Committee on Assessing the Risks of Unmanned Aircraft Systems (UAS) Integration

Unmanned Systems Certification

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FAA Small Airplane Directorate

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Guiding Principles

- FAA & Industry - Shared Responsibility For Safety & Innovation
- Collaboration With Industry To Manage Risks From UAS Integration, But a “Zero Risk” Is Not the Expectation
- Traditional Means Of Risk Assessment & Mitigation May Or May Not Be Appropriate For UAS – Design and Operational Risks

Fear, Risk, and Reward

- Fear (risk aversion) - Protection Mechanism
  - We fear what we cannot control or don't understand
- Some risk taking is healthy – a means to grow, learn, improve society/technology
  - We learn by doing – calculated risk leads to growth
  - Olympic athletes, Apollo Program, etc.
- Can't mitigate risks we don't understand or know about
  - Companies new to aviation are less risk averse
  - Must learn the real risks they are creating/facing

Consider the "Total Safety Equation"

- Not only "what could go wrong", but the net safety improvement from using UAS vs. manned aircraft
- Example: Infrastructure surveillance puts people at significant risk

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Defining Risk For UAS

- Contributing Factors
  - Vehicle Design/Systems – What is it?
  - Operational Risk – How will it be used?
  - Area of Operation/Airspace – Where will it be flown?
  - Airspace – What's its Separation Strategy?
  - Human vs. Automation – Have you Planned for Errors?
- We need a clear, documented Concept of Operation, and Operational Risk Assessment
  - Proposed Mission Drives Requirements and FAA Involvement
  - Main Issue is Safe Operational Integration
  - Level of Airworthiness Appropriate

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Managing Risk for UAS

- Manage Design & Operational Risk to Public
  - Apply FAA Resources/Rigor Based on Risk
- Certification manages risk through **“Safety Assurance”**
  - Confidence a proposed product or action will meet FAA safety expectations to protect the public
- Safety Does not Rely on Luck
  - Requires Active Risk Management and Risk Based Decision Making

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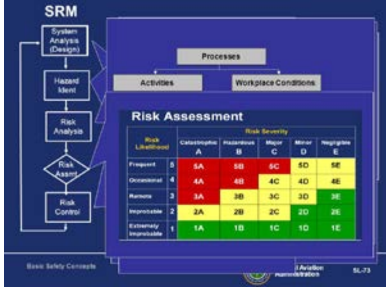
"Safety Assurance" Risk Controls

- Comes from Combination of Established Processes/Factors
  - **Airworthiness** – Condition for safe flight for its intended use
  - **Design** – Verify design, engineering, construction, etc. meet applicable requirements in certification basis
  - **Pilot** – Train for aircraft and level of risk
  - **Maintenance –** Repair/replace prior to failure
  - **Operation** – Limitations sufficient for the expected/acceptable level or risk
  - **Airspace** – Level of Integration, Traffic Exposure, Controller Involvement, and Equipage

