ODM and SVO
Related Research & Development

March 7, 2016

Steve Velotas and Lisa Rippy

Crew Systems and Aviation Operations
NASA Langley Research Center
Hampton, VA 23681-2199

lisa.o.rippy@nasa.gov, 757 864-6259
steven.velotas@nasa.gov, 757 864-6167
ODM Barriers

- Substantially Higher Operating Costs
- Poor Comparative Safety
- Onerous Training Requirements
- Poor Emissions
- Poor Community Noise
- Poor Dispatch & Trip Reliability
- Increased Traffic Density of Airspace
- Non-traditional NAS Entrance and Exit points
- Efficient Routes and Trajectories
R&D Toward Removing Barriers

Barriers

• Poor Comparative Safety
• Onerous Training Requirements
• Poor Community Noise
• Poor Dispatch & Trip Reliability
• Increased Traffic Density of Airspace
• Non-traditional NAS Entrance and Exit points
• Efficient Routes and Trajectories

R&D

• Intuitive and Adaptive Interfaces
• Operator Monitoring
• Advanced Alerting and Cueing
• Data Analytics for Safety
• Autonomous Systems
• Function Allocation Schemes
• Improved Training
• Human-Automation Teaming
• Operational Autonomy
• Efficient Trajectories and Trajectory Management
• New Airspace Architectures
• Improved Conflict Detection & Resolution Algorithms
• Connected Aircraft Solutions
• New Operational Procedures
Future Requisite Attributes

On Demand Air Transportation
Anyone can travel anywhere at any time.

Obtaining a pilot’s license may for some vehicles / Ops require about the same level of training as is needed to obtain a driver’s license.

Air Vehicles Operate Without Need For Pre-authorization.

Point to Point Travel is Possible

Almost all traffic control is decentralized and vehicle-centric.

Digital data communications

Airspace access for all people.

Fixed ground-based navigation and surveillance systems are minimal, thereby enabling a cost-effective scalable and demand-adaptive infrastructure.

System is robust and resilient.

Population standards ensure interoperability and safety - do not impede modernization, scalability.

Systems are scalable and demand adaptive.

The system is at least as safe as today’s system, even though it accommodates orders of magnitude more vehicles (>5x).

System takes advantage of increasingly autonomous systems.

The system is secure, protecting privacy, protecting national security.

Almost all traffic control is decentralized and vehicle-centric.

All weather operations

Mix of vehicles with mixed avionics equipage

CSAO R&D Swim Lanes

- Trajectory and Airspace Operations Flexibility
- Multi-Agent Teaming
- Human-System Interaction
- Trust and Certification
Trajectory & Airspace Operations Flexibility

- Flight Deck Trajectory Optimization Tool
  - Traffic Aware Strategic Aircrew Requests (TASAR)

- Conflict Detection and Resolution (CD&R) Algorithms
  - Autonomous Operations Planner (AOP)

- Vehicle Autonomous Operations
  - Autonomous Flight Rules (AFR)

- UAS Detect and Avoid Algorithms/Interfaces

- Arrival Spacing Tool and Procedures
  - Flight deck Interval Management (FIM)

- Trajectory Based Operations Solutions
  - Trajectory Management by Constraints

- Urban Metroplex-like Operations
  - Autonomous Departure and Arrival Procedures and Technology (ADAPT)
Multi-Agent Teaming

- **Operator State Monitoring**
  - Channelized/Diverted Attention
  - Optimizing Decision Making
  - Incapacitation

- **Function Allocation Assessments**
  - Separation Assurance Functions
  - Cockpit Roles – Ongoing with FAA OKC

- **Adaptive Automation/Cockpit Interfaces**
  - Collaborative Agent for Path Planning Execution (CAPPE)
  - Cockpit Alerting for Inattentive Operators
  - Traffic Surveillance by Increasingly Autonomous System

- **Connected Aircraft/Vehicles**
  - Dispatch-Aircraft Trajectory Collaboration

- **Vehicle to Vehicle (V2V) Collaboration**
  - Drone and Rover collaboration
  - V2V Teaming for CD&R
Human-System Interaction

• Vision Systems Technologies
  – Enhanced Flight Vision Systems (EFVS)
  – Synthetic and Enhanced Vision Systems (SEVS)
  – eXternal Vision Systems (XVS)

