FAA UAS SYMPOSIUM

Is Your UAS Safety Case Ready for Flight – Leveraging Research and Operations to Get to YES

Federal Aviation Administration

AUVSI

Is Your UAS Safety Case Ready for Flight – Leveraging Research and Operations to Get to YES

Sabrina Saunders-Hodge, FAA UAS Integration Office

Paul Strande, FAA UAS Integration Office

Jeremy Grogan, FAA Flight Standards Service

Mark Askelson, University of North Dakota (ASSURE)

Mark Blanks, Virginia Tech Mid-Atlantic Aviation Partnership (MAAP)

Todd Binion, State Farm

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Building a Safety Case: How We Got to "Yes"

Todd Binion

Manager – VMO/Claims Business Services

State Farm®

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Why Drones?

- State Farm requires the ability to quickly assess damage after significant weather events in order to provide claim service to our policyholders.
- Drone technology provides a technical capability to quickly deploy over an event site and assess damage from the air.
- Data obtained from drone flights can be used for determining severity of the event for better resource allocation as well as enabling claim decisions.

Challenges:

- Inspecting properties with UAS one at a time is **inefficient**
- It can be difficult to inspect more than one house at a time while maintaining **visual line of sight**
- Operating UAS in areas impacted by natural disasters may involve **operating over human beings**

In a Nutshell:

The key to a successful waiver application will be a robust safety case that effectively addresses all of the potential risks and hazards associated with the operation and is validated through testing that can provide detailed, relevant supporting data.

How We Got to a "Yes"?

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- Collaborated with Subject Matter Experts
  - Virginia Tech
    - MAAP - FAA Designated UAS Test Site
    - Center for Injury Biomechanics
  - UAS Manufacturer
    - SenseFly
- Tell your story with data
  - It's not enough to *describe* what you want to do
  - You also have to *demonstrate* how you will safely do it
  - The VT/MAAP Safety Case Development Framework was key to our success
- Engage the FAA along the way
  - We continuously engaged the FAA throughout the process
  - The FAA asked great questions
  - This feedback was very helpful

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Building a Safety Case:
How We Got to “Yes”

Mark Blanks

Director, Mid-Atlantic Aviation Partnership
Virginia Tech

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MAAP: UAS Test Site and IPP

UAS Test Site

- Open-ended testing and evaluation
- Testing latest technology developments and operational concepts

UAS Integration Pilot Program

- Narrowly focused, high-impact projects
- Investigating role of state and local government in drone regulation

Risk-Based Safety Case Development

FAA UAS SYMPOSIUM

1 Operational Context Definition

Concept of Operations
- Mission objectives
- Operational description
- Requirements definition

Risk Assessment
- Hazard identification
- Risk mitigation development
- Identify supporting data needed

Repeat until risks are mitigated to acceptable level

2 Data Collection

Test Planning
- Test/data requirements
- Scope and method of test
- Schedule and resources

Testing & Demos
- Quantitative data collected
- Verify sufficient data to support mitigations
- Data validates mitigations

Update ConOps and ORA if mitigations cannot be validated

3 Safety Case

Safety Case Compilation
- Final analysis of safety
- Compilation of all data
- Completed application package

Safety case complete when all mitigations are validated with data

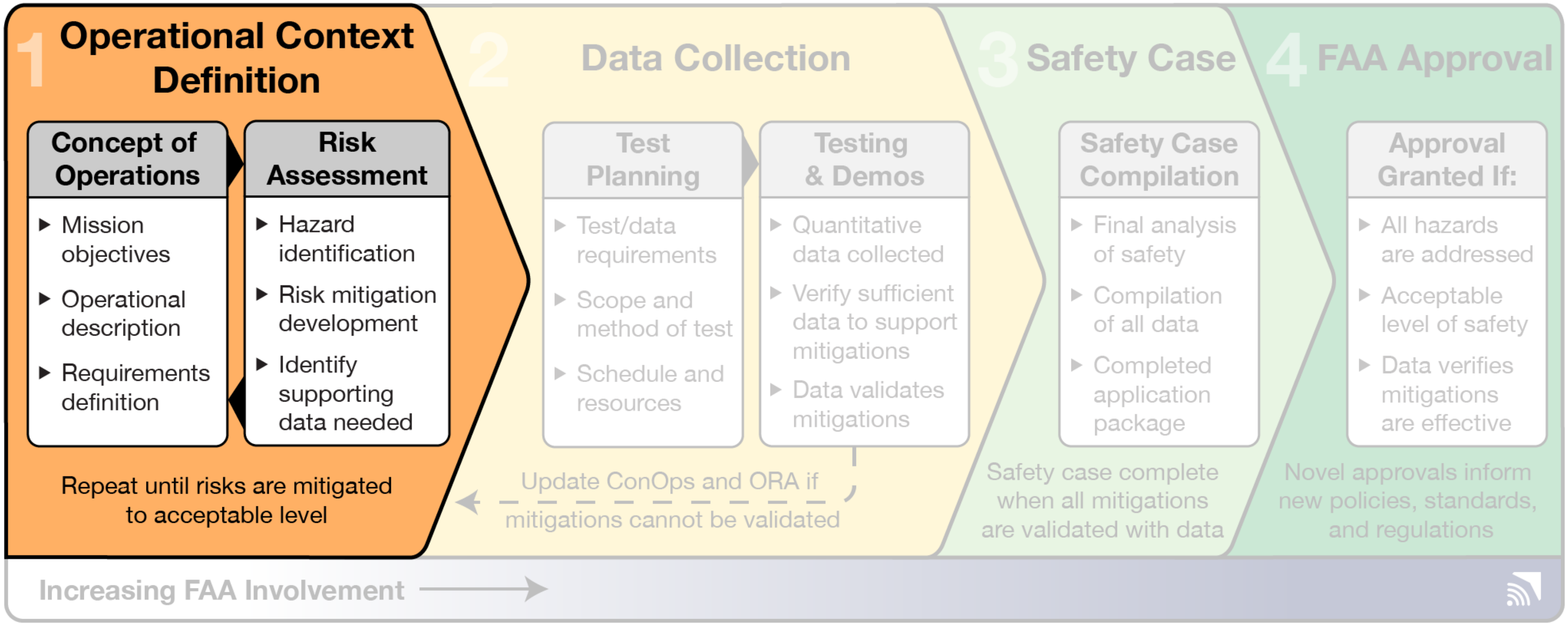
4 FAA Approval

Approval Granted If:
- All hazards are addressed
- Acceptable level of safety
- Data verifies mitigations are effective