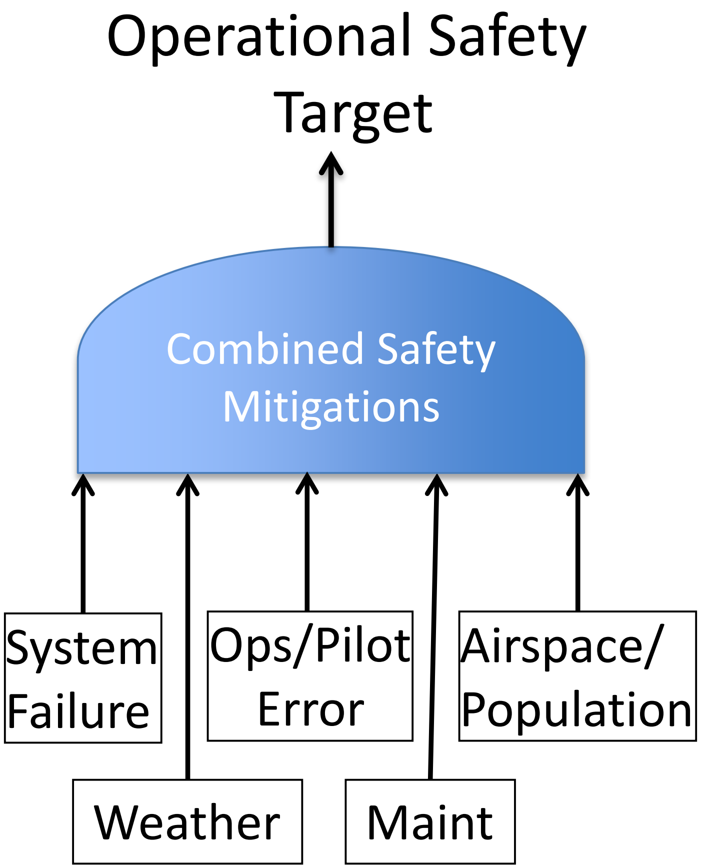
Challenges for Evolving UAS Integration



- Well Proven Design Techniques to Evaluate Risk for Manned Aircraft, but……
  - May Not Translate Well to UAS Design or Operational Risk
  - We don't have models for UAS operational safety yet
  - Probabilistic analysis difficult due to accurate data on operational facets of the analysis & assumptions
- Key - Mitigate Reasonably Foreseeable Failures/Issues
  - Design, Operations, Pilot Error, Weather, Maintenance, Geographic Area, Airspace all influence safety

Combined UAS Risk Controls

- Systems, airspace, ops, maintenance, & pilot error <u>all</u> feed into operational safety
- Typically Apply System Safety Techniques "XX.1309" for aircraft systems
- Some try to fix top level targets with increasing $10E^{-X}$ for system failures
- Not the right solution, we don't have data to model pilots, weather, etc.



What's Our Safety Target for UAS ?

- Depends, but FAA Expectation Not the Same For All UAS, and $10e^{-9}$ May Not Be the Default
- We don't have one target for manned Aircraft
  - We have Scalable, Multi-Tiered Safety Targets
    - Experimental, Amateur Built, Part 23 fixed wing, and part 27 rotorcraft, Part 25 transports and part 29 rotorcraft
  - Also have Multiple levels of Operational Oversight
    - Part 91, 121, etc.

Where Did 10^{-9} System Design Come From?

Transport Category Airplanes

Fatal accident rate at time of XX.1309 rule: 10^{-6}

- Data showed ~10% caused by system failures: 10^{-1}
- Assume 100 catastrophic failure conditions: 10^{-2}

Results in probability: 10^{-9}

Small Single-engine Airplanes

Fatal accident rate at time of XX.1309 rule (IN IMC): 10^{-4}

- ~10% caused by system failures: 10^{-1}
- Assume 10 catastrophic failure conditions: 10^{-1}

Results in probability: 10^{-6}

Tiered Risk Exposure Factors – Manned A/C

Aircraft/Ops	Passengers	Complex Parts/Systems	Annual Hours Flown
Small Single /Recreational	1's	10's	10's
Large Twin /Business Use	10's	100's	100's
Airliner /Commercial	100's	1000's	1000's

A Single Level of Safety for all Segments of Aviation Would Not Reflect Safety Continuum

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Resulting Logical System Safety Design Targets

Aircraft/Ops	Passengers	Complex Parts/Systems	Annual Hours Flown	Theoretical Target
Small Single /Recreational	1's	10's	10's	10E-6
Large Twin /Business Use	10's	100's	100's	10E-8
Airliner /Commercial	100's	1000's	1000's	10E-9

Created Tiered Approach to Theoretical Probability of Catastrophic Failure from Manned System Design

Certification Focus on Net Safety Gain

- New Technology Introduces Risk with its Benefits
- Example: Capstone Program in Alaska
  - Glass Displays for GA - lower design assurance levels
  - Resulted in a 40% reduction in fatal accidents
  - Significant Initial resistance

- UAS
  - Will provide societal benefits
  - Risk-based, step-wise integration will manage risk

