I PREDICT:
The Future Will Be What We Make It To Be
This Is A NASA Funded Project With The Purpose Of Enabling And Encouraging Advanced Air Mobility (AAM) Through Development Of An Airmen And Aircraft Certification Path To Facilitate AAM.

The FAA Is Participating To Guide This Project In Such A Way That The Proposals Are Feasible From A Regulatory View.
We Consider The Proposals Provided To Be Set Solidly In Jell-O®.

We Have Asked You To Be Part Of Our Advisory Team To Help Make Them More Solid.

This presentation and accompanying report are a work in progress. As such, they are incomplete.
Designed for Future Cockpit Users

When the computer fails, give control to the pilot.

Rodger Ramjet
Airplanes / Helicopters
Designed for Current Skilled Pilots
Conventional Controls

Pilot Skill

Cockpit Design Philosophy

PAST

PRESENT

FUTURE

Automation

Just get me there quickly and safely.

Nintendo Kid
eVTOL
Designed for Future Cockpit Users
Controls that Cannot be Managed by a Human

I PREDICT:
Our Kids Will Outlast Us and Take Over
We MUST Move Past the Philosophy that the Pilot Backs Up the Automation so we can Improve Safety and Utility

When the computer fails, give control to the pilot.

Just get me there quickly and safely.

Conventional Aircraft with Mechanical Controls That Have Separate Propulsion and Control Systems That Can be Managed by a Human
- Designed With the Assumption that the Pilot Saves the Aircraft After Automation Failure
- Designed for Current Skilled Pilots but if the Pilot Errors and Loses Control of the Aircraft it Crashes

Fatal Loss Of Control Due To Pilot Error in Single Pilot Operations: \( \sim 10^{-5} \)

Reliability Of Automation: Whatever We Design It To Be

eVTOL Aircraft with Electronic Integrated Propulsion and Control Using Multiple Motors That Cannot be Managed by a Human
- Automation is Designed to be Fail Operational but if the Automation Fails Completely the Aircraft Crashes
- Designed for Future Cockpit Users where the Automation Saves the Aircraft From Pilot Errors

Rodger Ramjet

Nintendo Kid

~10E-5
**Normal Category Aircraft Certification Parts:**
- Airplanes (Part 23)
- Rotorcraft (Part 27)
- SVO (Part 53?)

**Pilot License Categories and classes:**
- **Airplane**
  - Single Engine Land
  - Multi-engine sea
  - Etc.
- **Rotorcraft**
  - Helicopter
  - Gyrocopter
- **Powered Lift**
- SVO
  - SVO-1
  - SVO-2

**Definitions (FAR Part 1):** SVO-1 and SVO-2 are aircraft that meet the SVO-1 or SVO-2 (Part 53?) requirements. They can be airplanes, rotorcraft, or something else. The form of energy used, number of powerplants and means of generating lift is immaterial. What differentiates an SVO aircraft from others is the flight characteristics from the pilot’s perspective.

**Aircraft and Airman Certification Definitions:**
- **Airplane:** Supported in Flight by a Fixed Wing(s)
- **Rotorcraft:** Supported in Flight by Rotor(s)
- **SVO:** Has Safety, Automation, and Flight Characteristics that Define SVO

An SVO Aircraft Can Be An Airplane, Rotorcraft, Powered Lift, Or Use Any Combination of Lift And Propulsion
Current Aircraft and Pilot Certification Methods

Airplane and rotorcraft design has stabilized for many years. Development involves relatively minor changes to aircraft operational characteristics over time. The current regulations have evolved to accommodate these operational characteristics.

Custom Aircraft and Pilot Certification Methods

New technologies have created the opportunity to change the fundamental way that aircraft operate. These changes can be in conflict with the regulations and regulatory philosophies developed for current aircraft.

The FAA has methods to accommodate this kind of change. Special Conditions are used to for aircraft design. Each applicant will develop model-specific pilot training and certification requirements with the FAA.

These methods require more time compared to a standardized method and consume significantly more resources for both the applicant and the FAA.

Standardized SVO / eVTOL Aircraft and Pilot Certification Methods

After new regulations have been developed for SVO / eVTOL aircraft the certification process for these vehicles is similar to the current methods.
The color intensity of the bar indicates the number of aircraft using each certification method.

Now  Time

- The Current and SVO certification methods are similar in that they use defined rules that were developed to accommodate these aircraft.