Novel approvals inform new policies, standards, and regulations

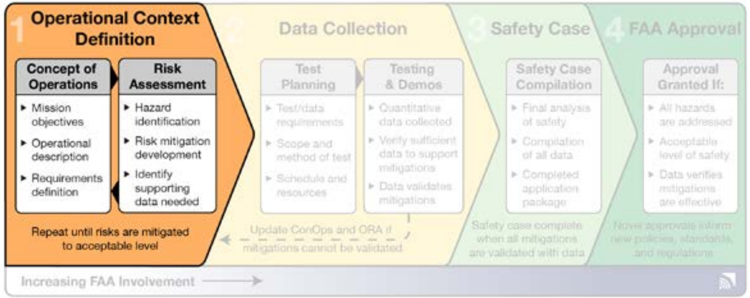
Increasing FAA Involvement →

Defining the Operational Context

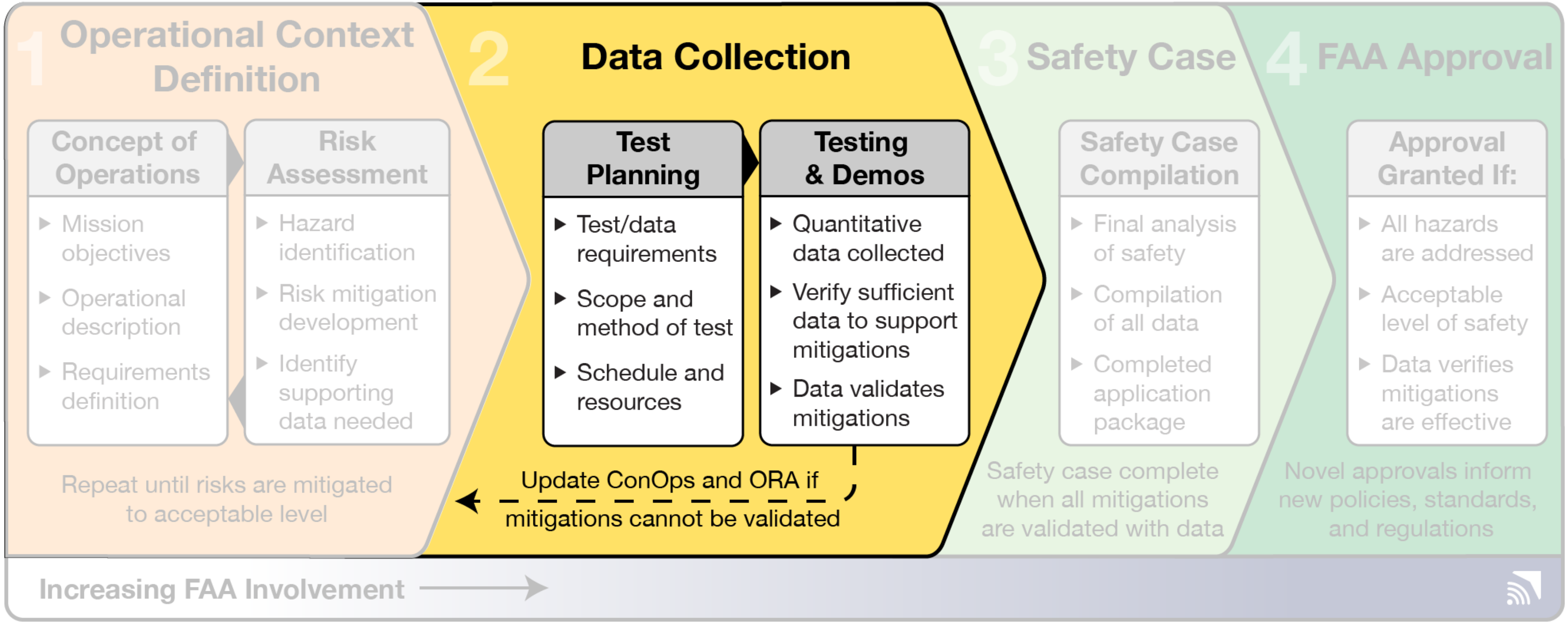


Example: Selecting an Aircraft

- Able to perform the mission
- Needed risk reducing features:
  - Proven reliability
  - Low injury risk
  - Optimized flight behavior/logic
- Reputable manufacturer
- Readily available