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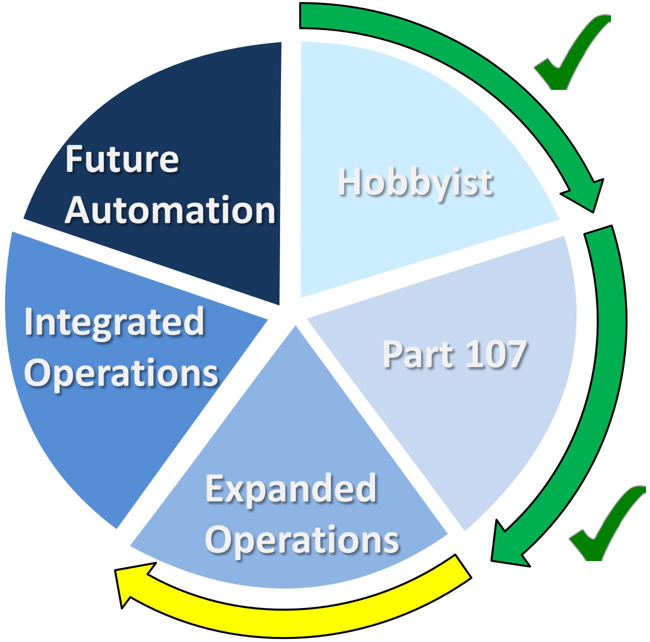
Safety Assurance By Regulatory Buildup

- Hobbyist/Recreational Operations
- Low Altitude Small UAS (Part 107)
  - In line of sight of operator
- Operations Over People (107 Expansion)
  - Working Regulation Now
- Beyond Visual Line Of Sight (Permit to Fly)
  - Enable Low Risk, Small UAS First
- Integrated/Controlled UAS Ops (TC/PC)
  - Changes to ATM and Mature Technology
- Future Automation – "Pilotless" Ops
  - Only as ATM and Automation Allow



Future Rulemaking and Waivers

UAS Regulatory Structure
Risk Based Approach

Increasing risk to public / mitigations / requirements

Part 107, Small UAS

Operating Limitations
Size / Energy

Part 21 "Permit to Fly"
Pending Rule

Airworthiness Certification
Industry Standards
Operating Limitations
Size/Energy

14 CFR 21.17(b) Special Class Type Certification

Airworthiness Certification
Production Approval/PC
Design Approval/TC
Customized Standards
Operating Limitations
Size/Energy

