



Working Group Update

SIMPLIFIED VEHICLE OPERATIONS (SVO) & ODM AIRSPACE INTEGRATION

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Ken Goodrich, Workgroup Lead



➤ SVO

- Small aircraft safety and ease of use
- Flight systems, interfaces, operations, training that make ODM aviation as accessible & practical as driving
- Practical transportation -> target all-weather operations
- Incremental revolutions: 1) Expert -> 2) Operator -> 3) User

➤ ODM Airspace Integration

- Procedures by which individual and multiple vehicles operate, ultimately at traffic levels significantly above current (long term, 10-100x? Current peak, ~10,000 aircraft aloft over US)
- Airspace tends to lag vehicle capabilities
 - Integrate with & simplify within the present system
 - Create the future, leveraging other new airspace users (e.g. UAS)

➤ Proving ground for scale-up and down technology applications

On-Demand Mobility Goals



10 Prioritized Feasibility Barrier Goals

Ease of Certification <u>Metric</u> Time/Cost Required	Affordability <u>Metric</u> Total Operating Cost/Pax Mile	Safety <u>Metric</u> Fatal Accidents per Vehicle Mile	Ease of Use <u>Metric</u> Required Operator Training Time & Cost	Door to Door Trip Speed <u>Metric</u> mph	Average Trip Delay <u>Metric</u> Time	Community Noise <u>Metric</u> Perceived Relative Annoyance @ Community Stand-off Distance	Ride Quality <u>Metric</u> Passenger Comfort Index	Efficiency <u>Metric</u> Energy/Pax Mile	Lifecycle Emissions <u>Metric</u> Total Emissions /Pax Mile
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SVO & Airspace Contributions to ODM Goals



Ease of
Certification

Metric
Time/Cost
Required

- Clear standards and compliance methods for SVO functions, systems & technologies
 - ASTM F39 and F44 provide mechanisms for new airworthiness standards (...if there's industry interest and consensus)
 - Also need to impact *pilot licensing and operations*

SVO & Airspace Contributions to ODM Goals



Safety

Metric

Fatal

Accidents per
Vehicle Mile

- Comprehensive, system safety perspective
 - Unified consideration and analysis of...
Pilot + Aircraft & Systems + Independent Safety Backups + Off-board Support + Airspace Systems + Operations
 - Consensus AC 23.1309 interpretation and nominal performance/reliability allocations between system and sub-system elements
- Top safety opportunities
 - Loss of control, CFIT, unstable approaches, go-arounds, fatigue & fitness for duty,
 - System and mode complexity, degraded modes

SVO & Airspace Contributions to ODM Goals



Affordability

Metric

Total Operating
Cost/Pax Mile

- Resilient configuration design
 - Aero-propulsive control integration
- Analytical and software-based redundancy
 - Information and sensor cross-checking for fault or hazard detection & mitigation
- Fault-tolerant, COTS-based, avionics
- Actuation for critical, augmented flight control

SVO & Airspace Contributions to ODM Goals



Ease of Use

Metric
Required
Operator
Training
Time & Cost

- Initial training
- Recurrent training
- Workload
 - Planning
 - Preflight preparation and inspection
 - Ground and flight operations (aircraft and airspace)
 - Post-flight

SVO & Airspace Contributions to ODM Goals



Door to Door
Trip Speed

Metric
mph

- Planning time
- Ground handling & inspection time
- Inter-modal connectivity and coordination
- ATM routing & procedures
- ATM delays

SVO & Airspace Contributions to ODM Goals



Average Trip
Delay

Metric
Time

- Weather penetration
 - E.g. anti-icing, ride-quality in turbulence
- Accurate weather avoidance during planning and in-flight
- System, dispatch reliability

SVO & Airspace Contributions to ODM Goals



Community
Noise

Metric

Perceived
Relative
Annoyance

@

Community
Stand-off
Distance

- Airspace routing and procedures for reduced community impact
- Aircraft-specific noise abatement procedures

SVO & Airspace Contributions to ODM Goals



Ride Quality

Metric
Passenger
Comfort
Index

- Integrated flight & propulsion control for simplified flight path management with high-wing loading
- Active ride control?