- The Custom certification methods represent the current situation where technology has developed such that current regulations don’t apply well for either aircraft certification or pilot certification. Custom certification uses special conditions for aircraft and applicant specific procedures for pilots.
SVO-1, SVO-2, and SVO-3 General Philosophy

**SVO1:**
- Leverage current fixed wing pilots
- Significantly reduce the burden to learn VTOL and hover operations
- Improve reliability of existing automation (autopilots, FMS, etc.) to eliminate manual backup
- Use data from existing operations of automation for aircraft certification credit
- New SVO pilot license with SVO1 rating – easy add-on for existing pilots, reduced training for novice pilots

**SVO2:**
- Designed for pilots with no previous aircraft experience
- Command flight path
- Focus on navigating – not maneuvering
- Most pre-flight planning is automated
- New SVO pilot license with SVO2 rating – easy add-on for existing pilots, minimal training for novice pilots (targeting 1-2 weeks total including instrument rating)

**SVO3:**
- Point and click control – fully autonomous normal operation after destination is identified
- Fully automated preflight planning
- ATC or fleet operator can change destination or routing
- No pilot license
Certify New Technology Functionality via Special Condition – No Credit Given

New Operational Capability But Pilot Skill is Backup

Add Pilot Training Tasks (Learn Manual Operation Plus Automated Operation No Operational Standard)

Historical Certification Path for Technology

New Certification Approach for SVO

Determine Desired Pilot Tasks for Automation Along With Pilot Interface

Determine Desired Operational Capability

Develop Aircraft Certification Requirements for Automation Including Functionality and Interface

Simplified Vehicle Operation Through Standardized Automation and Elimination of Manual Tasks

Need to generate operational data with new technology for the FAA to provide credit for it
Current Safety Philosophy

- Powerplants and Flight Controls are Governed by Design Requirements
- Flight Instrumentation and Systems are Governed by Severity of a Failure and Probability of Failure
- After a Failure, it is Assumed that the Pilot will Always do the Right Thing
- Systems are Designed Assuming the Pilot is a Backup to the Systems
- Reliability Levels are Set According to the Number of Passengers that can be Onboard

New SVO Safety Philosophy

- All Systems and Components (Including Powerplants and Control Systems) are Governed by Severity of a Failure and Probability of Failure – Not Design Requirements
- A Single General Aviation Pilot Represents a Failure Rate of ~10E-5 during Normal Operations (from accident data)
- In Emergency Situations the Pilot Error Rate is Higher
  - A Single Pilot Error Cannot Cause a Catastrophic Event
  - No Pilot Action is Required to Continue Safe Flight After any Single Failure
- The Pilot is NOT Automatically Considered an Acceptable Backup
- Reliability Levels are Set According to the Number of People Potentially Involved in an Accident (including on the ground)
• Unified Controls – flies mostly like an airplane but significantly simplifies VTOL and hover operations
  • Stable in all axes in all flight conditions
  • Envelope protections – stall, bank, overspeed, settling with power, etc.
  • Ground collision avoidance
• Use flight instrumentation typical of today’s glass cockpits
• Use autopilots with today’s functionality but at reliability levels of FBW controls
• Use climb, cruise, descent VNAV functionality of today’s glass cockpits
• Eliminate need to manually setup or fly instrument approaches
• Automated preflight planning including
  • Weight and balance
  • Weather
  • Routing
  • Energy reserves
  • Filing flight plans
  • Aircraft performance
  • etc.
• Automatic systems protections – Temp limits, current limits, RPM limits, etc.
• Airport navigation and operations assistance
• Level button
SVO2:

- **EZ-Fly VTOL Controls / Display / Navigation**
  - Designed from scratch to be human-centric without the constraints of previous aircraft / technology
  - Control -> aircraft motion is identical for all flight conditions
  - Display is optimized for navigation, not vehicle control
  - Tightly integrated controls, display and navigation functions
- Fully automated preflight planning and flight plan filing
- Automated barometric settings and weather updates / re-routing suggestions
- Automated ATC communications
- All flights done under Instrument Flight Rules
- Automated traffic avoidance
- Automatic takeoff and landing
- Automatic failure protection (powerplant failure, comm failure, unexpected low energy level, etc.
- Other automated features from the SVO1 package
SVO-3 Concept

SVO-3:
• Point and click control – fully autonomous normal operation after destination is identified
• Fully automated preflight planning
• ATC or fleet operator can change destination or routing
• No pilot license required
• Details are fuzzy, details of SVO3 are not part of this contract

Significant Implication:
Since SVO3 does not require a pilot license, responsibility for safety cannot rest on the pilot.

