Operations

(Chief Pilots/ADS-B Flight Following/FDM/Wind)

Antitrust Checklist

We should always....

- **Not** discuss competitive cost, production, market analysis or other competitive trade sensitive data
- **Have** an agenda
- **Report** to our own counsel any concerns that we have of variation from the agenda
- **Keep** minutes for a record of our discussions

HSAC ANTI TRUST STATEMENT

- **The Sherman Act and the Clayton Act are federal statutes which make certain agreements in restraint trade illegal. Violators can be subject to criminal penalties and large monetary damages.**

- The purpose of antitrust policies is to **restrict communications concerning cost, production or other trade sensitive information which could be the foundation for such illegal agreements**.

HSAC ANTI TRUST STATEMENT

Trade Associations / Industry Groups

- Trade associations are generally recognized as a legitimate forum for competitors to share ideas which promote the efficiency of the industry.

- **<u>Example</u>:**
  - How to do things safer, better, more efficiently.
  - However, any discussion which involves the use of cost information (even historical) or other competitive information should not take place without specific authorization of antitrust counsel.

Chief Pilot

- Weather Box Expansion- Shawn Silverman
- 10-year GOM Accident History
- AWOS Weather Stations
- WRA Slide Review
- MSY Airspace Discussion
- Terry Gambill

Single Engine Operations in the GOM

- First offshore drilling was in 1942
- Approximately 7,200 Oil and Gas structures have been installed
- Today about 1,200 active helidecks remain (from BSEE data)
- Estimated that 250-500 helidecks that are restricted to single engine helicopters
- Average 20,000 POB on these structures and movables (from BSEE)

10-year GOM Accident History

(from NTSB reports)

2022

Date	Type	Fatalities	Injured	None	Description	Cause
29-Dec 22	BH-407	4	0	0	On takeoff from offshore platform aircraft rolled over on helideck	Dynamic Rollover
15-Dec 22	BH-206 L4	0	3	0	On take off from offshore platform aircraft skids became stuck and aircraft rolled over on helideck	Dynamic Rollover
26-Oct 22	BH-407	1	2	0	Pilot stated to passengers "He was not going to make it"	Pilot Incapacitation
14-Jan 22	BH-407	2	0	0	Pilot experienced sudden loss of consciousness in flight	Pilot Incapacitation

2021

Date	Type	Fatalities	Injured	None	Description	Cause
25 Sep 21	BH-407	0	0	3	While hovering at the base, aircraft contacted another aircraft during pedal turn	Pilot's failure to maintain adequate clearance

10-year GOM Accident History

(from NTSB reports)

2019						
Date	Type	Fatalities	Injured	None	Description	Cause
10-Mar 19	BH-407	2	0	0	Cruise flight pilot reported deteriorating weather. Impacted marsh during low-level turn	Spatial Disorientation while operating close to the surface
7-Dec 19	BH-407	2	0	0	Engine power loss due to No 3-bearing failure.	Engine Failure

2017						
Date	Type	Fatalities	Injured	None	Description	Cause
6-Feb 17	BH-206B	1	0	2	After night departure from oil tanker in Galveston Bay aircraft likely entered IMC	Unrecognized descent and collision with water
27-Feb 17	BH-407	1	0	0	Flight offshore to onshore without passengers	Collision with water for undetermined reason
2-May 17	BH-407	0	0	6	Pilot detected aircraft vibration and landed aircraft. Inspection found TRB tip cap weights missing.	Inflight separations of TRB tip cap weights

10-year GOM Accident History

(from NTSB reports)

2015

Date	Type	Fatalities	Injured	None	Description	Cause
8-Jun 15	BH-407	0	0	5	Pilot reported strong vibrations and landed in the marsh.	Failure of TRGB Studs possibly caused by imbalance associated with loss of TRB tip weights
28-Jun 15	BH-407	0	1	0	As the aircraft was starting on an offshore helideck, a strong wind pushed the aircraft off the helideck	Pilot's loss of aircraft control due to high winds
30-Oct 15	BH-407	0	0	1	Pilot started aircraft with main rotor blade tied down which broke the blade	Pilot's failure to untie blade

2014

Date	Type	Fatalities	Injured	None	Description	Cause
5-Jan 14	BH-430	0	0	2	While maneuvering on offshore helideck, aircraft's TRB contracted handrail	Pilot's failure to maintain adequate clearance
11-Jun 14	BH-206	2	0	0	Helicopter began to spin on approach to offshore facility	Pilot's loss of control for unknown reasons

10-year GOM Accident History

(from NTSB reports)

2013						
Date	Type	Fatalities	Injured	None	Description	Cause
11-Aug 13	BH-407	0	3	0	Pilot reported a "bang" on liftoff and departing an offshore facility	Engine ingestion of vented methane gas
9-Oct 13	BH-206	1	3	0	Witnesses heard a pop as aircraft departed an offshore facility. Engine exam reveled failure of second-stage turbine.	Engine Failure

10 Year Totals							
Accidents	Fatalities	Injured	None	Leading Causes			
				HFACS	System Component Failure	Pilot Incapacitation	Unknown
17	16	12	19	9	5	2	1

10-year GOM Accident History

(from NTSB reports)

HFACS

Five accidents involving aircraft contacting a helideck or obstacle or failure to maintain control

Three events involving weather

One accident related to pre-flight

System Component Failure

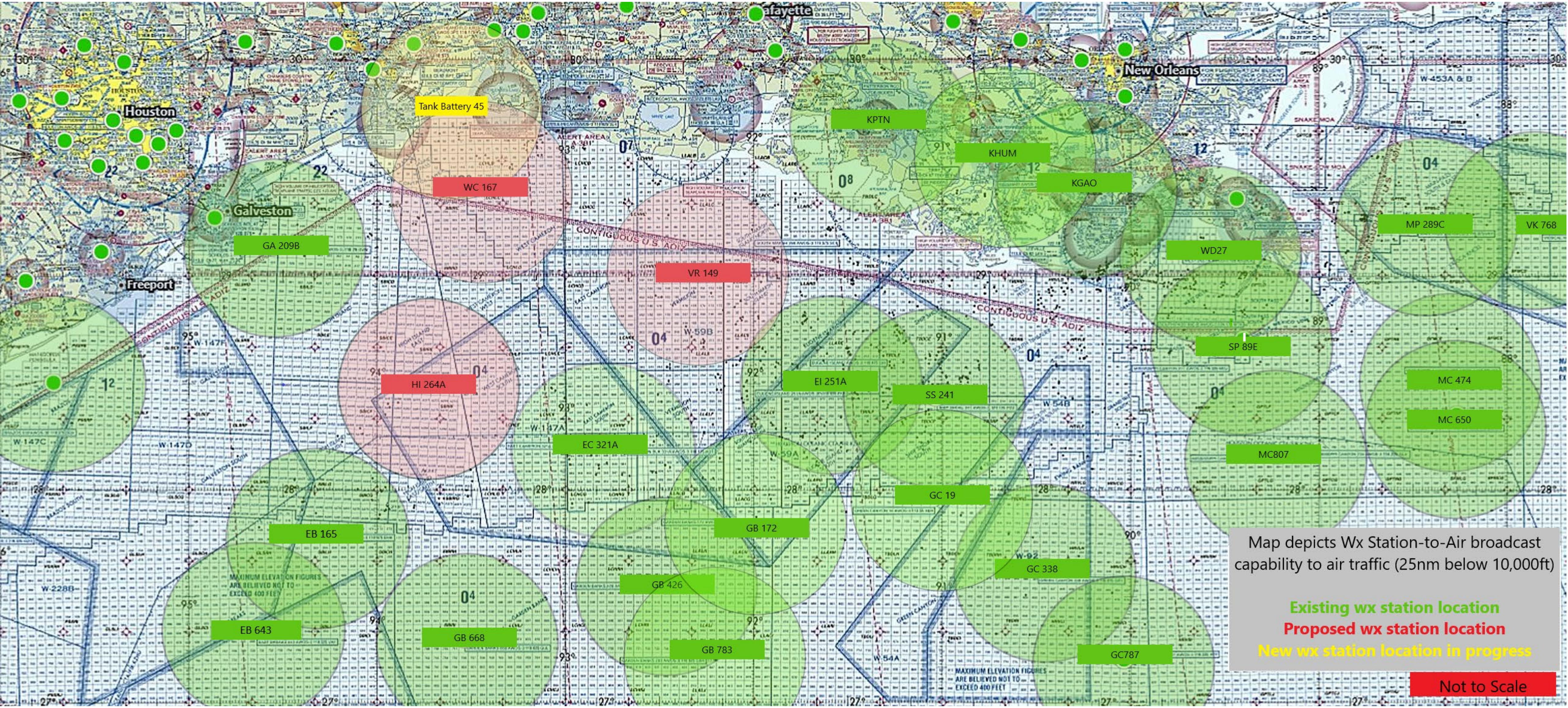
Three accidents related to engine malfunctions or failure

Two accidents related to tail rotor tip weights

Pilot incapacitation

Two accidents related to in-flight medical issues with pilots

GOM Aviation Weather



Flight Following/ADS-B
October 11, 2023

Agenda:

- IFR Traffic Count
- CPDLC Discussion
- HSAC Frequency Changes
- FAA

Flight Following/ADS-B

FAA Traffic Count

Total Operations from 07/01/2023 through 09/30/2023.

	INSTRUMENT OPERATIONS					CLASS B/C/VFR OPERATIONS					
Airport	AC	AT	GA	MI	TOTAL	AC	AT	GA	MI	TOTAL	GTOT
GAO	0	1040	250	10	1300	0	107	170	7	284	**1584**

Flight Following/ADS-B

FAA Traffic Count

Total Operations from 07/01/2023 through 09/30/2023.

	INSTRUMENT OPERATIONS					CLASS B/C/VFR OPERATIONS					
Airport	AC	AT	GA	MI	TOTAL	AC	AT	GA	MI	TOTAL	GTOT
2LS	0	0	0	0	0	0	1	0	0	1	1

Flight Following/ADS-B

FAA Traffic Count

Total Operations from 07/01/2023 through 09/30/2023.