SVO & Airspace Contributions to ODM Goals



Efficiency

Metric
Energy/Pax
Mile

- Efficient ATM routing
- Optimal aircraft speeds and configuration management
- Wind aware flight planning
- Relaxed stability for reduced trim drag?

Lifecycle
Emissions

Metric
Total
Emissions
/Pax Mile

Strategy: Expert -> Operator -> User



➤ Epochs 1, 2 & 3

- 1) Foundational technologies & partial integration; 2) Integrated system for credit; 3) Long-term

➤ Guidelines for epoch 2, integrated system and Simplified Pilot Certificate:

- Initial operating capability approximately 10 years out, 2025
- Still has an “operator in command” responsibility for overall safety, but freed from many low-level skills, monitoring tasks, reversionary interventions, specialized knowledge
- Operation in low-visibility is essential for reliable transportation
- Will initially operate within NextGen airspace
- ~40 hours of training non-commercial operator and 250 hours for Part 135 pilot-in-command
- The operator supported by vehicle systems that dramatically simplify the tasks of vehicle control, systems management, navigation, communication, regulatory compliance, obtaining and integrating weather and other information, and flight and performance planning and monitoring.
- As a cross-check of, and back-up to the operator, the vehicle should be capable of detecting and recommending appropriate mitigations for all “routine” aviation hazards. The ability of the automation to autonomously act to maintain safety of flight in the event of operator impairment or inaction is a potential area of development although the capability probably appears later rather than earlier in Epoch 2.
- The vehicle should have an independent back-up safety capability, such as a whole aircraft parachute, providing additional, dissimilar protection to vehicle occupants and persons & property on the ground.

SVO & Airspace Technology List



➤ Foundational technologies and analysis

- Top-level, preliminary system safety assessments for representative concepts
 - Targeted roles, responsibilities, reliabilities for operator, aircraft, and airspace elements
- Low-cost, fault-tolerant, COTS-based avionics architecture
- Software cross-checking for fault & hazard detection & mitigation
- Certification of “nondeterministic” systems
- System modeling and identification for design, certification & training
- Digital communications for advanced ATM, flight information, operations support applications
- Standard atmospheric turbulence & disturbance models aircraft and control system design & verification
- Aero-propulsive integrated control design guidelines (with Electric Propulsion and Configuration Integration workgroup)
- Independent, emergency safety backup (with MISC workgroup)

SVO & Airspace Technology List



➤ **Pilot aids, automation, and autonomy**

- Integrated flight and training system for Simplified Pilot Certificate (Epoch 2)
- Pre and post-flight automation for airworthiness assurance
- Automated weight and balance verification
- Augmented Flight Controls (AFC)
- Pilot training & licensing for distributed propulsion configurations with augmented control
- Autonomous traffic, hazard & feature detect & react
- Comprehensive self-preservation / refuse to crash
- Integrated flight & contingency planning, monitoring, and management

➤ **Airspace System and Operations**

- Simplified interface to current, voice-based ATC system (e.g. speech to digital)
- Autonomous Flight Rules for high-density ODM enroute and terminal operations
- Automation assisted VFR for technology proof of concept
- Low-noise procedures for community compatibility

Summary and Guidance for Breakouts



- **Focus on foundational technologies and 2025 integrated system**
 - Foundational technologies enabling to early distributed electric configurations
 - Flight critical, AFC exercises integration of airworthiness and pilot certification considerations
 - Operational experience essential to development and acceptance of integrated system
 - Integrated system targeting simplified operations and SPC
 - Initial development guided by training and safety targets and system safety assessment
- **Breakout tasks**
 - Review strategy and identified technologies
 - Additional technologies
 - Certification requirements, compliance methods, and supporting data
 - Other essential activities
- **Contact k.goodrich@nasa.gov to be added to svo-airspace mail list**