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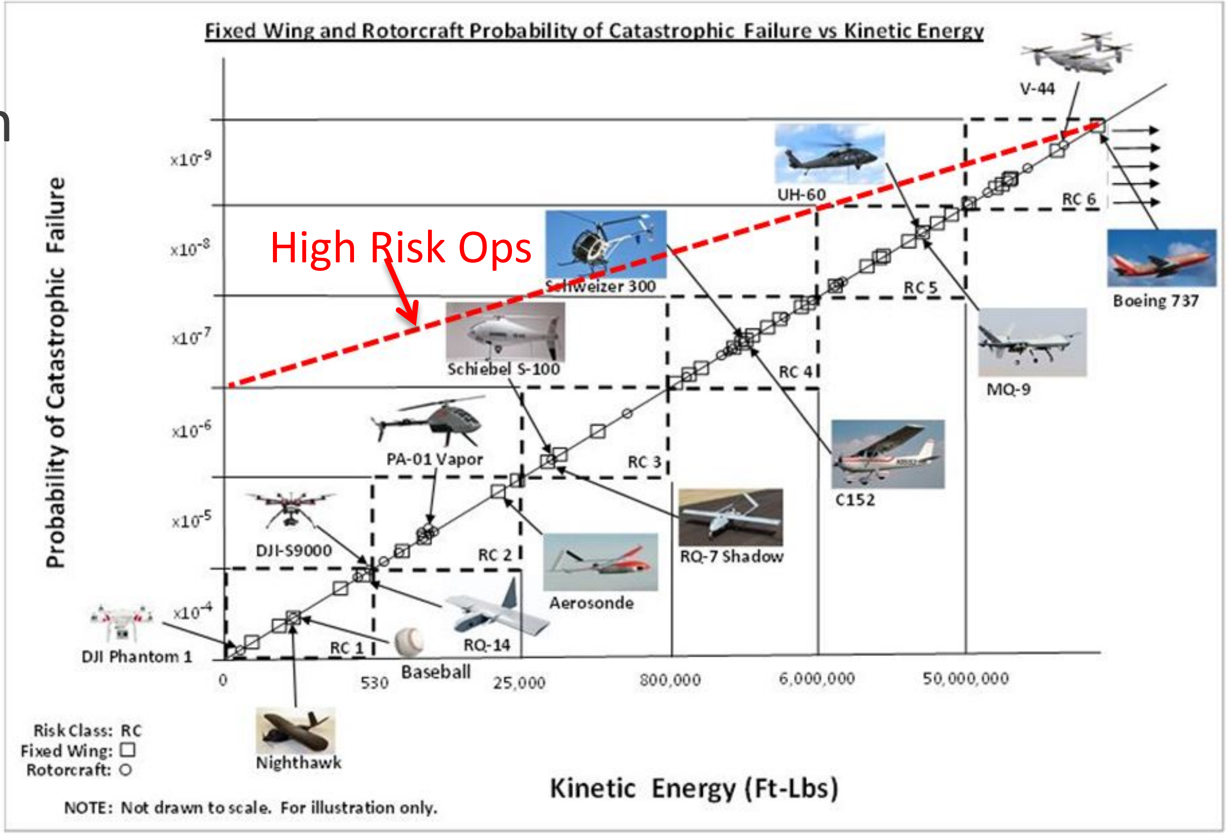
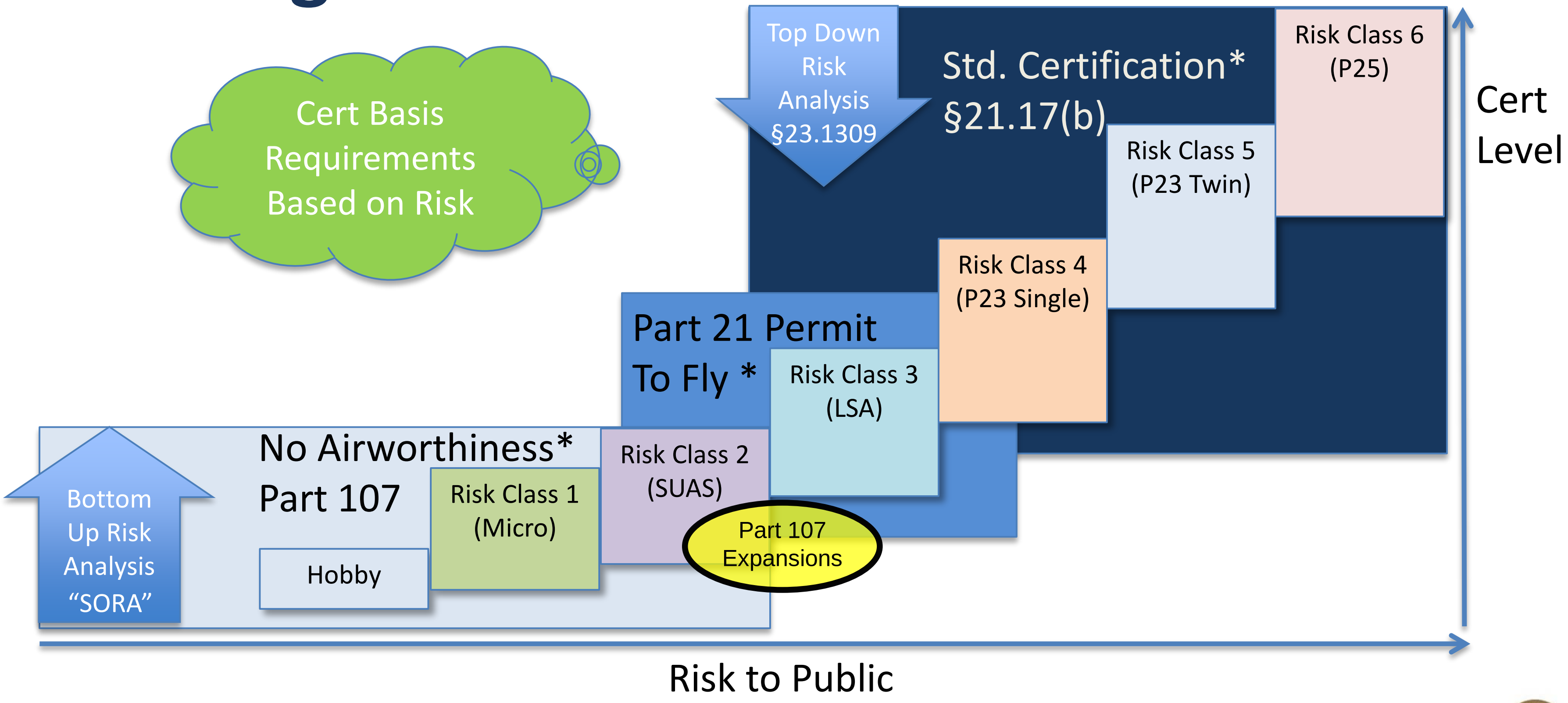
UAS System Safety Targets – Initially Energy Based