Airport	INSTRUMENT OPERATIONS AC	AT	GA	MI	TOTAL	CLASS B/C/VFR OPERATIONS AC	AT	GA	MI	TOTAL	GTOT
HUM	1	4118	721	7	4847	0	99	534	28	661	5508

Flight Following/ADS-B

CPDLC Discussion: How can we move forward?

HSAC Frequency Changes are Currently Under Revision

Surveillance and Broadcast Services

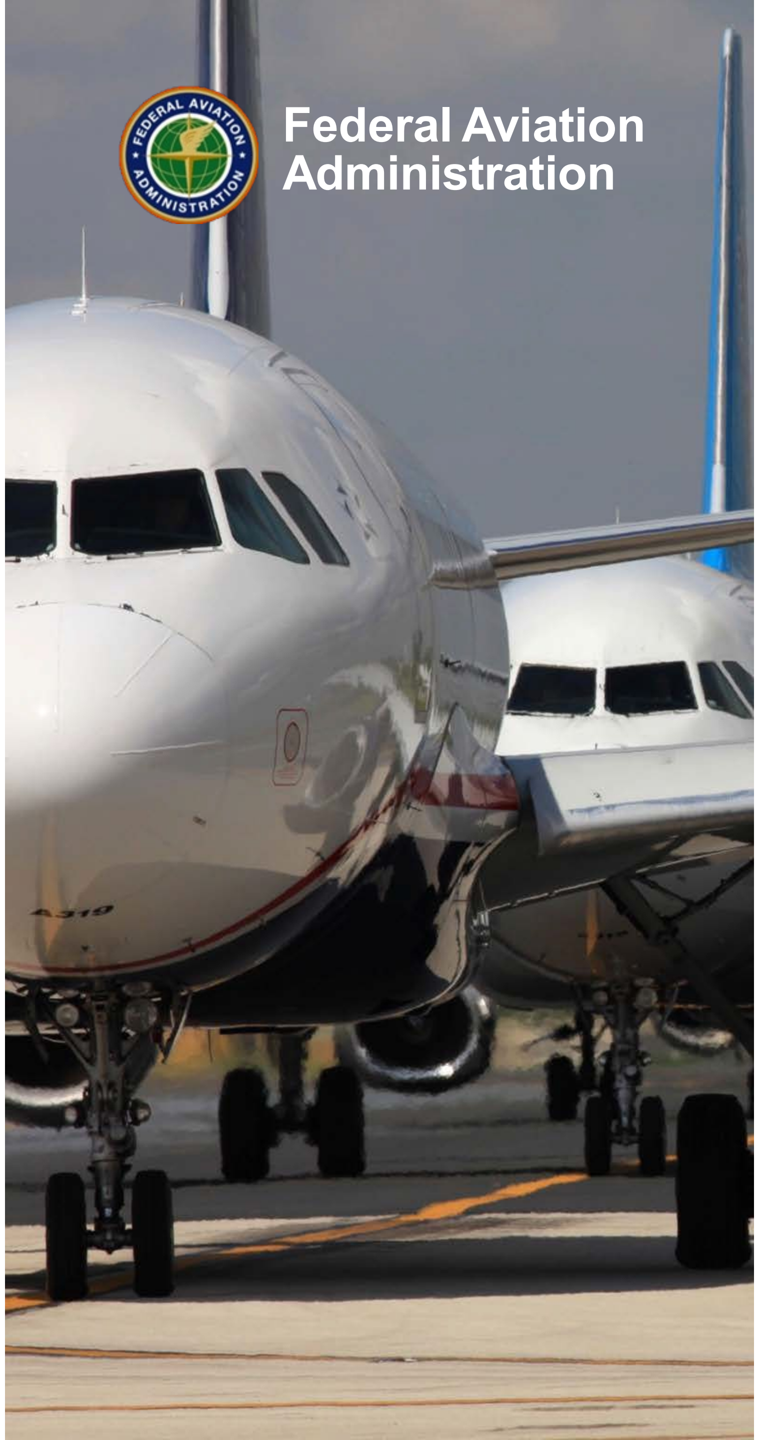
Offshore Infrastructure Management and Engineering

OIMe
"To The Power of Engineering"

Presented to Helicopter Safety Advisory Committee (HSAC) Operations Workgroup

By: Rana Obeid, Federal Lead

Date: October 11, 2023



Agenda

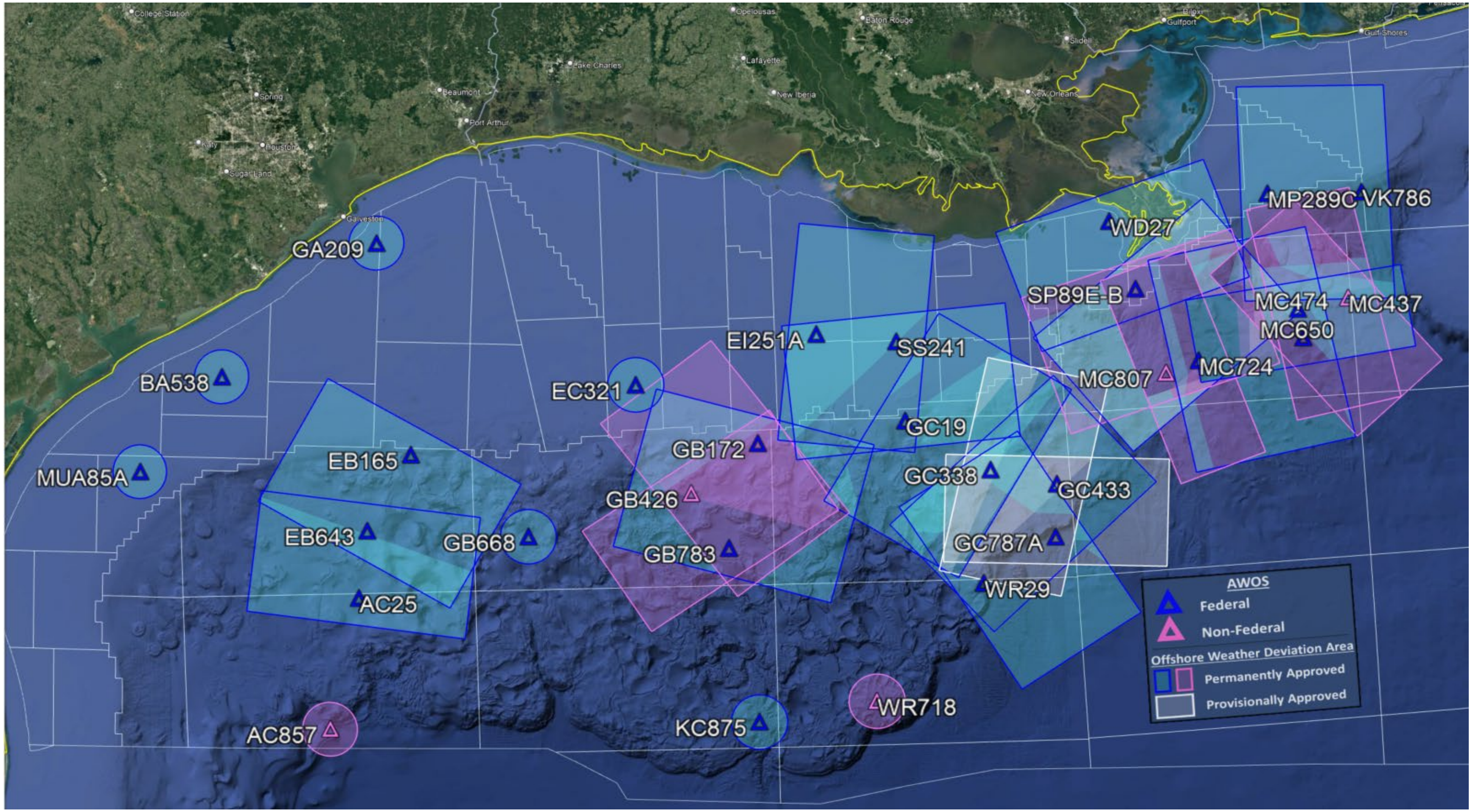
- AWOS Coverage
- ADS-B & VHF Coverage
- Projected Losses
- IFR Traffic Trends