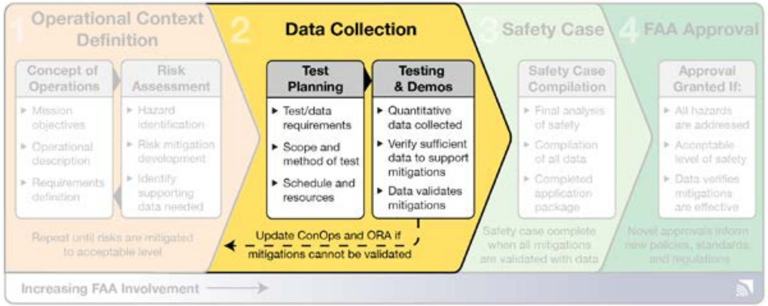


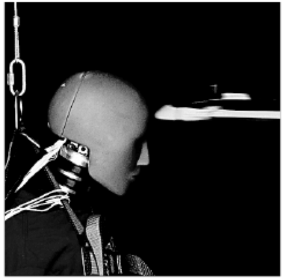
Collecting the Right Data



Example: Determining Injury Risk

- Risk Mitigation: Very low injury risk
- Test Planning:
  - Determined possible failure modes
  - Identified angles and speeds of descent
  - Calculated impact test requirements
- Testing:
  - Impact testing
  - Laceration testing





Compiling a Safety Case

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Increasing FAA Involvement →

Helping the FAA Say "Yes"

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Increasing FAA Involvement →

A Repeatable Process

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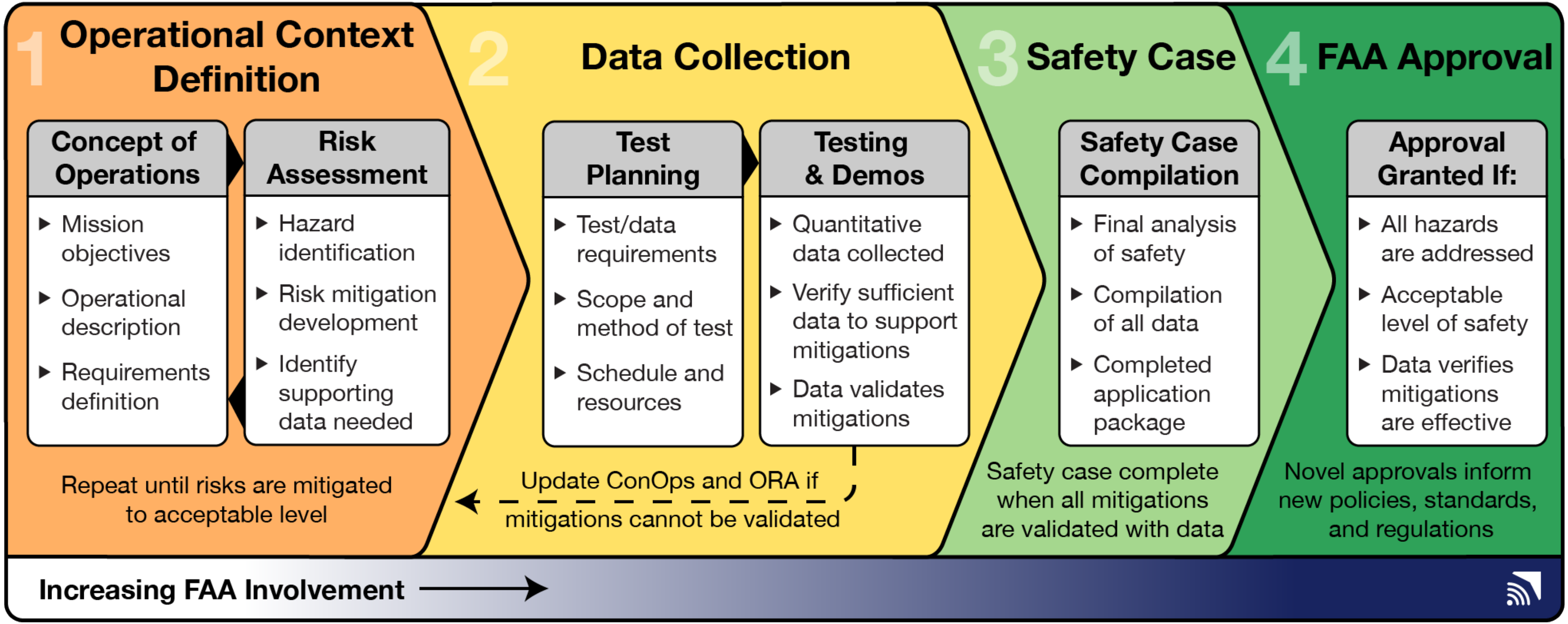

What We’ve Learned

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- Keys to success:
  - Thoroughly explain all aspects of the operation
  - Use a proven methodology to assess risk
  - Provide data to support risk mitigations
  - Work with the FAA to resolve concerns (don’t give up)

- This is a learning process for all, including the FAA
  - Prior work by others is helpful, but may not always be directly applicable
  - Learning takes time: plan to crawl for a while before you run

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UAS Test Data Collection and Analysis

Mark Askelson

Interim Executive Director, Research Institute for Autonomous Systems
University of North Dakota