- For Applicability of Airworthiness & Design Requirements
  - RC1 and RC2, Small UAS (Open, Part 107)
  - RC2 and RC3, Mid-Sized (Specific, PTF)
  - RC4 to RC6, Large UAS (Certified, Std. Cert)
- Does Not Set "Operational Safety"" Target



Resulting Risk-Classes Overlaid with Rules



* Dependent Upon Operational Integration

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Risk-Based Operational Classification Strategy

- For Applicability of Operational Requirements - Address Operational Risk Exposure While Avoiding a "Zero-Risk" Mentality

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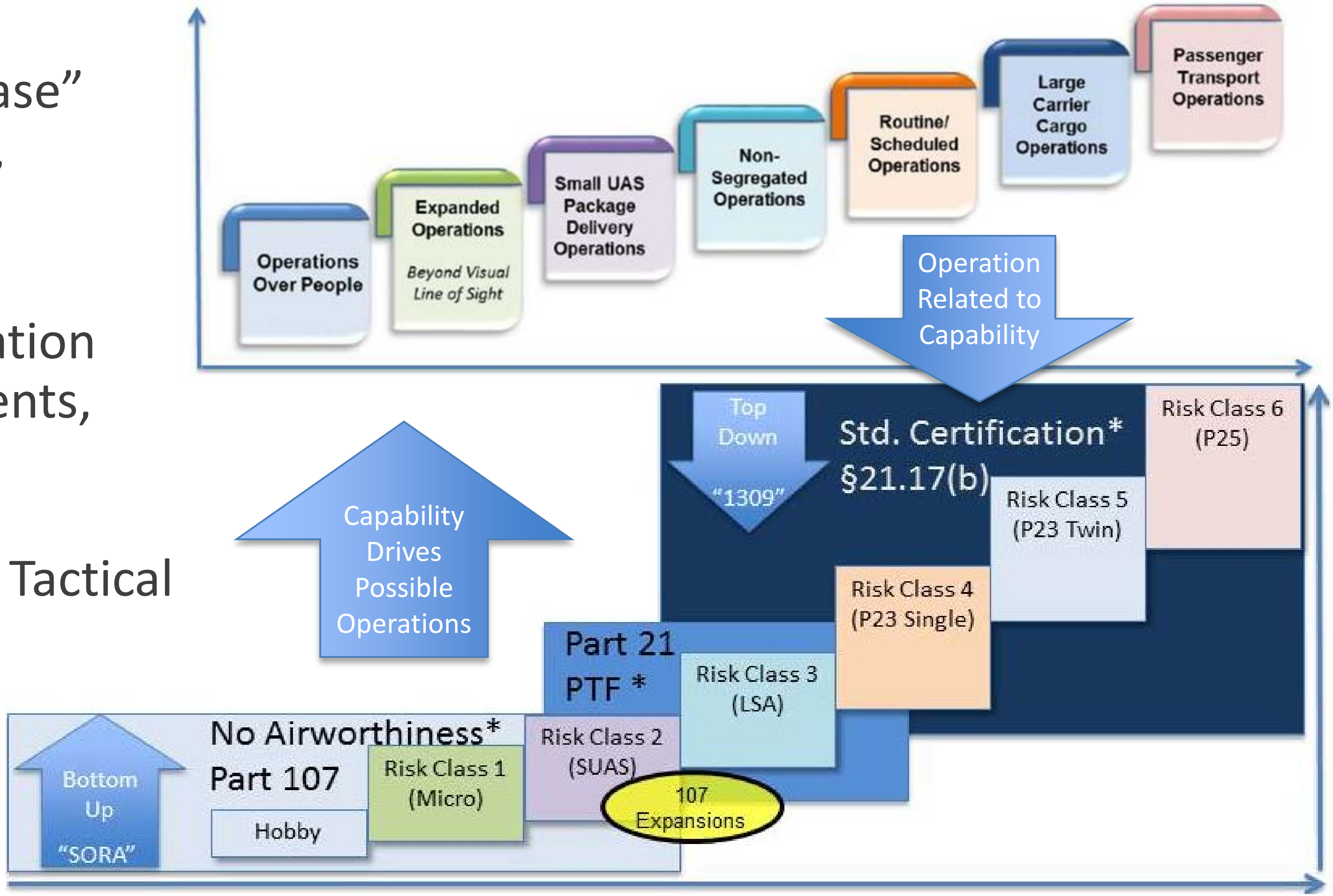
The Two Classifications Are Notionally Related

