Workshop Outcomes—More than Roadmap

- Community
- Vision for ODM and On-Demand Aviation (ODA)
- Preliminary technology roadmap
  - Critical enabling capabilities
  - Technology gaps & barriers
  - High-priority, technologies and supporting precompetitive tools, guidelines, standards and certification methods
- Working groups to continue roadmap development beyond workshop
- Partnership and research opportunities
Areas of Interest from Registration Survey

- Improved Safety
- Reduced Ease of/Reduced Training
- Reduced Community Noise
- Reduced Emissions
- Improved Ride Quality
- Improved Trip Reliability
- Operating Cost Reduction
- Improved Regulations to Implement Advanced...
- Increased Operation Traffic Density/Airspace...
- Reduced Vehicle Cost/Improved Manufacturing...
Workshop Overview

October 21: Developing common vision and understanding

- Workshop overview and introductions
- NASA’s emerging ODM vision and technology interests
- FAA thrusts and priorities
- Industry and academia perspectives
- Full-group discussion: Top priorities and supporting-priorities

October 22: Roadmap and Partnership Building

- Roadmapping overview & preliminary examples
- Roadmapping breakout sessions
- Breakout session reports
- Partnerships discussion
- Post-workshop working groups
- Wrap-up, adjourn
Roadmap Elements

- Goals
- Milestones
- Gaps and barriers
- Action items
- Priorities and timelines
Roadmap Elements, cont.

Goals: A clear and concise set of targets that, if achieved, will result in the desired outcome; quantified goals (e.g. “improve energy efficiency in commercial buildings by 25% in ten years”) provide the most specific guidance.

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Action items: Actions that can be taken to overcome any gaps or barriers that stand in the way of achieving the goals; typical solution actions include technology development and deployment, development of regulations and standards, policy formulation, creation of financing mechanisms, and public engagement.

Priorities and timelines: A list of the most important actions that need to be taken in order to achieve the goals and the time frames, taking into account interconnections among those actions and stakeholder roles and relationships.
Pre-Competitive Research and Products

- The focus of any R&D collaboration in the U.S. must by law be on precompetitive deliverables.

- Public-good primary justification for public investment:
  - Public benefit without private preference desired
  - Temporary, head-start for certain types of contracts & agreements (e.g. 5 year nondisclosure period for SBIRs)

- For aviation, typically:
  - Industry design tools and guidelines
  - System and operational standards (e.g. RTCA MASPS and MOPS)
  - Certification Methods
Questions?
Introductions
- NASA
- FAA and other Government
- Nonprofit and Edu
- Industry
## Workshop Participants, NASA

<table>
<thead>
<tr>
<th>NASA</th>
<th>Organization</th>
<th>Title</th>
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<tbody>
<tr>
<td>Rohn, Douglas</td>
<td>Headquarters</td>
<td>Program Director, Transformative Aeronautics Concepts</td>
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<tr>
<td>Ginn, Tony</td>
<td>Armstrong</td>
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<tr>
<td>Jankovsky, Amy</td>
<td>Glenn</td>
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<td>Jansen, Ralph</td>
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<tr>
<td>Finelli, George</td>
<td>Langley</td>
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<tr>
<td>Ferebee, Michelle</td>
<td>Langley</td>
<td>Strategy and New Business Manager</td>
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<td>Moore, Mark</td>
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<td>Goodrich, Ken</td>
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<td>Bauer, Steven</td>
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<td>Fredericks, William</td>
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<td>Holland, Scott</td>
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<tr>
<td>Mukhopadhyay, Vivek</td>
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<tr>
<td>Parikh, Paresh</td>
<td>Langley</td>
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<td>Patterson, Michael</td>
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<td>Rhew, Ray</td>
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<tr>
<td>Rippy, Lisa</td>
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<td>Head, Crew Systems and Aviation Operations Branch</td>
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# Workshop Participants, FAA & other Government

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<tr>
<td>Johnson, Mel</td>
<td>Small Aircraft Directorate</td>
<td>Acting Directorate Manager</td>
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<tr>
<td>Fernandez, Jorge</td>
<td>Engine and Propeller Directorate</td>
<td>Aerospace Engineer</td>
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<tr>
<td>Foster, Lowell</td>
<td>Small Aircraft Directorate</td>
<td>Flight Test Engineer</td>
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<tr>
<td>Greene, Kevin</td>
<td>Transport Airplane Directorate</td>
<td>Flight Test Pilot</td>
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<tr>
<td>McGuire, Robert</td>
<td>Aviation Research Division (Tech Center)</td>
<td>Aerospace Engineer</td>
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<tr>
<td>Ryan, Wes</td>
<td>Small Aircraft Directorate</td>
<td>Manager, ACE-114</td>
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<tr>
<td>Sizoo, David</td>
<td>Small Aircraft Directorate</td>
<td>Exp Flight Test Pilot and HF Specialist</td>
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<tr>
<td>Sparacino, Peter</td>
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<td>FAA Program Manger for the Center of Excellence for Aviation</td>
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<tr>
<td>VanHoudt, John</td>
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<tr>
<td>Witzig, William</td>
<td>Engine and Propeller Directorate</td>
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<tr>
<td>Schultz, Warren</td>
<td>Naval Research Laboratory</td>
<td>Associate Superintendent, Chemistry Division</td>
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## Workshop Participants, Non-Profit and Edu