Federal Aviation Administration

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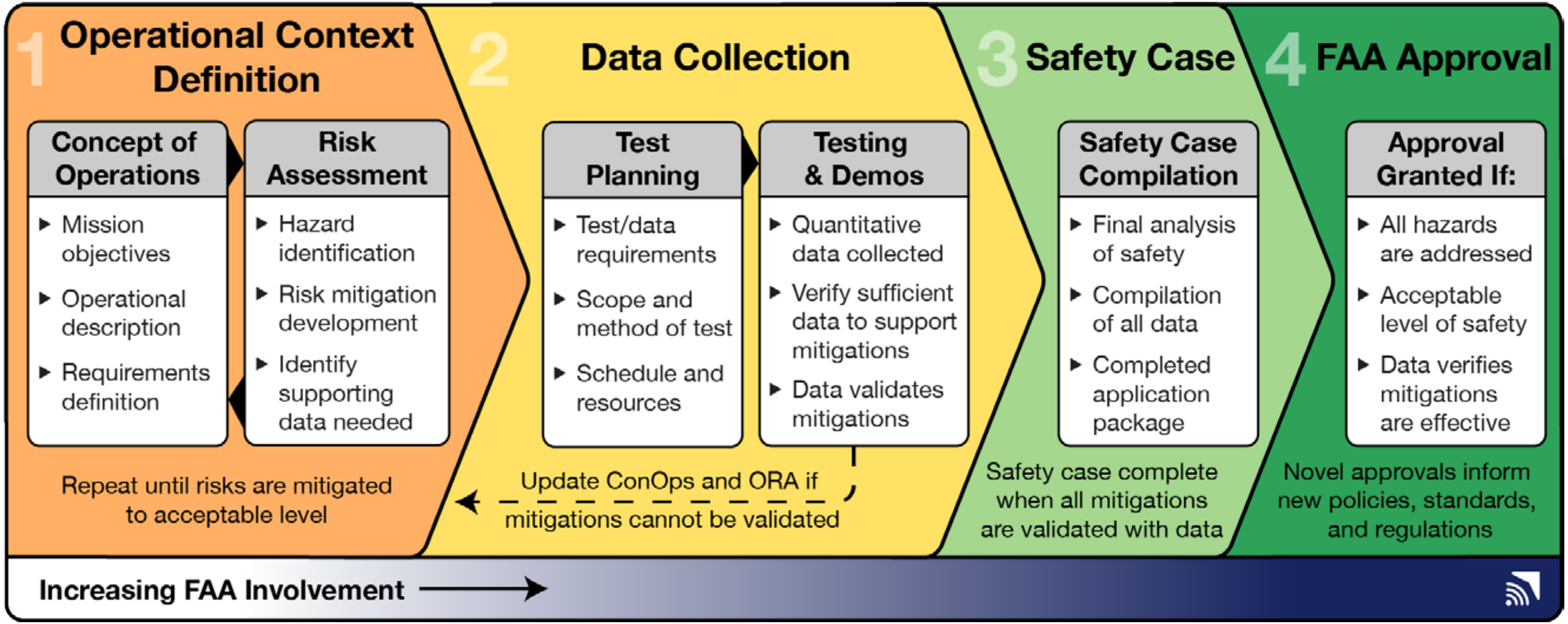
UAS Test Data Collection and Analysis

- Overview
  - ASSURE
    - Alliance for System Safety of UAS through Research Excellence
  - Description
    - Develop an **enhanced test data collection framework** and **safety analysis tools** to **inform the UAS Integration Research Plan** by enabling users to **cross-check needs for UAS data/research with test data** stored in the system as well as **enabling analysis to determine if the data meets the need** and **whether additional data/testing would be required**.

UAS Test Data Collection and Analysis

- Framework



Courtesy of Mark Blanks

UAS Test Data Collection and Analysis

- Data Schema
  - Given Framework
    - Identify base data elements & definitions
    - Determine alignment with FAA functional areas & research domains
    - Draft data reporting formats

UAS Test Data Collection and Analysis

- Challenges & Opportunities
  - Challenges
    - Balance detail vs. utilization
    - Balance use for specific projects vs broad-scale use
    - Not operational data
      - Desire to link to such data (e.g., ASIAS)
    - Flexibility
  - Sharper tool
    - Understanding safety
    - Understand research needs
    - Repeatability & streamlining

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Leveraging Research and Operations to Get to YES

Paul Strande, PMP

Deputy Director, FAA UAS Research Division (AUS-300)