Newly Commissioned AWOS

Chevron's Anchor
Green Canyon 763

Arena's
South Timbalier 52

AWOS Coverage – May 8, 2023

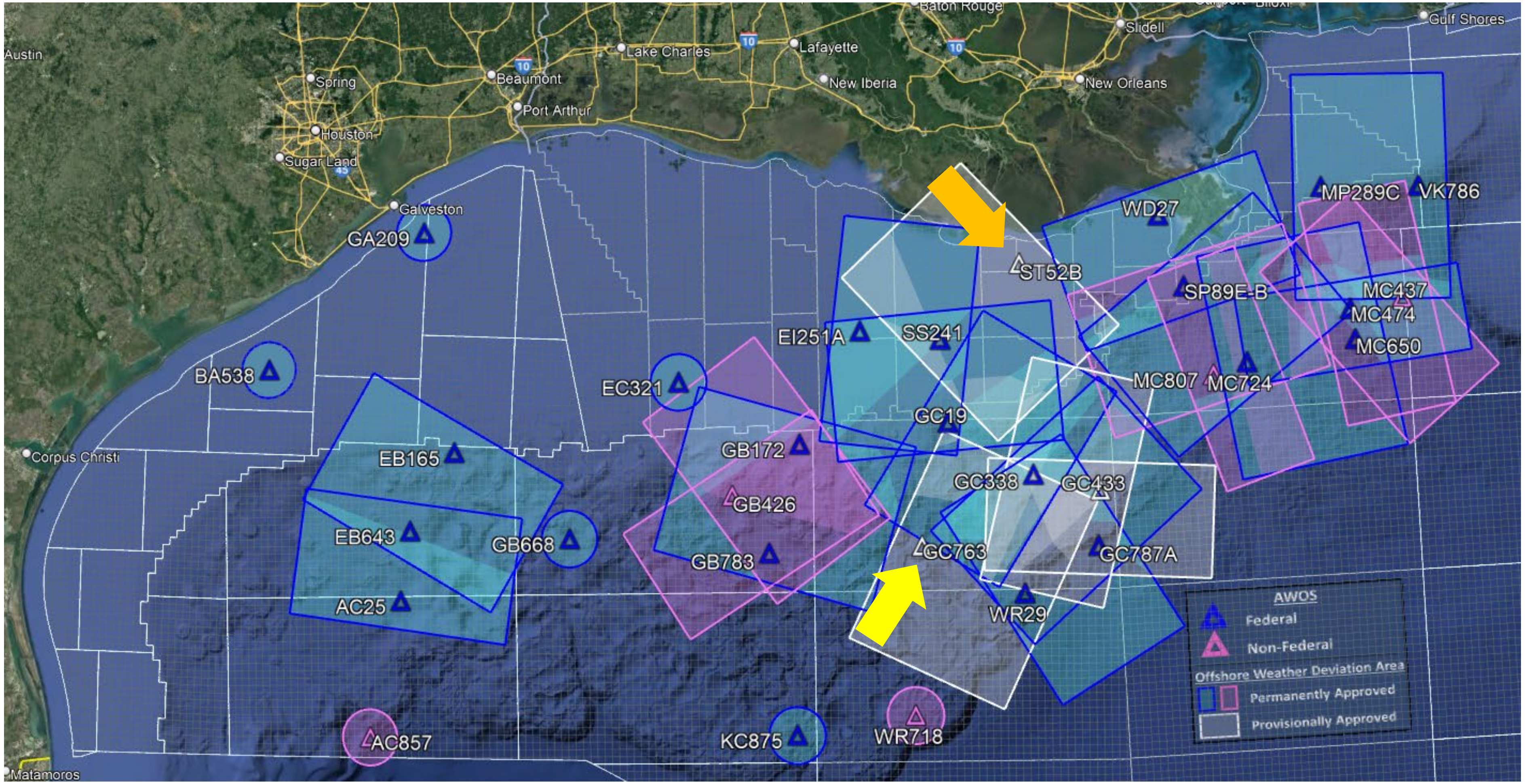


▲ Out of service due to hurricane damage
(none)

Federal AWOS in Operation*: 25/25

***Additional AWOS may be temporarily out of service due to required maintenance**

AWOS Coverage – Oct 12, 2023

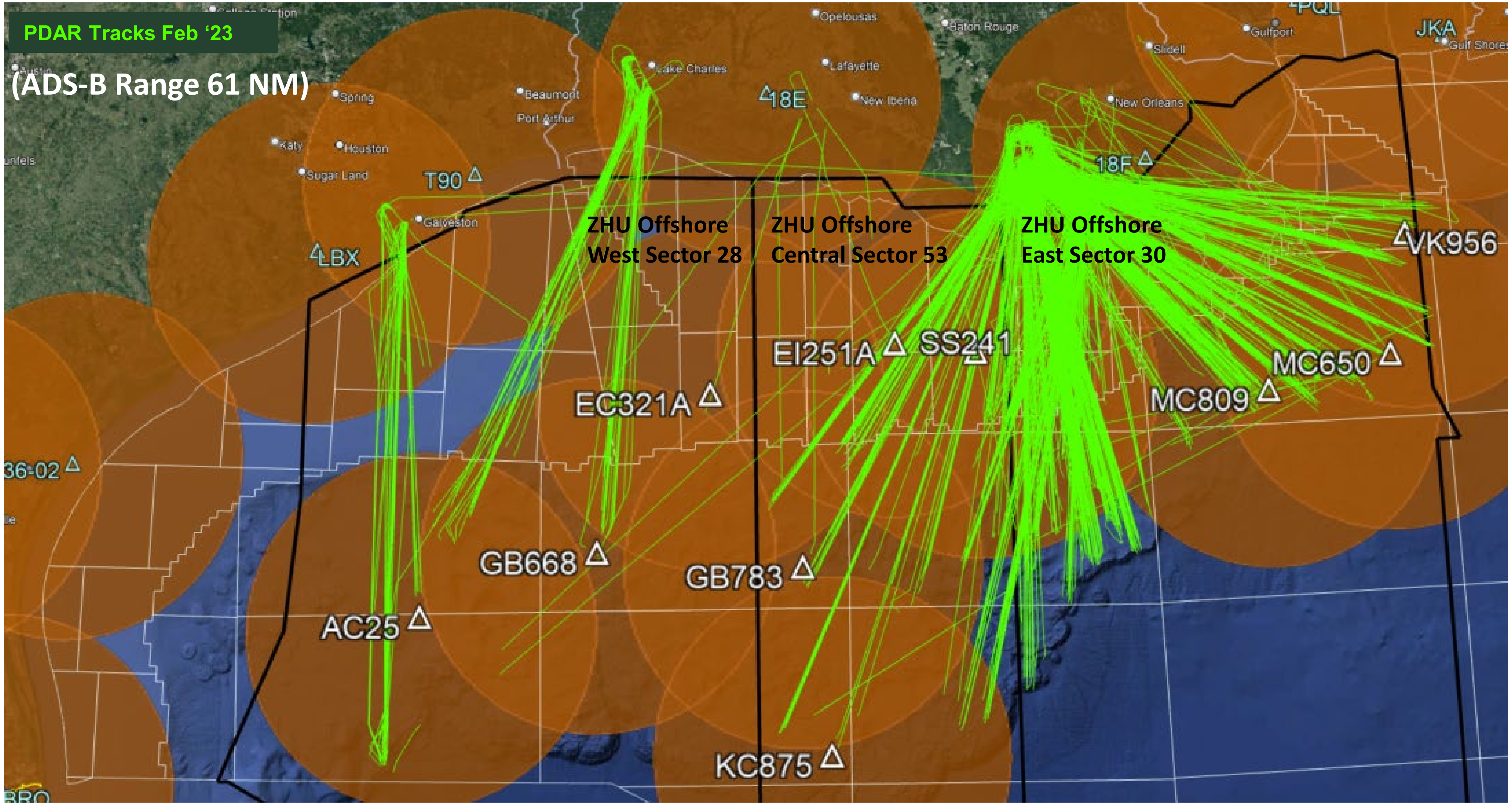


▲ Out of service due to hurricane damage (none)