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<tr>
<td>Landsberg, Bruce</td>
<td>AOPA</td>
<td>Senior Safety Advisor</td>
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<tr>
<td>Aldag, Tom</td>
<td>National Institute of Aviation Research</td>
<td>Director, R&amp;D</td>
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<tr>
<td>Stanley, Doug</td>
<td>National Institute of Aerospace</td>
<td>President</td>
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<tr>
<td>Crossley, William</td>
<td>Purdue University/FAA Center of Excellence for General Aviation</td>
<td>Professor of Aeronautics and Astronautics/PEGASAS Director</td>
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<tr>
<td>Hook, Loyd</td>
<td>University of Tulsa</td>
<td>Professor</td>
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<tr>
<td>Zheng, S. Charlie</td>
<td>University of Kansas</td>
<td>Professor</td>
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# Workshop Participants, Industry

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Alejo, Dominique</td>
<td>SAFRAN</td>
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<tr>
<td>Anemaat, Willem</td>
<td>Design, Analysis and Research Corporation</td>
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<td>Anghel, Christian</td>
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<td>Armstrong, Mike</td>
<td>Rolls-Royce North American Technologies, Inc.</td>
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<tr>
<td>Bar-Yohay, Omer</td>
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<td>Devine, Thomas</td>
<td>Thomas International, Inc.</td>
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<td>Dietrich, Carl</td>
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<td>Duerksen, Noel</td>
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<td>Foster, Trevor</td>
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<td>Gundlach, John</td>
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<td>Latham, Geoffrey</td>
<td>Bell Helicopter</td>
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<td>Mochida, Kazuhiko</td>
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<td>Nuss, Marv</td>
<td>Nuss Sustainment Solutions</td>
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<td>Ouellette, Richard</td>
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<td>Rodeman, Boyd</td>
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<td>Santucci, Chris</td>
<td>Toyota Motor North America, Inc.</td>
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<td>Sarh, Branko</td>
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<td>Skriba, Bud</td>
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<td>Thibodeau, Phillip</td>
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<td>Willford, Neal</td>
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<td>Ximenes, Samuel</td>
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<td>Yadgar, Avi</td>
<td>Phinergy LTD</td>
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<td>Yarbrough, Jon</td>
<td>Yarbrough Capital</td>
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Industry and Academia Perspectives

12:30 PM  Joby Aviation
12:45 PM  Phinergy LTD
1:00 PM   Tzunum
1:15 PM   Eviation LLC
1:30 PM   Avionics Technologies, Inc.
1:45 PM   Honeywell
2:00 PM   Emmett Kraus
2:15 PM   Naval Research Laboratory
2:30 PM   AOPA Senior Safety Advisor
2:45 PM   IAI
3:00 PM   Adaptive Aerospace Group
3:15 PM   University of Kansas
3:30 PM   Boeing
Roadmapping Breakout Session Overview

Ken Goodrich

October 22, 2015
**Definition**

**Roadmap:** a specialized type of strategic plan that outlines activities an organization can undertake over specified time frames to achieve stated goals and outcomes.
Roadmap Elements

- Goals
- Milestones
- Gaps and barriers
- Action items
- Priorities and timelines
Roadmap Elements, cont.

**Goals:** a clear and concise set of targets that, if achieved, will result in the desired outcome; quantified goals (e.g. “improve energy efficiency in commercial buildings by 25% in ten years”) provide the most specific guidance.

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Goals for Today’s Breakout Sessions

- Build on priorities expressed during yesterday afternoon’s group discussion
- Breakouts for EP, SVO, and Other
- 3 x 30 minute sessions for participation in multiple topics
  - Encouraged to rotate, but may repeat

Process
- Facilitators briefly surmise previous sessions
- Clarify goals, milestones, gaps & barriers as needed (~5 minutes)
- Primary focus is on identifying possible technical approaches and supporting actions (e.g. studies) and pre-competitive products (~15 minutes)
- Briefly consider desired (but realistic) timeframe for key products (~5 minutes)
- Today’s focus on capturing action space of participants; refinement comes later
- Express dissent but allow majority to continue
Questions / Comments?
Simplified Vehicle Operations
Example Roadmap
Decomposition

Ken Goodrich

October 22, 2015
Top-Level ODM Barriers & SVO

Current General Aviation (GA) Aircraft compared to Commercial Airliners

• Poor Aerodynamic and Propulsive Efficiencies
  • Aerodynamic efficiency measured as Lift/Drag ratio is 9-11 compared to 17-20.
  • (Thermal) x (propulsive efficiency) of 20-24% compared to 36-40%.

• Poor Emissions
  • High Hydrocarbon, Green House Gas emissions, particulates and lead pollution.

• Poor Community Noise
  • Similar levels and certification compliance with few improvements for the past 50 years.

• Poor Comparative Safety
  • Accident rate 56x worse than airlines, 15x worse than autos per 100 million vehicle miles traveled.