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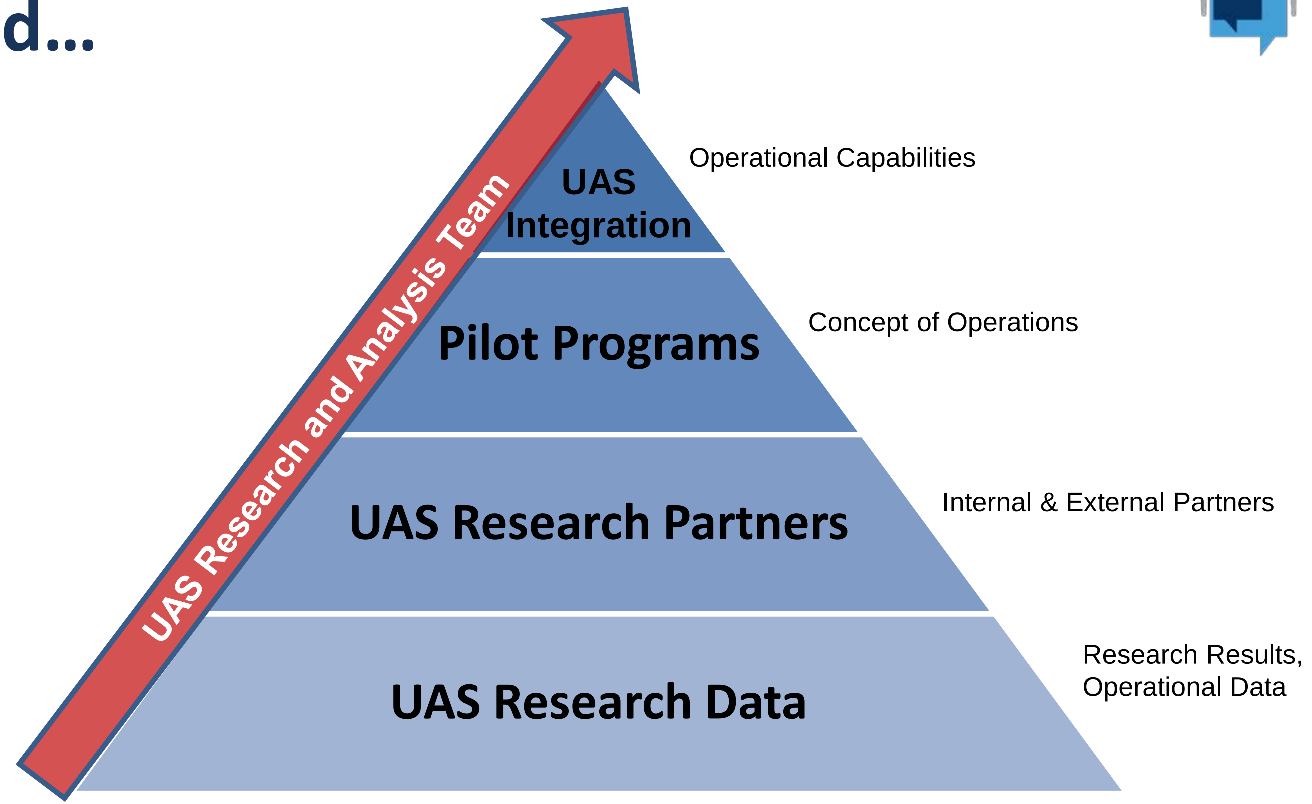
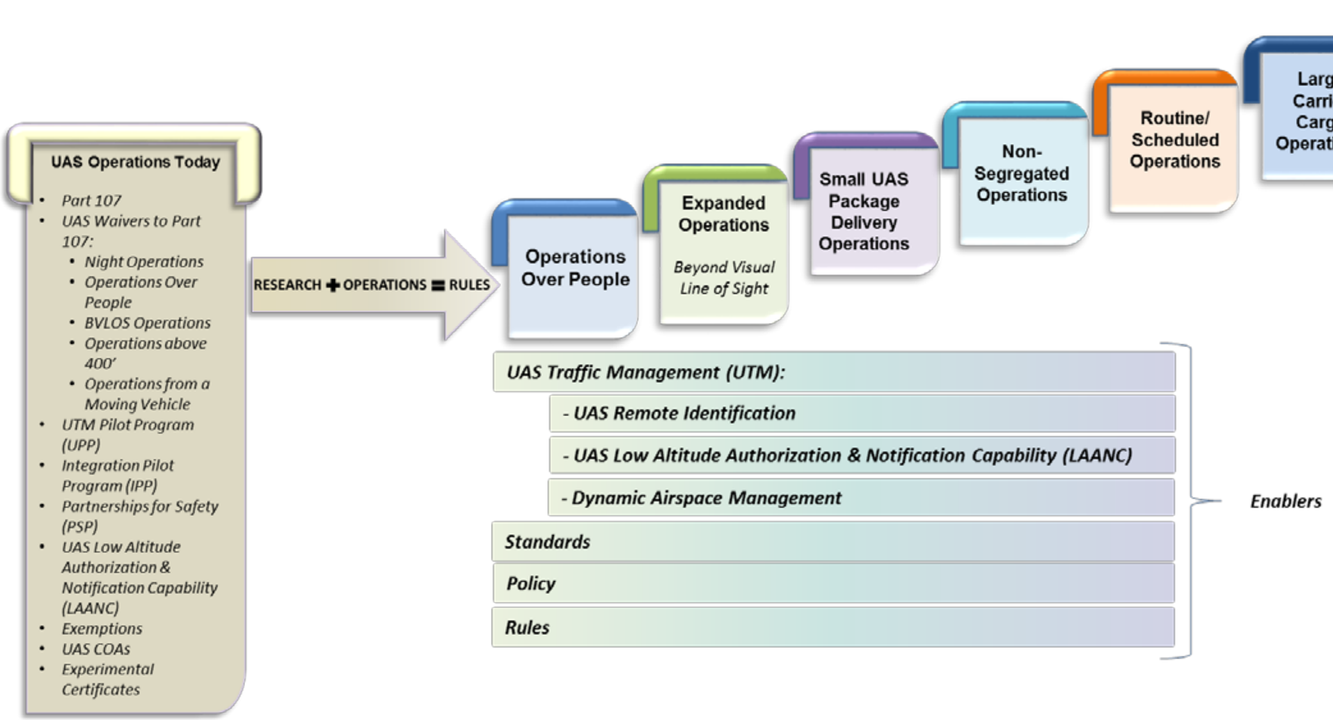
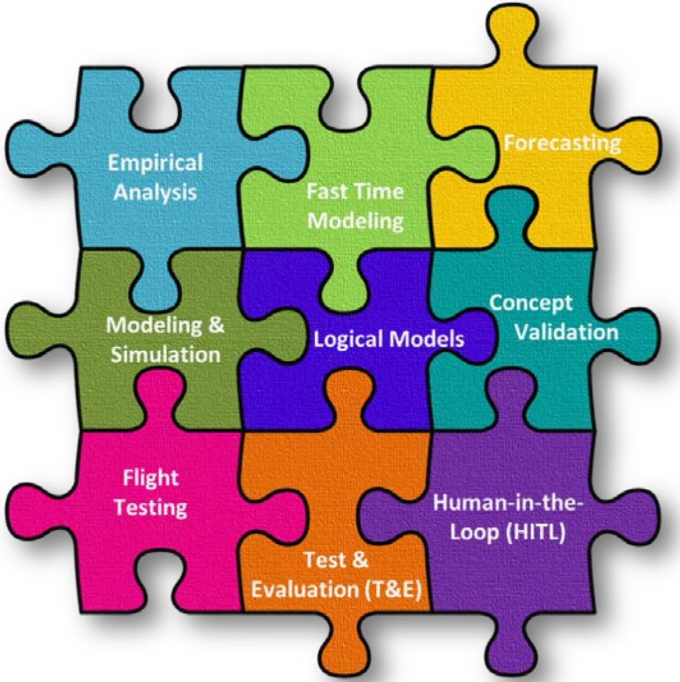
Safety Case - We Pull the Research Thread...