SVO3 only works as part of a Part 135 / 121 operation within a controlled environment. Responsibility for safety rests on the operating organization.
Proposed Certification Path

It is unlikely that we will get another rewrite of 14 CFR Part 23 in the foreseeable future, this results in:

- Individual Special Conditions for every new eVTOL / SVO design
- Individual model specific training and pilot certification requirements for each new eVTOL / SVO design

Step 1:
- Create a generic set of Special Conditions that can apply to all (most) of the eVTOL designs
  - This creates aircraft certification expectations that companies can design to
  - It improves the certification process for both applicants and the FAA
  - It reduces certification risk
- Create a minimum set of automated functions that can be lumped together as SVO-X packages for the purpose of creating a standard set of pilot knowledge and skills for SVO aircraft using current ACS / PTS
  - Current Airman Certification Standards can be used with the result being a normal license with restrictions to limit operations to SVO aircraft with standardized features
  - Minimal impact for Flight Standards

Step 2:
- Aircraft Certification - Convert the generic Special Conditions into a new part (14 CFR Part 53?).
- Airmen Certification - Create an SVO – specific license and ACS set with SVO-1 and SVO-2 ratings.
**Changes Since the Last Update**

**Aircraft Certification**
Created a complete first draft of a proposed part 53 for SVO1 and SVO2 aircraft to be used instead of part 23 / 27 and special conditions. This is Appendix A of the report.

Created separate reliability requirements for aircraft used as public transportation primarily over densely populated areas and aircraft used for recreation over mostly sparsely populated areas (Appendix B).

Started a proposed advisory circular AC 53-1 to provide a means of compliance for part 53 (Appendix E).

**Airman Certification**

Proposed additions to part 61 for SVO1 and SVO2 including student pilot, private pilot, instrument rating, commercial pilot and ATP (Appendix C).

**Operational Rules**

Proposed additions to 91.205 – Instrument and Equipment Requirements to match SVO1 and SVO2 aircraft requirements (Appendix D).

More part 91 and 135 changes that apply only to SVO1 and SVO2 aircraft are still coming.
### Some Significant Proposed Changes to Part 23

<table>
<thead>
<tr>
<th>Part 23</th>
<th>Part 53</th>
</tr>
</thead>
<tbody>
<tr>
<td>Must have “static longitudinal stability” and “static lateral stability” – this forces coupling between speed / flight path and roll / yaw.</td>
<td>Must have stability in each axis. All axis are decoupled.</td>
</tr>
<tr>
<td>Propulsion and control safety through design requirements.</td>
<td>Design requirements replaced with reliability requirements.</td>
</tr>
<tr>
<td>No envelope protections.</td>
<td>Must have envelope protections.</td>
</tr>
<tr>
<td>Aircraft is allowed to stall.</td>
<td>Aircraft is not allowed to stall.</td>
</tr>
<tr>
<td>No maneuver margins are required.</td>
<td>Gust and maneuver margins at minimum allowable speed are required.</td>
</tr>
<tr>
<td>No requirement for automated flight.</td>
<td>SVO1 and SVO2 aircraft must provide the ability to couple to published instrument approaches. Credit for pilot backup is not allowed.</td>
</tr>
<tr>
<td>No requirement for on board flight planning.</td>
<td>Automatic on-board flight planning, replanning and filing is required.</td>
</tr>
<tr>
<td>No requirement for a level function.</td>
<td>LEVEL button is required for SVO1. Centering the controls results in straight and level for SVO2.</td>
</tr>
<tr>
<td>Transition from wing borne flight to rotor borne flight is not addressed.</td>
<td>Stability and handling qualities requirements for transitions.</td>
</tr>
</tbody>
</table>
Please Be A Part Of Making The Future The Best That We Can Make It

Working document “3_SVO1_Rev_October_2020.docx” includes:

- Important assumptions and background pages 2-18
- Important SVO building blocks pages 19-23
- SVO-1 standardized features pages 23-27
- SVO-2 standardized features page 27-30
- Appendix A – Proposed Part 14 CFR Part 53 for SVO pages 31-112
- Appendix B – Proposed Aircraft Design Requirements for Category A aircraft pages 113-124
- See document for additional Appendices C-G

We currently consider the proposals in the document and this presentation as set in Jell-O®. Please provide comments. That is why we asked you to be part of our advisory team.

Please provide your feedback via email to borja.martos@gmail.com
How Will Future Pilots and Aircraft Designers View This Time?
Q&A
Remaining Time
BY MODERATOR / ONLINE QUESTIONS
Backup Slides
State of Aircraft / Pilot Certification Today

Conventional Normal Category Civil Aircraft Being Produced Today (part 23/27)
• All airplanes use control schemes developed before 1920
• All VTOL aircraft (helicopters) use control schemes developed before 1950
• These control schemes require the pilot to provide stability & be the manual backup
• All aircraft use cockpit instrumentation developed before 1960 to allow the pilot to provide stability
• Existing aircraft and pilot certification rules were developed around these technology levels
• Few special conditions or pilot restrictions are required for current production aircraft
• Strong standardization