• Head Worn Displays
  – Improve Operator’s Situational Awareness
  – Augmented Reality

• Training for Attention Management
  – Addressing and Improving Operator Self Management
    • Aircraft State Awareness/Instrument Scan
  – Increased Efficiency in Ground Training

• Advanced and Configurable Cockpit Displays
  – Vehicle Attitude Awareness and Safety
  – Traffic and Constraint awareness

• Gesture and Voice Controls
  – Small UAS Management and Control
  – Voice Activated Cockpit Management System
Trust and Certification

• Development of Human-Autonomous System Teaming Metrics
• Trusting Non-Deterministic Autonomous Agents
• Trust of Humans by Increasingly Autonomous Systems
• Assured Algorithms for Trajectory Prediction and CD&R
• Certification Considerations for Non-Deterministic and Adaptive Systems
How Do We Get to the Future?

Vehicles: Manually Piloted / Remotely Piloted / Passengers / Occupants/ Fully Autonomous / Optionally Piloted / Tethered / Flocked / Floating

Air Vehicles Operate Without Need For Pre-authorization.

System standards ensure interoperability and safety - do not impede modernization, scalability.

On Demand Air Transportation
Anyone can travel anywhere at any time.

Fixed ground-based navigation and surveillance systems are minimal, thereby enabling a cost-effective scalable and demand-adaptive infrastructure.

The system is at least as safe as today’s system, even though it accommodates orders of magnitude more vehicles.

The system is secure, protecting privacy, protecting national.

Obtaining a pilot’s license may for some vehicles / Ops require about the same level of training as is needed to obtain a driver’s license.

Almost all traffic control is decentralized and - vehicle-centric.

PAVs

Air Taxi

Helicopters

Autonomous

Cargo

Supersonic Vehicles

Legacy

UAVs

There Are Many Possible Outcomes / Instantiations of What the Future Will Be… We Need To Create Technologies That Can Enable Any Number Of These Possibilities
Research and Development Swim Lanes

1. Trajectory and Airspace Operations Flexibility
2. Multi-agent Teaming
3. Human-System Interaction
4. Trust and Certification

Delegated Separation
Autonomous Vehicles
V2V Wake and Wx Mitigation
ADAPT
AFR
Ab Initio NAS
A-IM
ODM
Alternative UAS
CERO
Connected Distributed ATM
V2V Collaboration
Flyer’s License
Self-aware Aircraft
Haptic Controls
Adaptive Automation
Cockpit of the Future
Brain-computer Interface
Trust – machine
Trust – machine
Trusted Attention
Certification Transformation for Autonomy

Traditional Certification Methods

En route CD&R
Surface CD&R
ITP
Stratway
SVS
EFVS
SEVS
HWD
Daidalus
ASTAR
TASAR
SPO
RCO
CSM
SEVS
HWD
TDM
CAPPE
V2V Wake and Wx Mitigation
ADAPT
AFR
Ab Initio NAS
A-IM
ODM
Alternative UAS
CERO
Connected Distributed ATM
V2V Collaboration
Flyer’s License
Self-aware Aircraft
Haptic Controls
Adaptive Automation
Cockpit of the Future
Brain-computer Interface
Trust – machine
Trust – machine
Trusted Attention
Certification Transformation for Autonomy

Increasingly Autonomous Systems

Metrics for Increasingly Autonomous Systems
Where CSAOB Wants to Go With R&D

• Adaptive Human-Automation Interaction/Teaming
• Vehicle Operational Autonomy
• Onboard Trajectory Management
• Cockpit of the Future
  – Including for Variably Crewed Vehicles
  – Operator Training and Certification Requirements
• Connected Aircraft and V2V Collaboration Solutions
• Increasingly Autonomous System Solutions for:
  – Emergency Response Vehicles
  – Thin Haul sized aircraft
  – General Aviation
• Certification, Trust, and V&V of Complex Systems
• Integration of Revolutionary Vehicles into the NAS
  – sUAS, PAV, VTOL, Supersonic, Fully Autonomous Vehicles
• Efficient Airspace Solutions and Procedures
  – Including Trajectory Based Operations
• Identification, Alerting, and Mitigation of Safety Issues
CSAO/LaRC Facilities

Phased, Complex UAS Test
LaRC / NASA / Industry
Questions?