UAS Research is Aligned to Operational Capabilities Towards Full UAS Integration



FAA Applied Research Supporting Expanded Operations

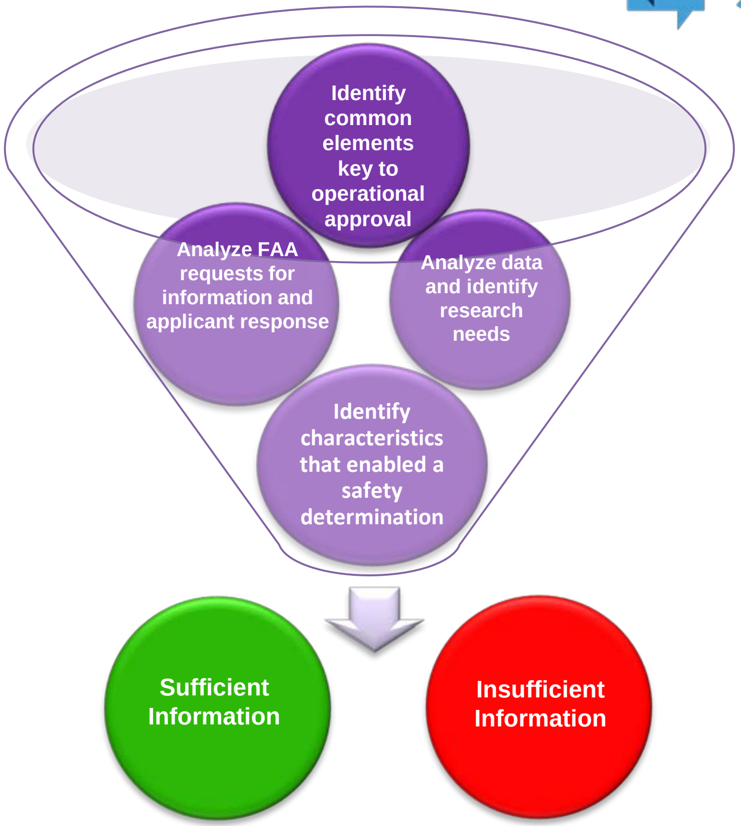


- UAS Ground Collision Severity Studies (Phase 1: Complete, Phase 2: Active)
- Strategies for Fusing Detect and Avoid Systems (Active)
- Test Site Data Collection (Active)
- UAS Test Data Collection and Analysis (Active)
- UAS Operations Over Moving Vehicles (Planned)
- Propose Viable Criteria and Thresholds for Assessment of Risk-Based Safety Case Submissions
- Establish Risk-Based Thresholds for Approvals Needed to Certify UAS for Safe Operations (Planned)

Operational Approval Trend Analysis

FAA DroneZone Waiver Database

- ✓ Concept of Operations (CONOPS)
- ✓ Operational Risk Assessment (ORA)
  - Identified Safety Risks
  - Mitigations
  - Residual Risks
- ✓ Test Data (to support the ORA mitigations)
- ✓ Operations Manual
- ✓ Vehicle Description
- ✓ Training Curriculum
- ✓ Other documentation to support the safety justification for the proposed operation



Operational Approval Trend Analysis

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- Beyond Visual Line of Sight (BVLOS) and Operations Over People (OOP) were chosen to be the first operations under the magnifying glass
- The vast majority of waiver applications are two sentences or less. This illustrates the need for tips and guidance to help applicants understand the qualities of sufficient waivers
- Focusing the trend analysis on waivers with FAA requests for additional information allowed the research team to more quickly analyze waivers with quality data