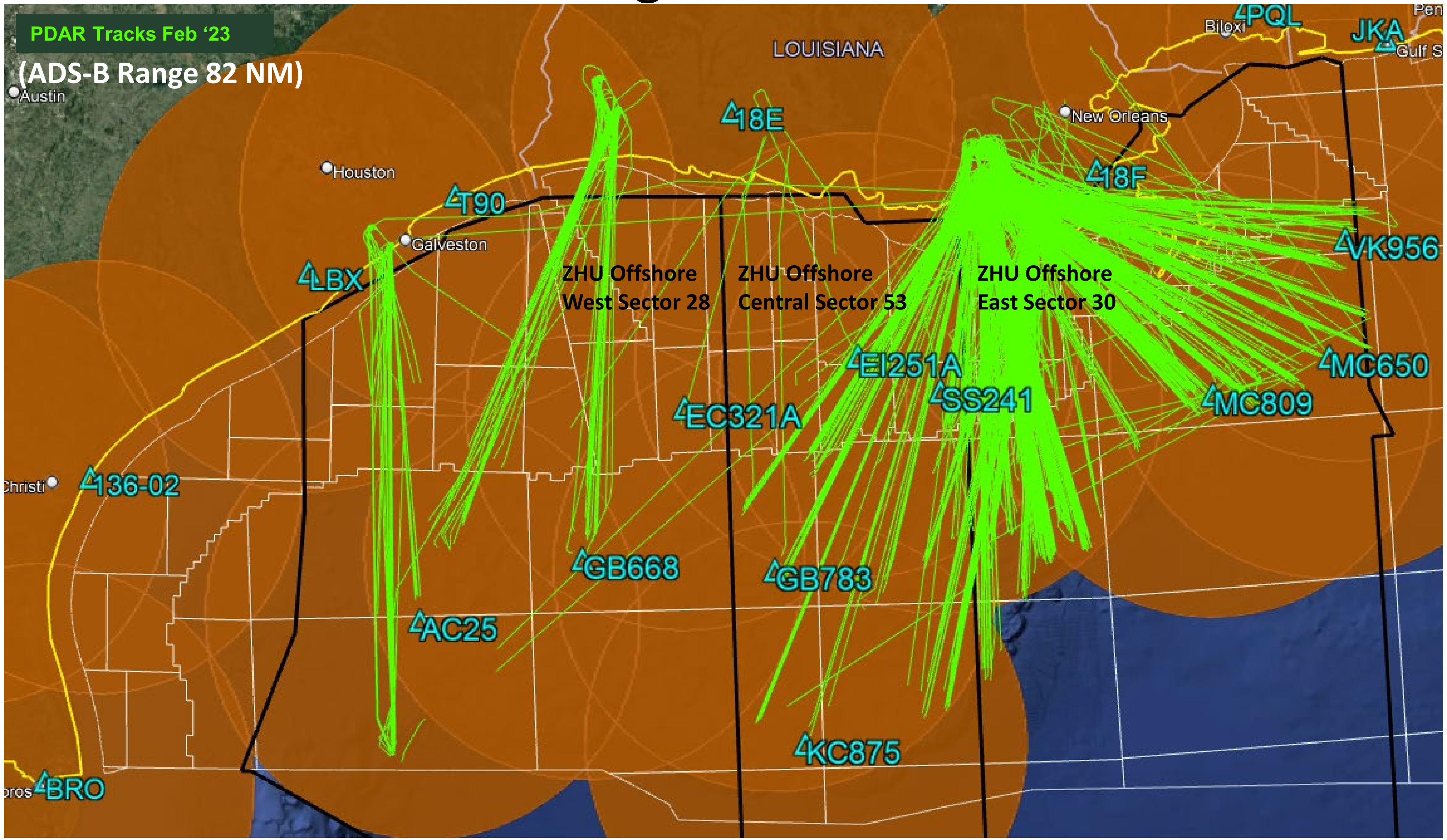
Federal AWOS Commissioned*: 27

*AWOS may be temporarily out of service due to required maintenance

Current ADS-B Coverage 1500' MSL



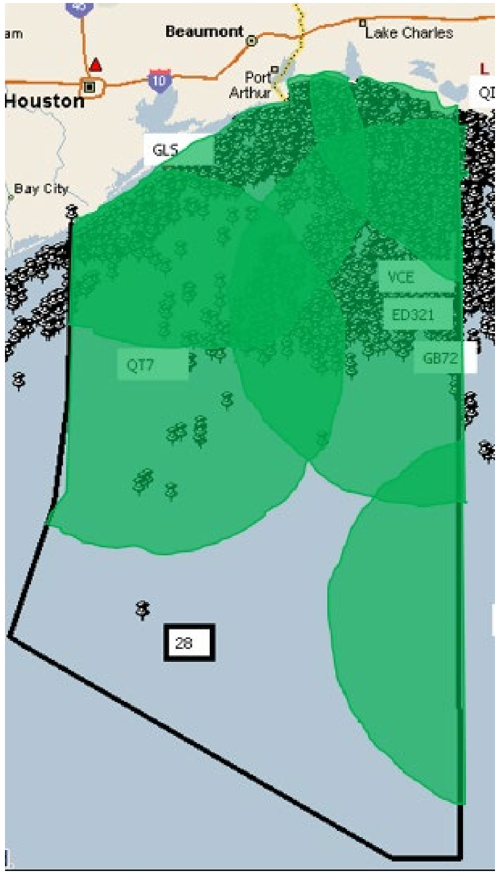
Current ADS-B Coverage 3000' MSL



VHF Comm Coverage 3,000' MSL

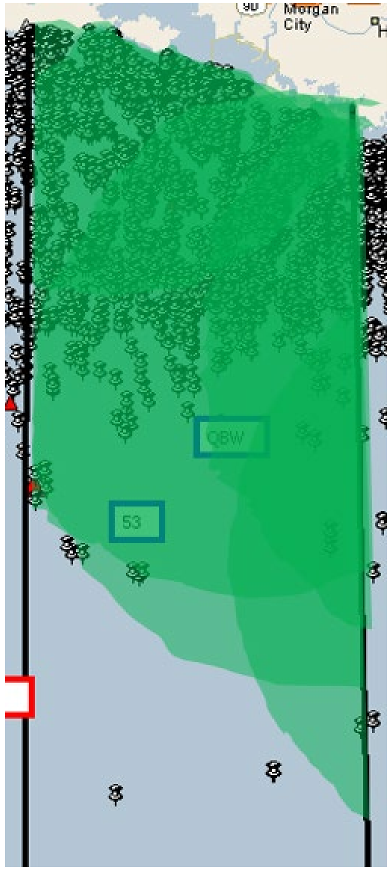
Offshore West /S28

GLS, QIC, QT7, EZP, 18H



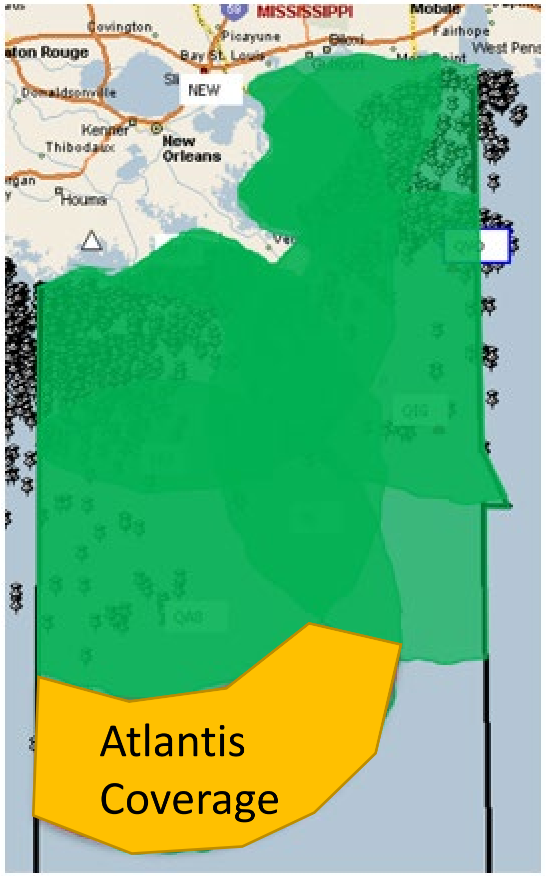
Offshore Central / S53

QIC, EKE, QA8, QBW, 18J



Offshore East / S30

GAO/GNI*, QA8, QVO, QIG, 18J

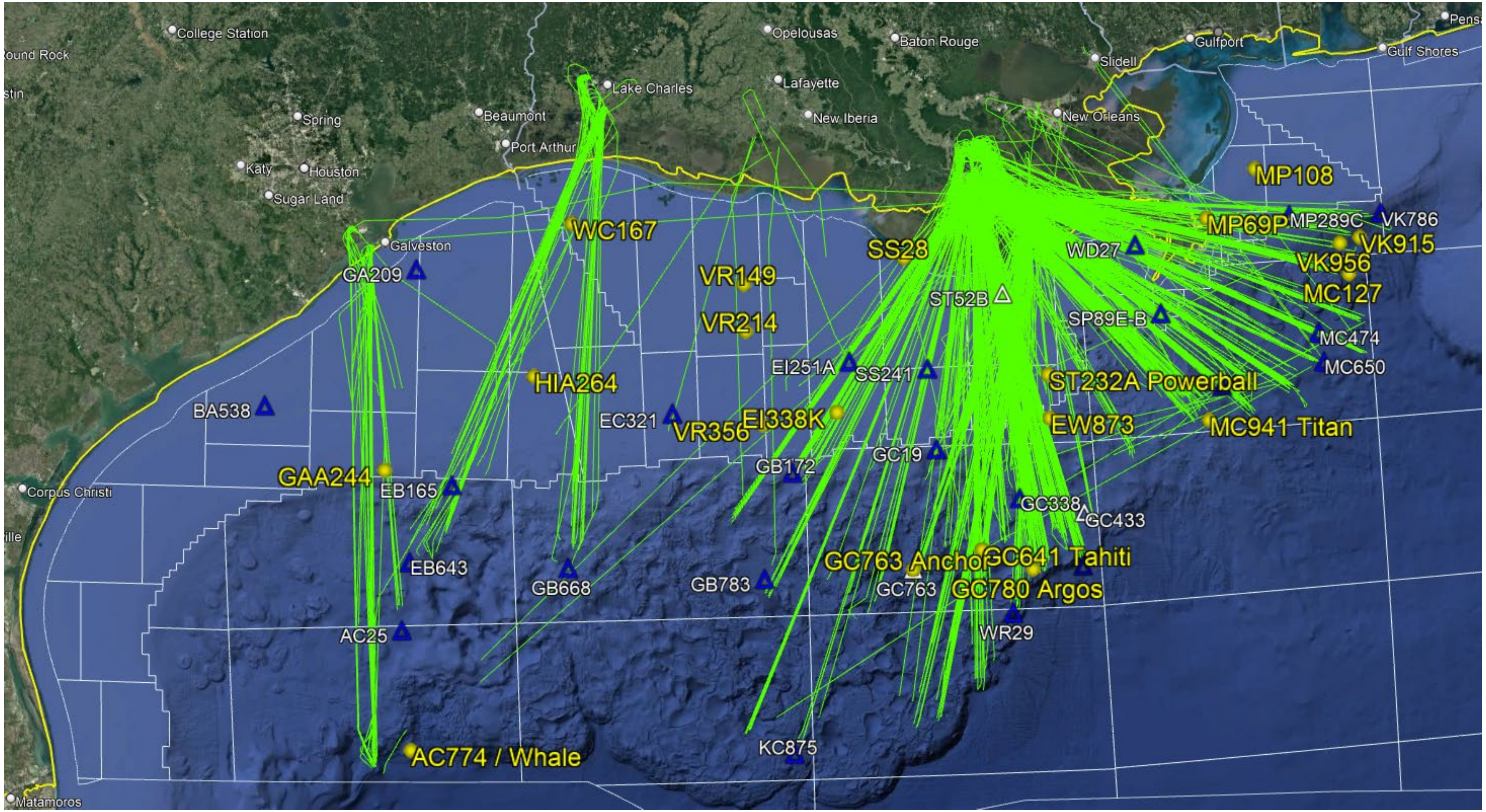


Projected AWOS Losses within 5 Years

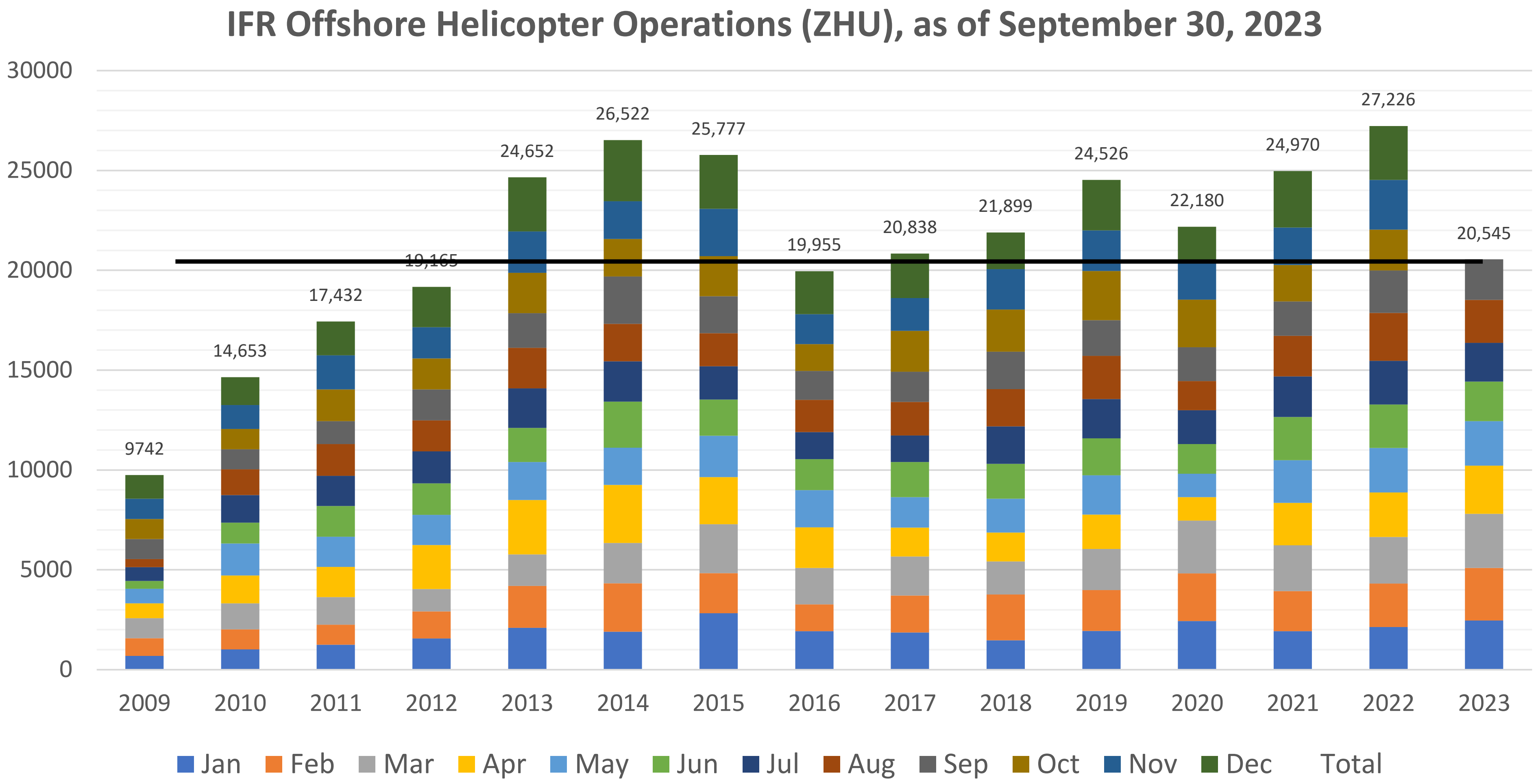
1. Alaminos Canyon 25
2. East Breaks 165 - Seeking additional options
3. East Breaks 643A
4. East Cameron 321A
5. **Garden Banks 668**
6. Garden Banks 783
7. **Mustang Island 85A**
8. Main Pass 289C

- ■ = No replacement identified, seeking replacement suggestions
- ■ = Replacement not planned
- ■ = Possible replacement identified

Candidate Sites Identified for AWOS Installation Within Next 5 Years



ZHU IFR Offshore Traffic Count Chart



FAA OIM^e Team

Offshore Infrastructure Management and Engineering Team

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FDM

