Unraveling Risk
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Joe Morra, FAA UAS Integration Office
Kelsey Muka, FAA Safety Policy & Promotion Branch
Jarrett Larrow, FAA Flight Operations Branch
James Foltz, FAA Aircraft Certification Service

#UAS2019
Understanding Hazards vs. Risk
The Risk Matrix (Small Aircraft)

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Frequency A</th>
<th>Probable B</th>
<th>Remote C</th>
<th>Extremely Remote D</th>
<th>Extremely Improbable E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severity</td>
<td>Minimal 5</td>
<td>Minor 4</td>
<td>Major 3</td>
<td>Hazardous 2</td>
<td>Catastrophic 1</td>
</tr>
<tr>
<td></td>
<td>[Green]</td>
<td>[Yellow]</td>
<td>[Red]</td>
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<tr>
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<td>[Green]</td>
<td>[Yellow]</td>
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<td>[Green]</td>
<td>[Green]</td>
<td>[Green]</td>
<td>[Yellow]</td>
<td>[Yellow]</td>
</tr>
</tbody>
</table>

*High Risk with Single Point and/or Common Cause Failures

Federal Aviation Administration

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# Breaking Down Severity

<table>
<thead>
<tr>
<th>Minimal</th>
<th>Minor</th>
<th>Major</th>
<th>Hazardous</th>
<th>Catastrophic</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Severity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal</td>
<td>Negligible safety effect&lt;br&gt;- Physical discomfort to persons&lt;br&gt;- Slight damage to aircraft/vehicle</td>
</tr>
<tr>
<td>Minor</td>
<td>4&lt;br&gt;- Physical distress or injuries to persons&lt;br&gt;- Substantial damage to aircraft/vehicle</td>
</tr>
<tr>
<td>Major</td>
<td>3&lt;br&gt;- Physical distress or injuries to persons&lt;br&gt;- Substantial damage to aircraft/vehicle</td>
</tr>
<tr>
<td>Hazardous</td>
<td>2&lt;br&gt;- Multiple serious injuries; fatal injury to a relatively small number of persons (one or two); or a hull loss without fatalities</td>
</tr>
<tr>
<td>Catastrophic</td>
<td>1&lt;br&gt;- Multiple fatalities (or fatality to all on board) usually with the loss of aircraft/vehicle</td>
</tr>
</tbody>
</table>
# Breaking Down Likelihood

## Qualitative

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent A</td>
<td>Expected to occur routinely</td>
</tr>
<tr>
<td>Probable B</td>
<td>Expected to occur often</td>
</tr>
<tr>
<td>Remote C</td>
<td>Expected to occur infrequently</td>
</tr>
<tr>
<td>Extremely Remote D</td>
<td>Expected to occur rarely</td>
</tr>
<tr>
<td>Extremely Improbable E</td>
<td>Unlikely to occur, but not impossible</td>
</tr>
</tbody>
</table>

## Quantitative – Time/Calendar-based Occurrences Domain-wide/System-wide

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent A</td>
<td>Expected to occur more than 100 times per year (or more than approximately 10 times a month)</td>
</tr>
<tr>
<td>Probable B</td>
<td>Expected to occur between 10 and 100 times per year (or approximately 1-10 times a month)</td>
</tr>
<tr>
<td>Remote C</td>
<td>Expected to occur one time every 1 month to 1 year</td>
</tr>
<tr>
<td>Extremely Remote D</td>
<td>Expected to occur one time every 1 to 10 years</td>
</tr>
<tr>
<td>Extremely Improbable E</td>
<td>Expected to occur one time every 10 years</td>
</tr>
</tbody>
</table>
Taking a Holistic Approach to Risk

Robustness of Mitigations

- Aircraft
- Operator
- Airspace

*Must be met in each area*

Individual Mitigation

Acceptable Level

Overall Mitigation

Acceptable Level

*Must be met overall*
FAA Safety Risk Management (SRM) Philosophy
FAA’s Role as a Regulator

- FAA has a responsibility to regulate with safety risk in mind
  - FAA uses regulations and standards to control safety risk in the system
  - Waivers are the removal of safety risk controls and therefore require a safety assessment

- FAA needs confidence that granting regulatory relief would:
  - Not adversely affect safety OR provide a level of safety at least equal to that provided by the rule being relieved
  - Control safety risk to an acceptable level (as determined by FAA Management)

- Operator still has ultimate responsibility for the safety of their operation and compliance with applicable regulations
Making the Case for Safety

The operator produces the safety assessment used as an input to the FAA safety review and approval/denial decision.

The FAA may perform a safety assessment of its own to provide confidence necessary for the approval/denial decision.
Basis for FAA Decision

For the FAA to reach a decision, it requires:

• A clearly defined operation (i.e., risk picture)
  – Include specific details of the operation (i.e., what, when, where, who, and how)
  – How is the operator controlling the severity and likelihood of what could happen for the proposed operation?
  – What is the predicted severity and likelihood with those controls in place?

• Solid rationale and supporting data (i.e., proof)
  – Manned aircraft within operating area
  – Population below operating area
  – Failure modes and rates
  – Reliability levels
  – Test results (i.e., occurrences rates)
SRM Interaction with Safety Assurance

**Flight Standards has a responsibility to:**

- Assess compliance with regulatory requirements and any other safety risk controls set by the FAA as well as those developed by a operator’s SRM process
- Measure and assess the effectiveness of safety risk controls and determine the need for changes to or additional safety risk controls

**SRM and Safety Assurance (SA) processes operate in a continuous exchange**
Properly Defining the System

• Understanding the different elements of the system is key to effective risk assessment and management

• New UAS operations challenge risk control framework of existing regulations
  – Operating regulations tie together the different parts of the system to enable safe operation (e.g. aircraft design, operating conditions, pilot qualification, airspace procedures, etc.)
  – Regulatory responsibilities may need to evolve to consider:
    • Increased level of automation
    • Use of UTM Service Providers
    • Novel business models

5M Model
AIR Efforts Towards Risk-Based Certification

- Level of Rigor Tied to Aircraft, Type of Use, and Area of Operation
- “Low Risk” UAS Ops Still Require TC for Compensation/Hire Commercial Use
- Creating Regulatory Structure for Low, Medium, High Risk UAS

- Certification manages risk through “Safety Assurance”
  - Confidence a proposed product or action will meet FAA safety expectations to protect the public
  - FAA risk-based TC processes are well-proven
- SORA-based Risk Analysis Tool Sets Level of Rigor In Development
  - Using Low, Medium, and High Classification for UAS to Set Level of Rigor
- Risk Framework - Two Dimensional Risk Framework Considers UAS Performance and Use Case

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AIR Tiered Risk Framework

- Combines JARUS SORA-like Airspace Encounter Classes and Energy Based Risk Classes
- Lower Risk Part 107 and TC utilizing reliability as MoC
- High Risk – Using 21.17(b) TC Process
- Medium Risk – To Be Addressed by MOSAIC Rule

### Airspace Impact on Design Rigor

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<tr>
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<tr>
<td>6</td>
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<td>Needs TC/PC</td>
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<td>Airworthiness On Industry Stds.</td>
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Lunch Plenary starts at 12:30 PM...

Delivery by Drone – On the Route to Routine

Boxed lunch available – Level 400 Ballroom

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Back-Up
5 Common Hazards

1. Technical issue with UAS
2. Deterioration of external systems supporting the UAS operation
3. Human error
4. Adverse operating conditions
5. Unable to see and avoid