030
New Aircraft Deliveries
$6.1 Trillion
Market Value

Airbus / Europe

Asia-Pacific Market is Nearly
40% of New Aircraft Deliveries

Bombardier / Canada

Embraer / Brazil

Global Competitors

2036
7.8 BILLION
PASSENGER TRIPS

78% of New Aircraft Deliveries are
Single Aisle Class (including Regional Jets)

Irkut / Russia

Comac / China

Global Competitors
Urban Air Mobility
Global Race to Achieve Leadership

These and many other U.S. and international competitors have the same vision and are capable of innovative vehicle design, development and flight demonstration.

Large projected market—McKinsey analysis of demand by 2030 in 15 major U.S. cities:
- 500 Million annual UAS package deliveries
- 750 Million annual passenger trips

Extrapolation to the global market would likely increase demand by 5 to 10x
Emerging Aviation Markets

Urban Air Mobility Example

Ehang - China  E-Volo - Germany  Aurora - US  Joby - US

U.S. and international competitors have the same vision. Many international competitors are capable of innovative vehicle design, development and flight demonstration.

The race to capture the market will be won based on:
• Ability to safely certify innovative aviation technologies and configurations
• Achieving equitable community noise standards
• Enabling safe airspace access at high densities
• Achieving safe vertiport infrastructure standards

Most demonstrations and early market adoption are happening overseas. The U.S. must lead or fall behind.

NASA is adjusting its portfolio to support FAA and industry to accelerate U.S. competitive posture through a technically sound, sustainable and scalable approach.
Emerging Markets - Integrated Challenges

NASA ARMD Programs pivoting to address complex challenges

Emerging Market Opportunities

- Small / Medium UAS
- Urban Air Mobility
- Thin/Short Haul Aviation
- Large UAS/HALE

Integrated Aviation System Challenges

- Electrified Aircraft Propulsion & Integration
  flight-critical, flight-weight power/energy
- Noise
  vehicle & fleet
- Weather/Environment-Tolerant
  vehicle robustness (wind/rain/ice…)
- Assured Autonomous Systems & Human Integration
  autonomous awareness and contingency management
  SVO, UAS mission management (one operator controlling multiple vehicles)
- Integrated ATM System
  Efficient, high density operations with access to diverse platforms in airspace with integrated air/ground/cloud technologies
## UAS Traffic Management (UTM) Technical Capability Levels (TCLs)

### CAPABILITY 1: DEMONSTRATED HOW TO ENABLE MULTIPLE OPERATIONS UNDER CONSTRAINTS
- Notification of area of operation
- Over unpopulated land or water
- Minimal general aviation traffic in area
- Contingencies handled by UAS pilot

Product: Overall concept of operations, architecture, and roles

### CAPABILITY 2: DEMONSTRATED HOW TO ENABLE EXPANDED MULTIPLE OPERATIONS
- Beyond visual line-of-sight (BVLOS)
- Tracking and low density operations
- Sparsely populated areas
- Procedures and “rules-of-the-road”
- Longer range applications

Product: Requirements for multiple BVLOS operations including off-nominal dynamic changes

### CAPABILITY 3: FOCUSES ON HOW TO ENABLE MULTIPLE HETEROGENEOUS OPERATIONS
- BVLOS of sight/expanded
- Over moderately populated land
- Some interaction with manned aircraft
- Tracking vehicle to vehicle, vehicle to UTM, and internet connected

Product: Requirements for heterogeneous operations

### CAPABILITY 4: FOCUSES ON ENABLING MULTIPLE HETEROGENEOUS HIGH DENSITY URBAN OPERATIONS
- BVLOS
- Urban environments, higher density
- Autonomous vehicle to vehicle, internet connected
- Large-scale contingencies mitigation
- Urban use cases

Product: Requirements to manage contingencies in high density, heterogeneous, and constrained operations

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Risk-based, Evolutionary Approach to Achieving Revolutionary Capability
Provide research findings, utilizing simulation and flight tests, to support the development and validation of DAA and C2 technologies necessary for integrating Unmanned Aircraft Systems into the National Airspace System.

**UAS in the NAS – Phase 2**

**Project Goal**

- **Technical Challenge-DAA:** Detect and Avoid (DAA)
- **Technical Challenge-C2:** Command and Control (C2)
- **System Integration and Operationalization (SIO)**
FROM SONIC BOOM TO SONIC "THUMP" OVER LAND
Market: Large UAS & HALE

- Large UAS
- Subsonic Fixed wing
- Supersonic Manned Aircraft

Market: Thin/Short Haul

- Small airport
- Weather Tolerant Operations
- Droneport
- Airport
- Vertiport at airport
- Weather Tolerant Operations
- Urban Vertiport

Market: Urban Air Mobility

- Market: Large UAS & HALE
- Market: Thin/Short Haul
- Market: Small / Medium UAS
- Market: Urban Air Mobility
A New Era of Flight is Emerging

NASA Aeronautics vision and leadership has stimulated national and international aviation and non-aviation communities to pursue a new era of aviation:

- Unmanned Aircraft Systems (UAS) Integration into NAS
- UAS Traffic Management (UTM)
- Electric Aircraft
- System Wide Safety
- Low Boom Supersonic Flight
Interesting Questions to Ponder

Is Google building an autonomous car or a big, multi-functional computer on wheels?

F-22: 1.7 million lines of software code
B787: 6.5 million lines of software code
M-B S class: 20 million lines of software code

After 110 years since Ford Model T was first introduced, software is the driving force, not hardware, for creating new markets in automotive industry
Interesting Questions to Ponder

Is Uber in taxi business or sophisticated IT business?

What industrial sector is Google in?

What is Amazon’s main product?

Progressive companies are coming up with innovative business models that are enabled by their core technologies. - traditional classification of business line does not apply anymore

Why do we think aviation industry would not face these changes in coming years or decades?