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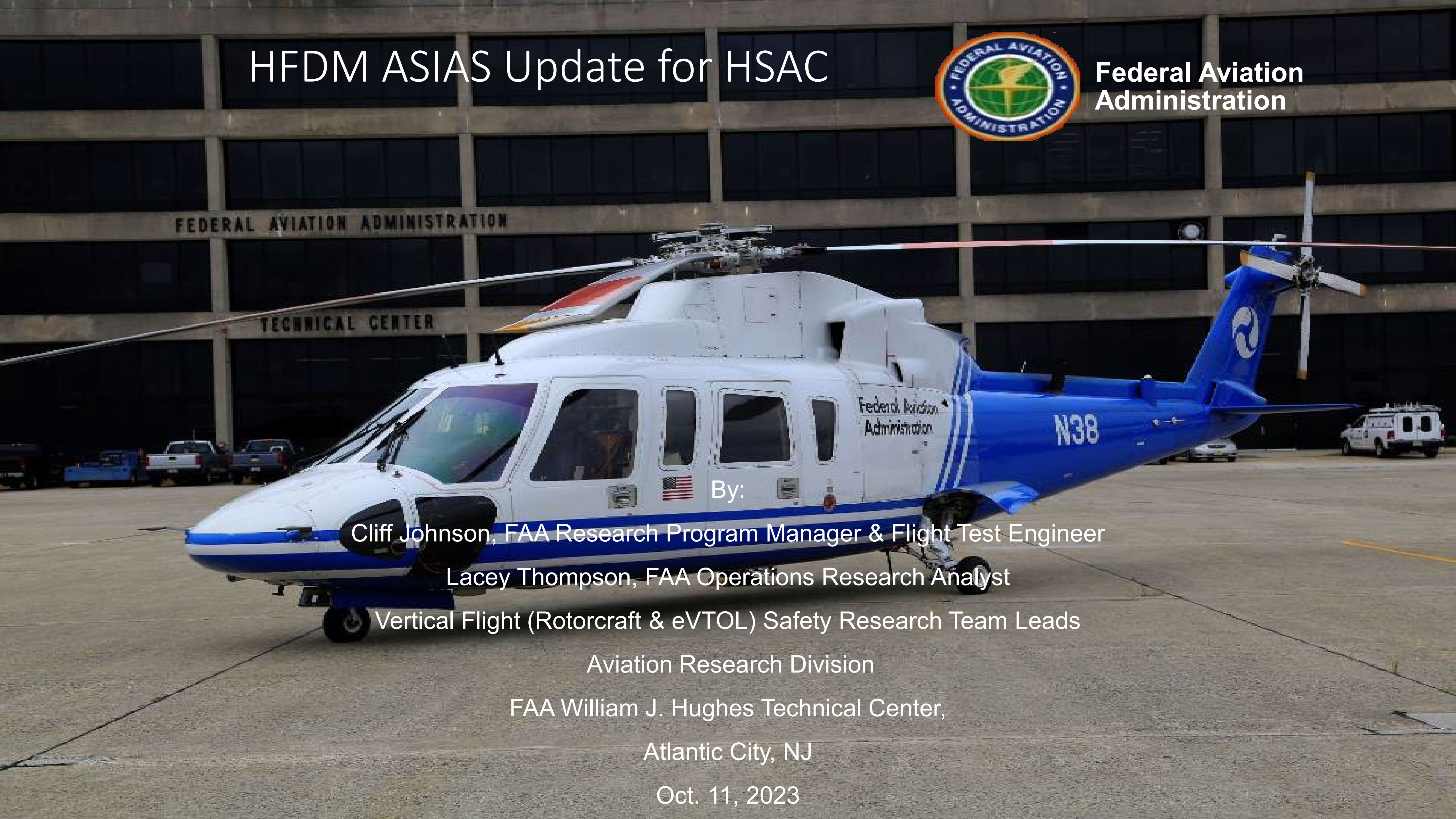
HFDM ASIAS Update for HSAC

Federal Aviation Administration



By:

Cliff Johnson, FAA Research Program Manager & Flight Test Engineer

Lacey Thompson, FAA Operations Research Analyst

Vertical Flight (Rotorcraft & eVTOL) Safety Research Team Leads

Aviation Research Division

FAA William J. Hughes Technical Center,

Atlantic City, NJ

Oct. 11, 2023

Aviation Safety Infoshare

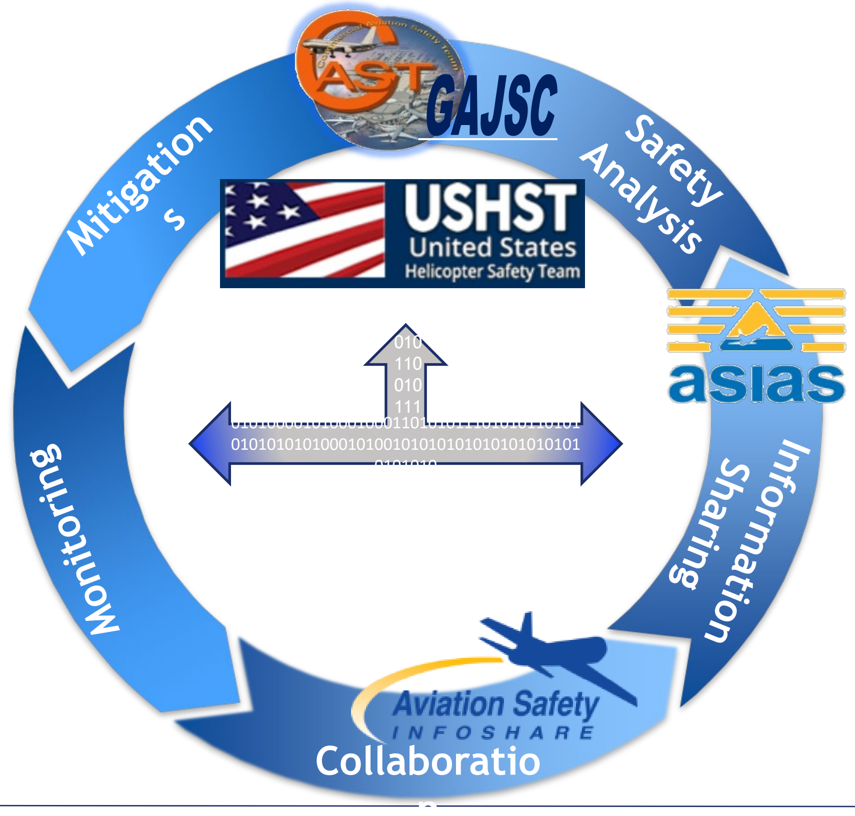
- Dallas, TX
- Helicopter Breakout Session is tentatively scheduled (note: not confirmed) for Wed. Dec. 13, 2023 from ~ 8:00 am-5:00 pm

Note: If interested in attending/presenting, please contact Sean Mulholland – Infoshare Industry Co-Chair, 7Bar Aviation/AirEvac Lifeteam/Global Medical Response

Email: Sean.Mulholland@gmr.net

Phone: 817-875-8856

ASIAS Continuous Improvement in Aviation Safety



Aviation Safety Information Analysis and Sharing (ASIAS)

A collaborative government and industry initiative on data sharing and analysis to proactively discover safety concerns before accidents or incidents occur, leading to timely mitigation and prevention