- "Typical Use-Case" Related to Size, Capability, & Performance
- Level of Integration sets Requirements, Level of FAA Oversight, and Involvement in Tactical Operation



Evolution of Safety Analysis

- Societal Expectations Have Changed
- Safety Requirements Have Evolved
  - 1938 CAR 3 – Does it work?
  - 1955 FAA – What if it fails?
    - Am I still safe? - Began evaluation of failures/malfunctions
  - 1968 FAA – Fail Safe Designs Required
    - Started Initial "1309" –Like Approach We Have Today
    - Mitigate Foreseeable Catastrophic Failures
- There are still no target probabilities in our regulations
- How can we safely enable UAS, and Future Transportation?

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Risk Assessment Tools

- FAA SMS System
- Order 8040.4A – Overarching Safety Risk Management Policy
- Safety Risk Management Guidance – ATO SMS Manual
- Operational Safety Compliance Philosophy
- SAE Aerospace Recommended Practice (ARP) or best practices documents & AC 23.1309-1E
- JARUS SORA – "Bottom Up" Approach to Risk/Mitigation
- Many More……

Evaluating Risk Tolerance

- New Companies Will be Risk Takers or Risk Tolerant
  - Innovation/Market Advantage/Reward
- Established Companies Will be More Risk Averse or Cautious
  - Familiarity/Comfort/Established Process/Product
- Societies Behave Similarly
  - Look at how playgrounds/toys have evolved
- A Zero-risk, or risk-free society is a stagnant society
  - Uber Elevate concepts make UAS integration very important

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Risk Analysis – Public Expectation

- The FAA is legally responsible for aviation safety – we have the safest system in the world
  - FAA must safely manage the airspace
    civil operations, per Title 49 U.S. Code § 40103(a)(1)
- The public depends on competent risk assessment and risk mitigation
  - When risks are overlooked--public skepticism abounds.
- Balance is important – overestimating risk can lead to high cost, complexity, and stagnation in innovation
  - New Transportation Concepts will challenge us all

Future Challenges for Risk Analysis

- UAS safely prototyping technology that will revolutionize flight
  - Automation & Flight Controls
  - Auto Collision Avoidance
  - Automation in Traffic Management
- Key to passenger carrying, highly-automated aircraft
  - Requires early collaboration
  - FAA, NASA, industry, academia, municipalities

Summary – Safety From Experience

- We have a history of finding ways to bring new technology into the National Airspace System safely
- We are already using a well-proven risk-based approach to safety
- Society Recognizes a need for balance regarding FAA Rigor vs. Safety Improvement – Drives cost, time for project
- UAS Certification will lead to future technology benefits for manned aviation

Managed Risk Will Enable Future Flight

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Questions?

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