• Poor Ride Quality
  • Low wing loading leads to bumpy ride along with gust sensitivity. (Note, technology needed for SVO also applicable to active gust alleviation)

• Poor Dispatch Reliability Rate
  • Maintenance and weather sensitivity result in <70% rate for trip completion.

• Substantially Higher Operating Costs
  • Compared to all other transportation options (car, airline, train).

• Onerous Training Requirements
  • Currently only 0.18% of the U.S. population is capable of flying GA aircraft compared to 69% who have a driver’s license.
SVO Roadmap: Goals

- Flight systems, interfaces, and operations that make ODM aviation as accessible and practical as driving + safer
- Simplified control of conventional and novel aircraft configurations
- Approach aligned with developing and operationally proving technologies beneficial to transport and other aviation operations
Pilot

Aircraft and systems

Remote support (e.g. dispatch, ground-pilot)

Airspace System & Operations

- Relatively inflexible in the near-term
- Must design for the present and possible futures
- Some near-term operational simplification possible by limiting navigation and operation options (...with some negatives)
Possible SVO Work Breakdown Structure

1) System concepts, integration, and evaluation
2) Pilot certification and training
3) Pilot-vehicle interface
4) Flight and trajectory control
5) Autonomous vehicle awareness, decision support, and hazard avoidance
6) Integrated vehicle health management
7) Safety-critical systems
8) Remote flight and decision support
9) Airspace Operations and Integration
Milestones: 3 SVO Epochs, 10 years?

- **SVO-1**, (2016-2026): Foundational Precedents & Capabilities
- **SVO-2**, (2021-2036): SPC, Simplified Pilot Certificate
- **SVO-3**, (2031-2051): Autonomous Operations,
**SVO-1: Foundational Precedent and Supporting Capabilities**

- Demonstrate transition of key skill/capability from pilot to aircraft
  - E.g., Simplified path control
- Moderate workload peaks and specialized skills
- Mitigate pilot as single-point of failure (...automation back-stops pilot)
- Other considerations:
  - Expect only incremental airworthiness certification accommodation, but lays foundation for future
  - Current FAA training required (e.g. ab initio-to IFR in minimum of 70 hours with combined private-instrument curriculum), but new pilots capable of more confident, near-all weather ops.
  - Benefits/grows thin-haul, air taxi, current and early adopter private-pilot markets
  - Operational experience for SVO-2, Part 121, and UAS applications
  - Operate within current and planned NextGen Airspace

- Simplified training & licensing based on research and operational experience from SVO-1

- Regulatory changes to knowledge, training, and experience requirements
  - Goal ab initio to near-all weather pilot in <40 hours (similar to driver training)
  - Reduced training, experience requirements for Thin-Haul pilots

- New flight system, interfaces, and operation standards that allow updates to training and operational regulations in Part 61, 91, and 135 taking full advantage of technology
  - E.g. possible expansions to Part 135 operations

- Initial airspace accommodations for simpler & higher-volume operations
  - Automated management of non-towered airports
  - More frequent use of data comm.
**SVO-3 (2031 - 2051): Autonomous Operations**

- Combination of aircraft and any off-board board support shoulder command responsibility; nominally accommodates user direction, but may modify or inhibit if deemed unsafe or disruptive

- Vehicle, automation, and airspace fully integrated
  - >>10x current operations
  - Runway independent operations very common
  - No need for voice communication
Example SVO-1, Gaps and Barriers

- Knowledge
- Standards
- Regulatory
- Economic
- Public acceptance
Example SVO-1, Gaps and Barriers

➢ Knowledge
  • Optimal roles, responsibilities, interfaces for simplified path control, systems, and mission management
  • Autonomous situation awareness, decision support, hazard protection with CRM-like interaction
    ▪ E.g. context aware including own limits,
  • Ultra-high integrity, available systems with graceful degradation
  • Alternate systems for safe recovery (e.g. ballistic chute)
  • Aids to simplify interactions with current and planned ATM system

➢ Standards
➢ Regulatory
➢ Economic
➢ Public acceptance
Example SVO-1, Gaps and Barriers

- **Knowledge**
- **Standards**
  - Design & flying qualities standards for simplified path control, normal and degraded modes
  - SVO equivalent of Basic-T & GAMA Publication #10
  - Standard architecture & AC23.1309 analysis
  - Minimum operatizing performance standards avionics
- **Regulatory**
- **Economic**
- **Public acceptance**
Example SVO-1, Gaps and Barriers

- Knowledge
- Standards
- Regulatory
  - Certification standards for core capabilities
  - Modified training and operational regs.
- Economic
- Public acceptance
Example SVO-1, Gaps and Barriers

- Knowledge
- Standards
- Regulatory
- Economic
  - Reusable, open architecture/design for flight-critical systems, reduced non-recurring development costs
- Public acceptance
Example SVO-1, Gaps and Barriers

- Knowledge
- Standards
- Regulatory
- Economic
- Public acceptance
  
  • Traveling demonstration for travel and transportation trade-shows
Summary

- Examples only—not constraints
- Time today is limited
  - Big picture, avoid weeds
  - Will flesh-out post workshop
- Questions?