ASIAS Stakeholders As of July 31, 2023

*Newest Member

47 Commercial Air Carriers

21Air
ABX Air
Air Canada
Air Transport International
Air Wisconsin Airlines
Alaska Airlines
Allegiant Air
Aloha Air Cargo
American Airlines
Amerijet International Airlines
Atlas Air/Polar Air Cargo
Avelo Airlines
CommutAir
Delta Air Lines
Eastern Airlines LLC
Empire Airlines
Endeavor Air
Envoy Air
FedEx Express
Frontier Airlines
GoJet Airlines
Hawaiian Airlines
Horizon Air
iAero Airways
JetBlue Airways
Kalitta Air
Mesa Airlines
Mountain Air Cargo
National Airlines
Northern Air Cargo
Omni Air International
Piedmont Airlines
PSA Airlines
Ravn Alaska
Republic Airline
Silver Airways
SkyLease Cargo
SkyWest Airlines
Southern Air
Southwest Airlines
Spirit Airlines
Sterling Airways
Sun Country Airlines
United Airlines
United Parcel Service
USA Jet Airlines
World Atlantic Airlines

158 General Aviation and On-Demand Part 135 Air Carriers

711 Cody, Inc.
Abbott Laboratories
ACAS
ACI Jet
Aero
Aero Charter
Airshare
Albertsons
Ameriflight
BCH, LLC
Best Jets International
Bombardier Flight Operations
Boston Scientific
*Business Jet Aviation Services
Cape Air
The Coca-Cola Company
Cook Canyon Ranch Aviation
Costco Wholesale
Crew Aviation LLC
CTP Aviation
Digital Monitoring Products
Eli Lilly
Embraer Executive Jets
Enterprise Holdings
Executive Fliteways
Executive Jet Management
FAA Flight Program Operations
Fair Wind Air Charter
Flexjet
Flight Options
*Four Corners Aviation
Gama Aviation Signature
Giostyle, LLC
Glazer's Inc.
GrandView Aviation
Gulfstream Aerospace Flight Operations
Hanover Foods Flight Ops
International Jet Aviation Services
Jet Access
Jet Aviation
Jet Edge International
Jet Linx
Johnson & Johnson
JSX
Key Lime Air
Kroger Aviation
LECO Corporation
Luck Companies
Mayo Aviation
MB Aviation
Mente LLC
Milliken
NetJets
Northeastern Aviation Corp.
Northern Jet
OnFlight, Inc.
Pacific Gas & Electric Co.
Parker Hannifin
Peace River Citrus Products
Priester Aviation
Qualcomm, Inc.
REVA
RTFlight
Sands Aviation, LLC
Sanford Health
SC Aviation
SC Johnson
SevenBar Aviation
Silver Air
Smithfield Foods Flight Department
Solairus Aviation
Stryker Corporation
Talon Air
Textron Aviation
Tradewind Aviation
Universal Flight Services
Valero Travel Services
Venture Jets
Vulcan, Inc.
Waltzing Matilda Aviation
Wing Aviation Charter Services
Wright Air Service
XOJET
*75 Additional Operators

Industry

COMMERCIAL
- A4A—Airlines for America
- ADF—Airline Dispatchers Federation
- AIA—Aerospace Industries Association
- Airbus
- ALPA—Air Line Pilots Association
- APA–Allied Pilots Association
- Boeing
- CAPA—Coalition of Airline Pilots Associations
- IBT—International Brotherhood of Teamsters
- IPA—Independent Pilots Association
- NACA—National Air Carrier Association
- NAFA—National Aircraft Finance Association
- NATCA—National Air Traffic Controllers Association
- RAA—Regional Airline Association
- SAPA—SkyWest Airlines Pilot Association
- SWAPA—Southwest Airlines Pilots Association

GENERAL AVIATION
- ACSF—Air Charter Safety Foundation
- AMOA—Air Medical Operators Association (also Rotorcraft Industry)
- AOPA—Aircraft Owners and Pilots Association
- Embraer
- GAMA—General Aviation Manufacturers Association
- Gulfstream Aerospace
- NBAA—National Business Aviation Association
- NJASAP—NetJets Association of Shared Aircraft Pilots
- Textron Aviation

ROTORCRAFT
- HAI—Helicopter Association International
- Sikorsky A Lockheed Martin Company
- Tour Operators Program of Safety (TOPS)

Rotorcraft

Air Evac Lifeteam
Metro Aviation
SevenBar Aviation
STAT MedEvac
U.S. Coast Guard Aviation Logistics Center
University of North Dakota

Flight Training

California Aeronautical University
FlightSafety International, Inc.
L3Harris
Liberty University
University of North Dakota
Southern Utah University
9 Additional Stakeholders

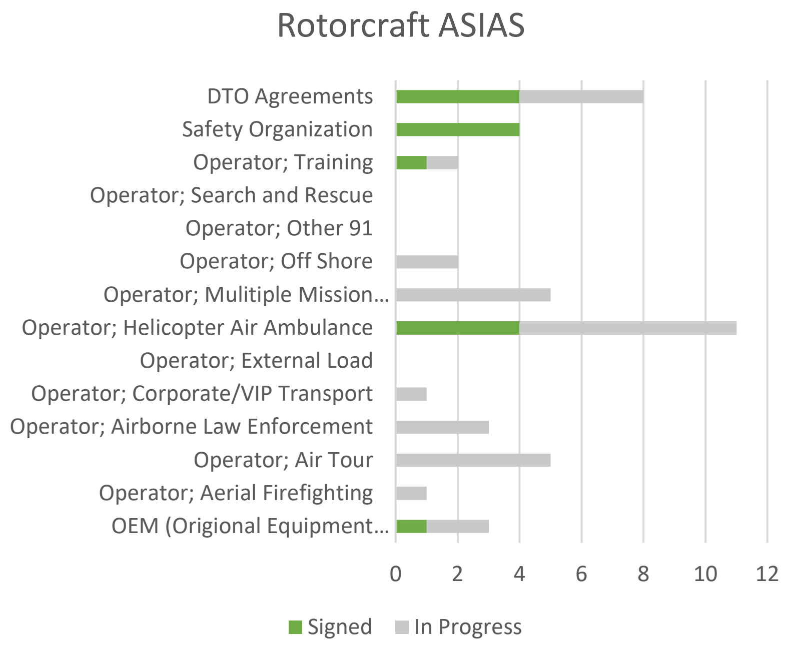
Government

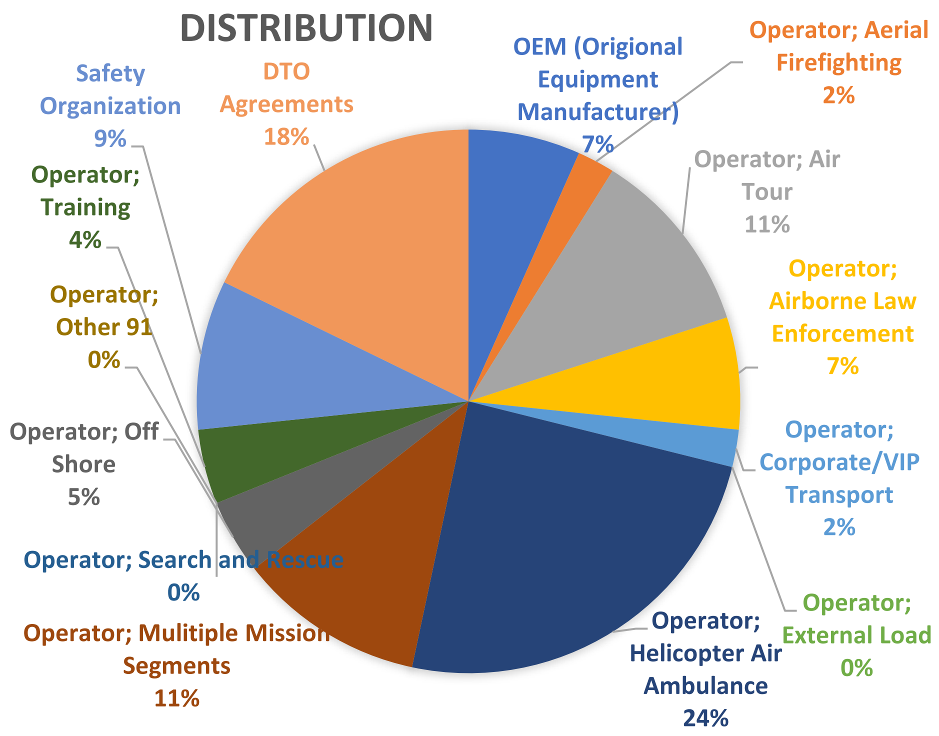
AMC—Air Mobility Command
FAA—Federal Aviation Administration
NASA—National Aeronautics and Space Administration
Naval Air Force Atlantic
USAF Safety Center

Maintenance, Repair, & Overhaul

AAR Aircraft Services
HAECO Americas

Outreach Efforts (2023)





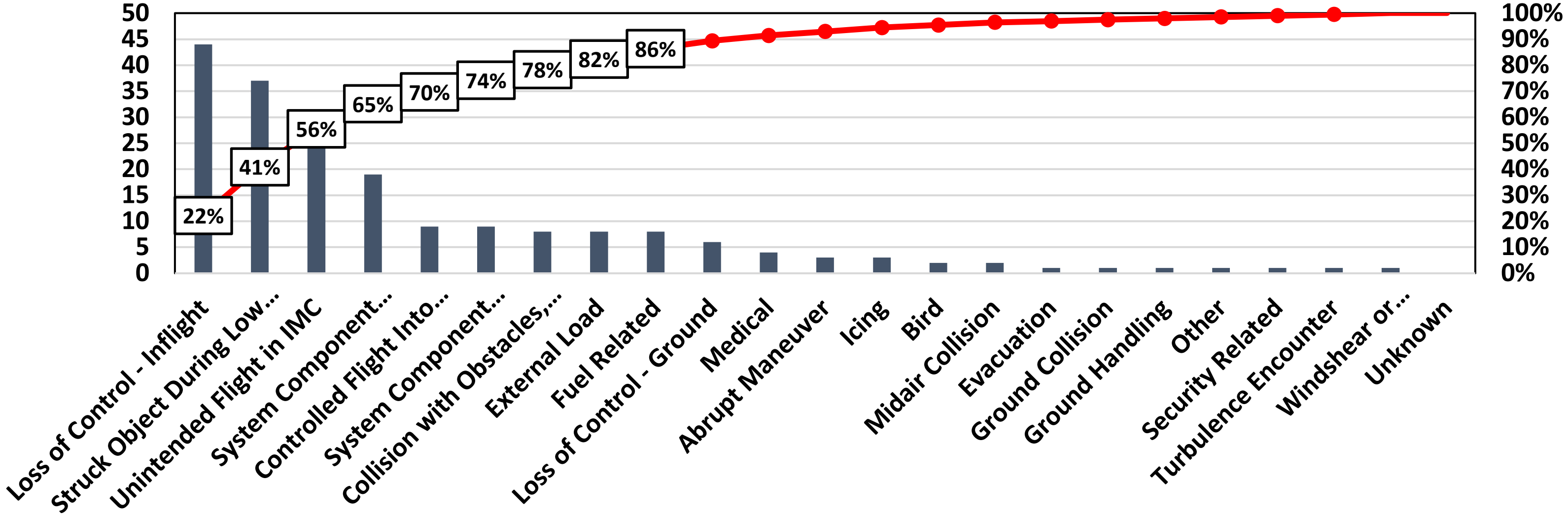
Motivation

Rotorcraft accidents rates have historically been ***higher*** compared to commercial and general aviation