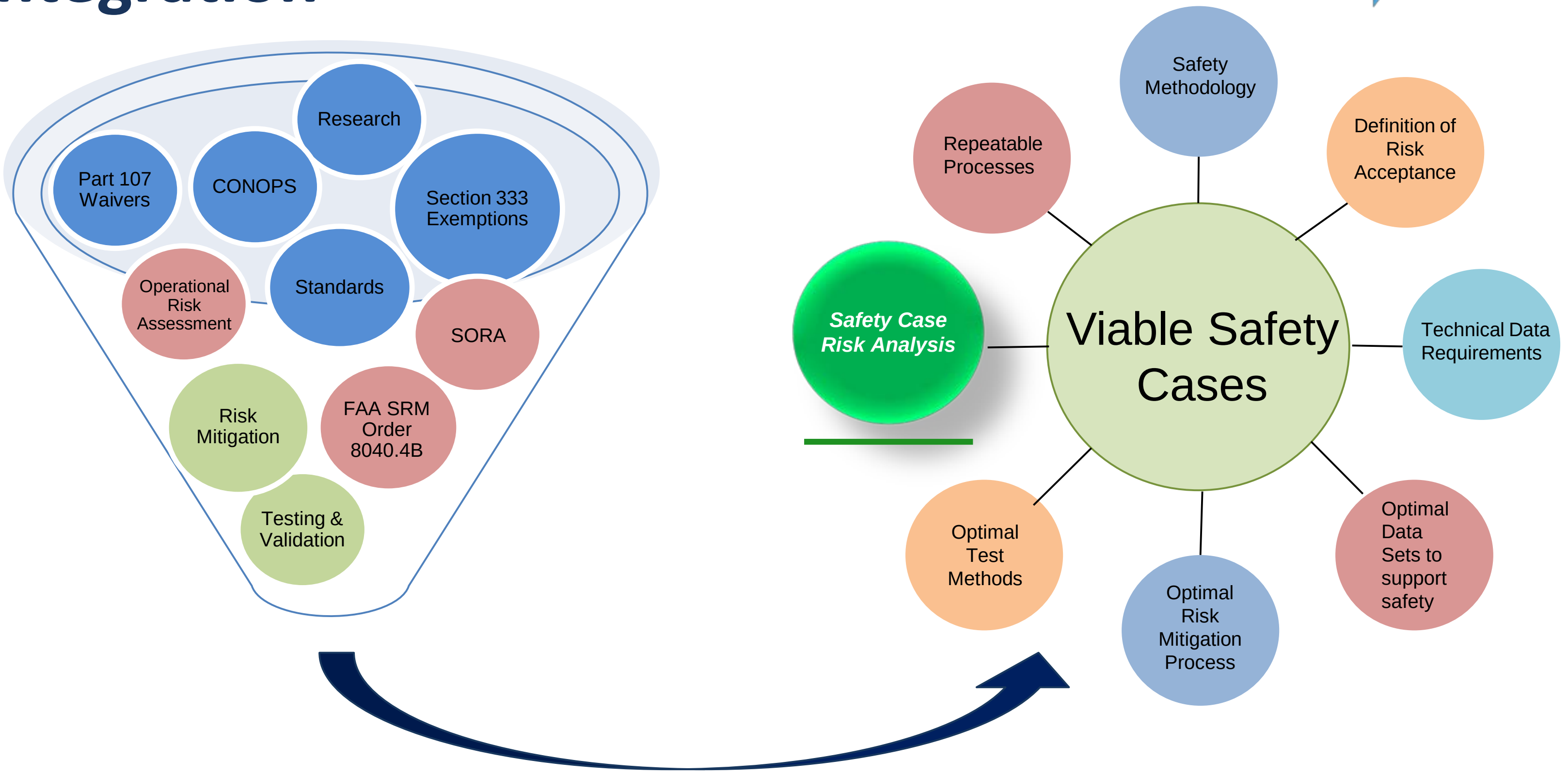
Non-Airspace Waivable 107 Parts	Total # Applied	Total # Appr. (Full Grant)	# Req. for Additional Info.	# Approved	# Part.Appr.	# Disappr.	# Cancelled
BVLOS Op	1813	27	39	5	1	27	6
OOP	2377	25	30	7	0	12	11
Night time Op	6019	1183	1151	657	12	216	266
Visual Observer	674	23	23	4	0	16	3
multiple sUAS Op	342	20	17	5	2	9	1
Op near a/c	426	0	4	0	0	1	3
Moving vehicle	852	1	12	0	0	8	4
Op limitations: ground speed	306	0	0	0	0	0	0
Op limitations: altitude	1055	17	66	14	1	30	21
Op limitations: minimum visibility	553	4	9	1	0	6	2
Op limitations: min dist from clouds	342	2	4	0	0	4	0

** DroneZone went live January 6, 2018. The numbers in this table and the trend analysis only reflect data for applications submitted after January 6, 2018 and before April 30, 2019. We acknowledge that many previous applications were processed.

	Beyond Visual Line of Sight (107.31) Waiver Trend Analysis - Common Elements Key to Operational Approvals			
Waiver Application Elements	**Command and Control (C2) Link and Emitters Performance Capabilities**	**Detect-and-Avoid (DAA) Methods**	**Weather Tracking and Operational Limitations**	**Training Requirements for Pilots and Other Participating Persons**
Sufficient Information -- Characteristics of the Beyond Visual Line of Sight (BVLOS) applications approved after requests for additional information	-**States and demonstrates** max range and envelope that C2 can definitely operate in, **taking into account geographic area, environment, and terrain** -Provides a **complete description of each emitter**, including the Federal Communications Commission (FCC) grant of authorization and FCC ID number for each transmitter/emitter on the sUA and ground control station	-Detailed **descriptions and procedures** for risk mitigations to avoid collisions with aircraft (ex. **Visual Observers**, technology)	-Details **when** weather reports will be gathered, **what** will be gathered, and **where** they will be taken from. -States **weather limitations**, such as small unmanned aircraft system (sUAS) manufacturer's limitations or wind speed	-Details an **employee training and testing program**. Example: -Lists out courses/subjects covered -Tests corrected to 100% and stored for easy retrieval later
Insufficient Information -- Characteristics of the Beyond Visual Line of Sight (BVLOS) applications after requests for additional information	-**C2 operational capabilities** not evident -Not **demonstrating** C2 can operate at stated max range or stating the envelope. i.e. **lacking data** -Lack of **FCC grant of authorization** or FCC identification number for each transmitter/emitter on the small unmanned aircraft system (sUAs) and ground control station	-Detailed **methods or procedures** to see and avoid non-participating aircraft and people are not evident -**Video feed** is not sufficient; limited to the direction the camera is pointing. Applicant needs to consider 360 degree awareness. -**Automatic dependent surveillance - broadcast (ADS-B)** not sufficient. ADS-B is for cooperative traffic. Uncooperative traffic needs to be addressed. -States 'evacuation of area', but doesn't mention **how** will the area will be evacuated. -'Will not fly over people' statement is not sufficient.	-**Providing general, or no statements** Examples: -'We only fly on clear days' -'Weather is to be of Visual Flight Rules in nature' is not sufficient - Multiple applications not addressing weather requirements	-Provision of a **method of assuring** all required persons participating in operation have knowledge in all aspects of BVLOS not evident -Not stating **who** will have the training, **what** the training will consist of, or a **method of assuring** all required persons have been successfully trained