AAM / UAM / SVO Aircraft under development today
• FBW control systems provide stability and envelope protection
• Cockpit displays need not provide information to the pilot to provide stability
• Current pilot licensing requirements often don’t make sense for new technology aircraft
• Many Special Conditions are required for certification
• Each company develops its own Special Conditions with the FAA to fit their particular design
• Each company develops and administers its own pilot training and licensing requirements
• No standardization in AAM / UAM / SVO aircraft or airmen certification
• Given time required for new aircraft/pilot regs, individual Special Conditions & training is the only option
After the First Wave of Pioneers to Certify Advanced Air Mobility (AAM), Urban Air Mobility (UAM) and Simplified Vehicle Operations (SVO) Aircraft

**WHAT:**
Improve the aircraft certification process (creating individual Special Conditions takes lots of time)
- Create standardized Special Conditions to reduce certification risk for designers
- Improve pilot cert to attract new pilots for AAM / UAM / SVO aircraft (training takes a lot of time)
- Provide pilot standardized skill set requirements for AAM / UAM / SVO aircraft

**HOW:**
1. Create proposed Special Conditions that are not designed for individual aircraft
2. Identify proposed automation that can be applied as a minimum set for all SVO aircraft
3. Create pilot licensing requirements that recognize automation with no requirement for manual backup
4. Identify impact of the above on operational rules

**RISK BASED APPROACH DEPENDING ON TECHNOLOGY LEVEL:**

- **SVO1: Unified Control** – Like a current airplane in cruise and simplified VTOL controls
  Uses automation in today’s aircraft but at a higher reliability level - no manual backup for automation

- **SVO2: EZ-Fly VTOL Control** – Flight path and speed command
  Uses automation designed for non-pilots

- **SVO3: Point and Click Control** – Identify the desired destination and the aircraft does the rest
  External control of destination and route through ATC (clearance change) or fleet operator
## Biggest Training Burden Items for Private Pilot from Flight School Data:

<table>
<thead>
<tr>
<th>Private Pilot Airplane</th>
<th>Task</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ground</strong></td>
<td><strong>Aerodynamics, Powerplants, Systems</strong></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td><strong>Weather – hazards, obtaining info</strong></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td><strong>Safe operations - collision avoidance, airport operations, etc.</strong></td>
<td>4.5</td>
</tr>
<tr>
<td><strong>Flight</strong></td>
<td><strong>Takeoff, Landing, Go around</strong></td>
<td>8.2</td>
</tr>
<tr>
<td></td>
<td><strong>Performance maneuvers and ground ref maneuvers</strong></td>
<td>7.7</td>
</tr>
<tr>
<td></td>
<td><strong>Navigation</strong></td>
<td>5.6</td>
</tr>
<tr>
<td><strong>Instrument</strong></td>
<td><strong>IFR Navigation and approaches</strong></td>
<td>5</td>
</tr>
<tr>
<td><strong>Ground</strong></td>
<td><strong>Use of IFR charts</strong></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td><strong>ATC system and instrument procedures</strong></td>
<td>4</td>
</tr>
<tr>
<td><strong>Flight</strong></td>
<td><strong>Instrument approach procedures</strong></td>
<td>18.5</td>
</tr>
<tr>
<td></td>
<td><strong>Flight by reference to Instruments</strong></td>
<td>8</td>
</tr>
<tr>
<td></td>
<td><strong>Navigation system operation</strong></td>
<td>8</td>
</tr>
</tbody>
</table>
## Biggest Training Burden Items for Helicopter Add-On from Flight School Data:

<table>
<thead>
<tr>
<th>Helicopter Add-On</th>
<th>Task</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ground</strong></td>
<td>Aerodynamics, Powerplants, Systems</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Hazards - Energy management, Low G, Low RPM, etc.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Weight and Balance</td>
<td>2</td>
</tr>
<tr>
<td><strong>Flight</strong></td>
<td>Takeoff, Landing, Go around</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>Hovering maneuvers</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>Performance maneuvers</td>
<td>4</td>
</tr>
<tr>
<td><strong>Helicopter Instrument Add-On</strong></td>
<td>Most ground knowledge from Airplane Instrument applies to Helicopter Instrument</td>
<td>-</td>
</tr>
<tr>
<td><strong>Ground</strong></td>
<td>Instrument approach procedures</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Navigation Systems Operation</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Flight by reference to Instruments</td>
<td>2.5</td>
</tr>
</tbody>
</table>
The Result of Our Current Path – Not Enough Pilots to Support the Initial AAM/ UAM Industry

1997 to 2017 BY THE NUMBERS:

• All Pilots (Pvt, Comm, ATP): 19% decline
• ATP: 22% increase
• Commercial Pilots: 22% decline
• Private Pilots: 34% decline
• Comm Airplane & Helicopter: Steady (~8,000)
• Private & Comm rate of decline is accelerating
• Student pilot dropout rate is as high as 80%.

A CIVILIAN POWERED LIFT RATING IS VERY RARE

Sources: GAMA 2017 Databook (pilot population)
FAA Active Pilot Data (Rotor & Heli)
AOPA's Growing the Pilot Population Initiatives (drop out rate)