Commercial and General Aviation have successfully used on-board data to help achieve ***higher levels of safety***

A collaborative environment enables the community to better identify and understand ***current and emerging risks*** to ***Rotorcraft*** aviation flight safety. This will enable stakeholders to take ***proactive steps to mitigate reported systemic risks***

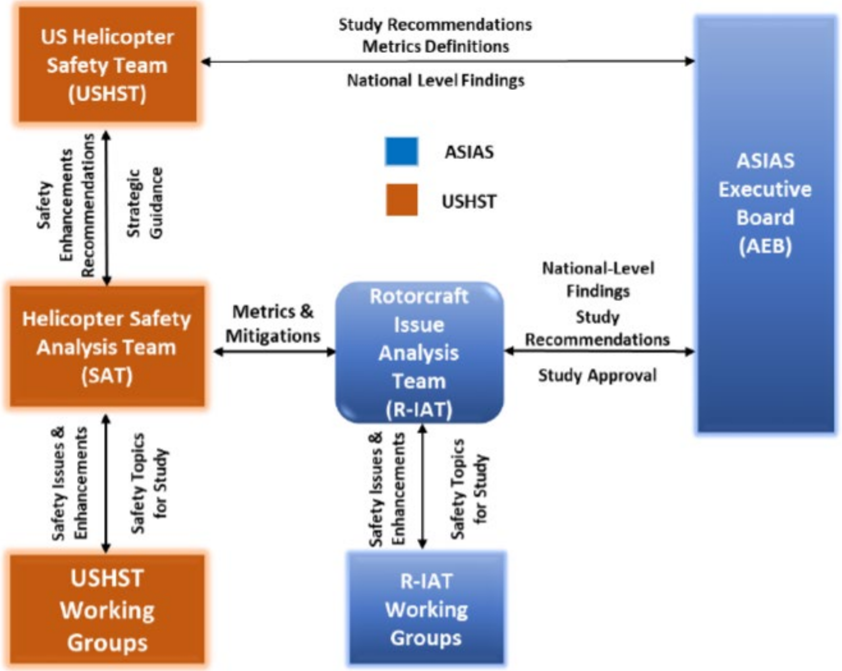
USHST – Pareto of Rotorcraft accidents (2009 – 2018)



asias

R-IAT Leadership:

- Operators
- Associations
- Manufacturers
- Academic Institutions
- FAA
- Other Government Agencies



ASIAS Outreach Working Group

The Rotorcraft ASIAS Outreach working group initiative is to increase community awareness of the R-ASIAS program and the management practices that could elevate their overall safety performance thru participation in Rotorcraft ASIAS program.

- Continued improvement in outreach principals and communication.
- Increase participation in Rotorcraft ASIAS
- Promotion of proactive safety programs
  - FDM/FOQA
  - Safety narrative reports (e.g., ASAP or internal safety reports
  - SMS

ASIAS Data Standardization Working Group

- The Rotorcraft ASIAS data standardization working group provides subject matter experts for the development of analytical capabilities and metrics for R-ASIAS.
- Focus of the working group is to standardize events, parameters, and safety indicators across diverse mission segments to enable safety risk identification.

Participation

Rotorcraft ASIAS Web Portal

https://www.rotorcraft.asias.info

Ways to Participate

- Third Party Cooperative Agreements – DTOs
- Cooperative Agreements – Operators
- Statements of Intent – R-IAT members or non-data providing organizations who meet the criteria for participation
- All participants must adhere to ASIAS Procedures and Operations (P&O) Plan

Rotorcraft ASIAS Points of Contact

Ed Stockhausen
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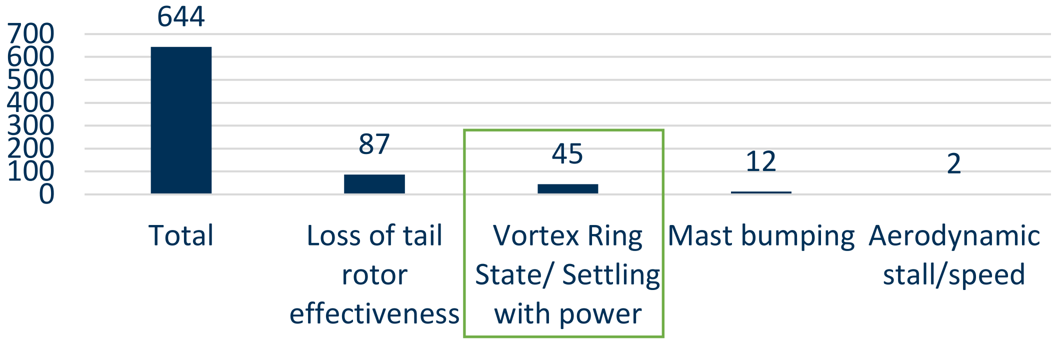
HFDM Research Activities

- Metrics & Directed Studies
  - Loss of Control
  - UIMC
  - Unstable Approach
- Vortex Ring State (VRS) Recovery Scenarios Testing
  - Recovery Techniques Comparison
  - Aerodynamic Modelling
  - Detection Algorithms
- Anomaly Detection
  - Takeoffs & Landings
  - Other Flight Exceedance Events

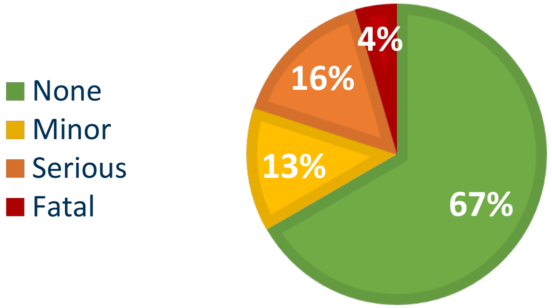
Introduction: Loss of Control In-Flight Accidents

- Introduction
- VRS Recovery Metrics
- VRS Accident Analysis
- Scenario-Based Simulations
- Conclusion

LOSS OF CONTROL IN FLIGHT EVENTS (2008-2021)



HIGHEST INJURY LEVEL % AMONG VRS ACCIDENTS (2008-2021)



https://www.rotorandwing.com/

https://www.knoxnews.com/

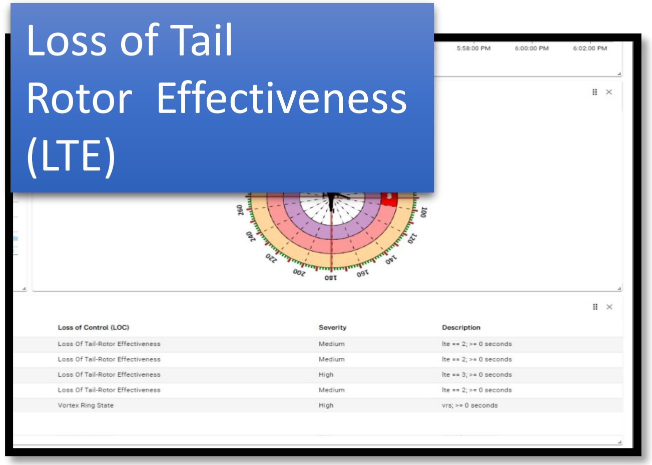
- In all cases, the helicopter suffered at least substantial damages

VRS is one of the most prominent causes of accidents related to loss of control in flight [1]

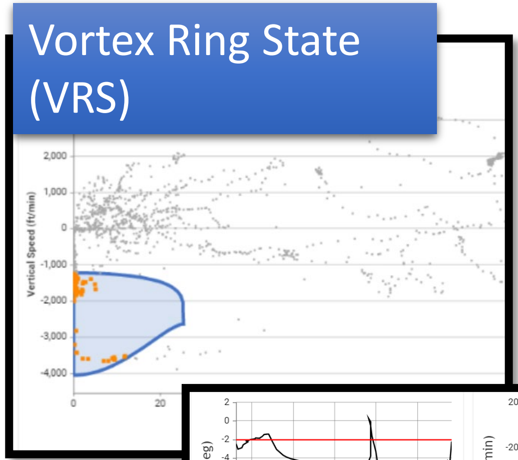
1. National Transportation Safety Board (NTSB). ”Case Analysis and Reporting Online (CAROL)”. https://data.ntsb.gov/carol-main-public/landing-page. [retrieved 10/01/22].