	Operations Over People (107.39a) Waiver Trend Analysis - Common Elements Key to Operational Approvals			
Waiver Application Elements	**Ground Collision Severity**	**Laceration Injuries**	**Description of the Operation**	**Unique Remote Pilot Experience**
Sufficient Information -- Characteristics of the Operations Over People (OOP) applications approved after requests for additional information	Applicants **provided their own impact / injury severity tests** for their requested small unmanned aircraft system (sUAS). --OR— Applicants chose a sUAS which had **impact / injury severity test data readily available.** Note: While not seen in the approved waivers with requests for additional information, other approved operations over people (OOP) applications show that providing **vehicle design and operational reliability data** (with other operational mitigations, typically including minimal population size/density and/or minimal time spent over people) in place of injury severity data can be sufficient.	Applicants **provided their own laceration tests** for their requested sUAS. --OR— Applicants chose a sUAS which had **laceration test data readily available.** Note: While not seen in the approved waivers with requests for additional information, other approved OOP applications show that providing **vehicle design and operational reliability data** (with other operational mitigations, typically including minimal population size/density and/or minimal time spent over people) in place of injury severity data can be sufficient.	Applicant proposed operational **limitations**: - Altitude; Airspeed (needed to protect people on the ground) - Time flown over people; population size & density – (minimizing is a plus) - Confined area of operation (most applicants geo-fenced) - Environmental limitations: maximum wind speeds, minimum visibility, temperature range Applicant described operating **conditions**: - Equipment that enhances safety (i.e., prop guards, parachute) - Training taken by Remote Pilot / Visual Observers Applicant described **procedures**: - Contingency actions for system faults (Ex: Return to Home mode)	Applicants provided an **extensive list of qualifications / experience** prior to operating over people. Example qualifications / experience that affected approval: - Part 107 pilot's license - Total hours operating sUAS - Total hours operating specific make and model of sUAS - Remote pilot specific Ops Over People training and testing to ensure pilot has necessary knowledge and skills. Applicant provides detailed description / curriculum for training. May include flight training and site training.
Insufficient Information -- Characteristics of the Operations Over People (OOP) applications after requests for additional information	(1) Applicants provided: • Impact / injury severity **test data for a different sUAS**. • Mathematical formulas and **calculations in place of test data**. Ex: Impact probability (2) Applicants stated a parachute will be used, but did not provide parachute test data. FAA asked if parachute met an industry standard. (i.e. ASTM F3322-18 Standard Specification for sUAS Parachutes).	Applicants provided: (1) Laceration injury **test data for a different sUAS** (2) A **statement** that propeller guards will be used, and/or the motors will stop upon impact, but **no supporting test data**. (3) No mention of laceration injury prevention / test data at all.	Applicants did not describe enough operating limitations / conditions / procedures. Applicants mentioned use of return to home mode as a fail safe, but did not provide method(s) to **mitigate the risk** of the sUAS entering the path of another aircraft or impacting people or structures while operating in return to home mode.	Applicants stated RPIC has a Part 107 pilot's license, but give **no other qualifications or experience** to show the FAA the pilot could safely operate over people.

Safety Case Development for UAS Integration



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Is Your UAS Safety Case Ready for Flight?

Leveraging Research and Operations to Get to YES

Jeremy Grogan

Part 107 Waiver Team Lead

Federal Aviation Administration

AUVSI

Getting to YES – Lessons Learned to Inform Your Safety Case

#UAS2019

Getting to YES – Lessons Learned from State Farm you can use to inform Your Safety Case

#UAS2019

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Getting to YES – Lessons Learned to Inform Your Safety Case

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- State Farm identified their needs first
  - Clearly identified and defined their CONOPS and business needs
  - Used the CONOPS to define aircraft requirements
    - Evaluated multiple aircraft and identified the one that best fit their unique operational requirements

Getting to YES – Lessons Learned to Inform Your Safety Case

- Leveraged previously performed research and experience
  - Identified how their operation is different
  - Developed a plan to address those differences

- Leveraged previously accepted risk thresholds
  - Researched issued waivers to search for trends
  - Injury risk of the sUA safety target is within the ANPRM parameters

Performed testing and collected data to validate and understand

- Human Injury Severity and Likelihood
  - Leveraged previous sUA human impact research
  - Injury risk was within ANPRM proposed injury thresholds
- sUAS Failure Modes and Rates
  - Assigned severity/likelihoods to each failure type
  - Allowed detailed likelihoods of human injuries in an impact scenario to be associated with different sUA failure modes

Performed testing and collected data to validate and understand

- BVLOS procedures and risk mitigation effectiveness
  - Determined safe distance for their operation to Detect and Avoid other aircraft
  - Determined C2 range and reliability in their operational scenario
  - Validated the minimum required RPIC and VO knowledge and skill-set was obtained using their developed training program

Prepared waiver application and safety justification which included:

- Validated mitigations included in their safety analysis
- Supplied the testing methods and data used to determine the residual safety level
- Included the mitigations found insufficient during testing
  - How they were updated to address the deficiencies
  - How the updated mitigation now meet the intended level of safety

Why was this approach successful

- State Farm managed their expectations
  - Proceeded from initial constrained CONOPS (crawl)
  - Used lessons learned from Crawl phase and made adjustments to the planned Walk Phase
  - Continue gathering data and lessons learned during Walk phase to apply for their future Run phase plans

Who is AFS and what role do they play in Waivers

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- AFS is the risk acceptor
- Leveraging A19 research
- Leveraged/Coincided with ANPRM injury thresholds
- What did the FAA learn
- You do not have to be a large company to achieve "yes" lessons learned are for you to incorporate into your application for waiver
- It does not take a research lab to do this research

Questions?

Lunch Plenary starts at 12:30 PM…

Keynote Remarks from Finch Fulton

Panel: From Strangers to Partners

Boxed lunch available – Level 400 Ballroom