Loss of Control - Inflight (LOC-I) Metric Development

Loss of Tail Rotor Effectiveness (LTE)



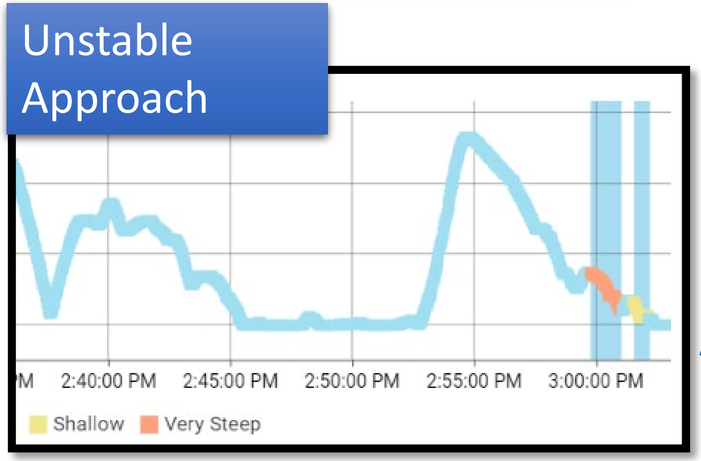
Vortex Ring State (VRS)



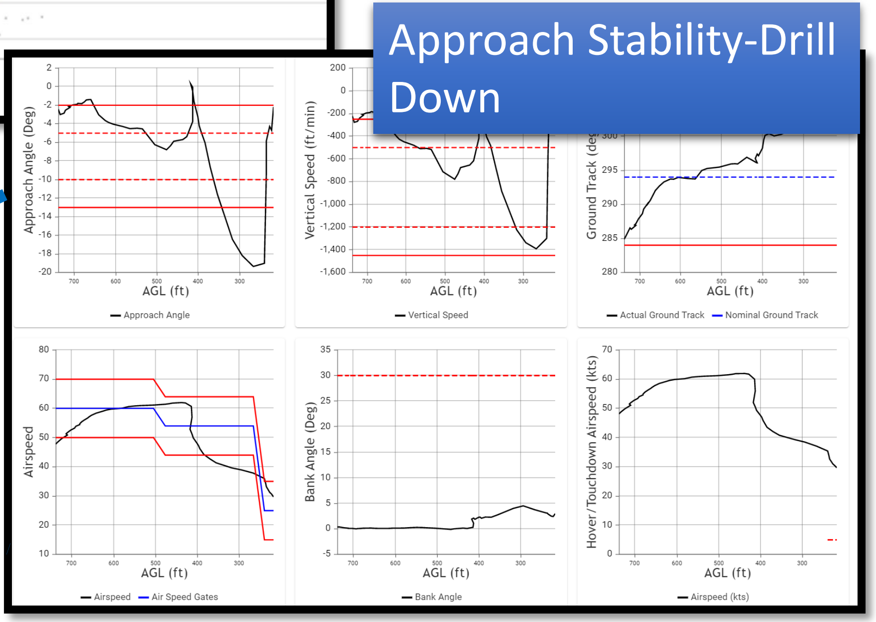
FAA and OSEs are developing metrics to support the ***identification*** and ***analysis*** of rotorcraft-related LOC-I events to support the development of ***mitigation strategies***

A final Directed Study report will be ***submitted to AEB***, and ***permission*** will be sought to ***release findings and/or aggregated data*** to safety teams (USHST, SAT), if required

Unstable Approach



Approach Stability-Drill Down



MOCK DATA DISPLAYED

asias

Unintended flight in Instrument Meteorological Conditions (UIMC) Metric Development

Over 80% of UIMC accidents result in fatalities

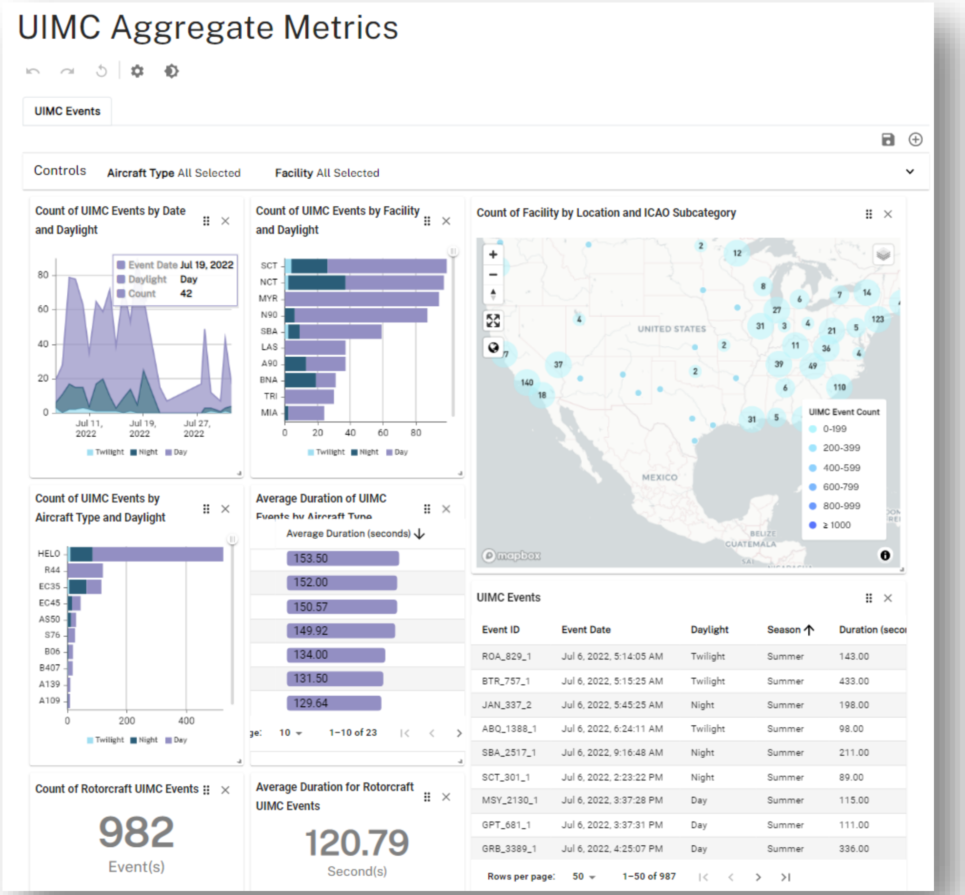
MITRE is leading the development and implementation of a UIMC event detection algorithm with surveillance and weather data in the FAA's Enterprise Information Management (EIM) platform

Ongoing Tasks

1. Adapt UIMC algorithm to include additional weather parameters and use Threaded Track data
2. Determine the confidence score of UIMC events
3. Profile flight tracks to identify rotorcraft operations

This metric will facilitate the analysis of rotorcraft-related UIMC events to support the ***identification of emerging safety issues***, and the ***monitoring*** and ***forecasting*** of safety trends

Permission will be sought from ***AEB*** to ***release aggregated data*** to the safety teams (USHST, SAT), if required

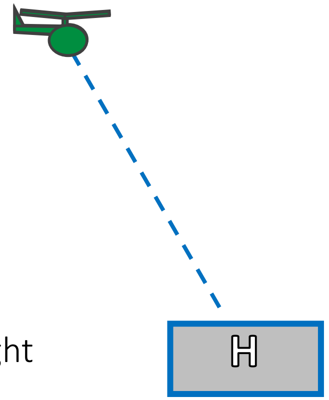


MOCK DATA DISPLAYED

Unstable Approach

- Stable approach: approximate constant approach angle glidepath with few fluctuations

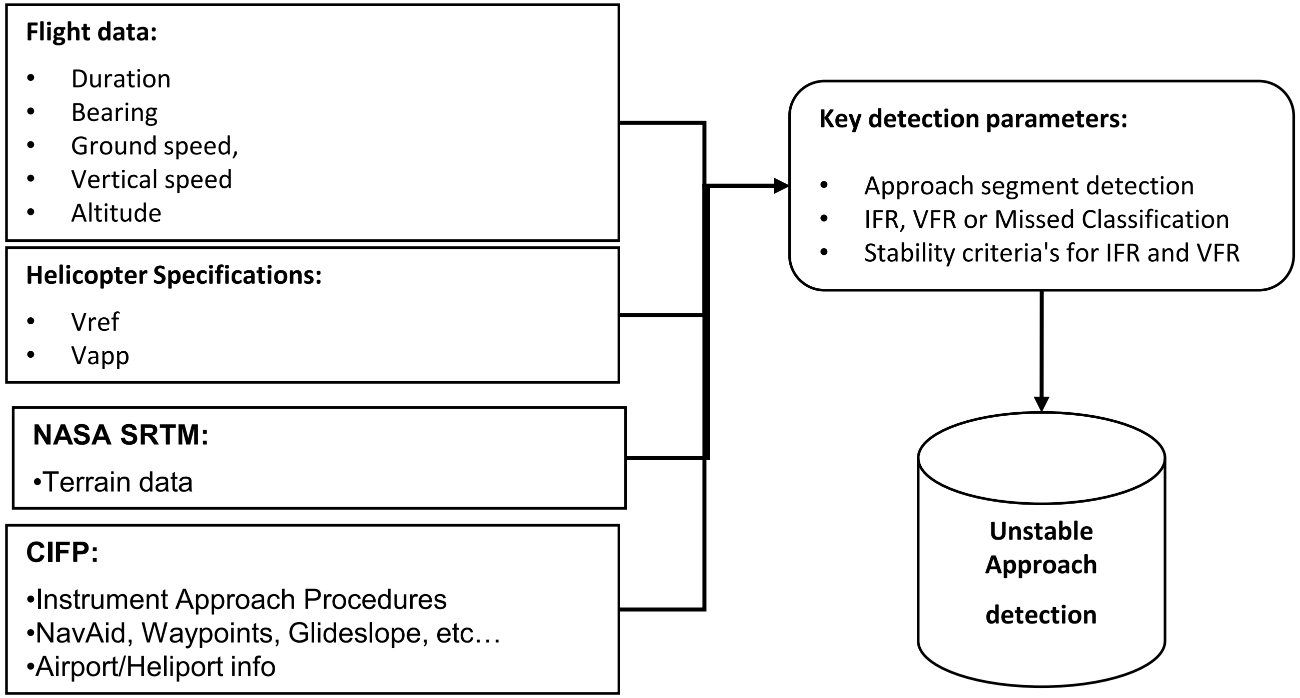
- Unstable approach: fluctuations in altitude, approach angle, airspeed and/or more:



- Goals:
  - Automatically identify approach segments in flight recorder data
  - Use **clustering techniques** and **performance metrics** to quantify the stability of each approach
  - Use **statistical analysis** and **machine learning** to search for patterns and correlations in the data, and identify precursors to “unstable approaches”
  - FAA has identified unstabilized approaches as a leading cause of helipad overruns and other approach/landing accidents

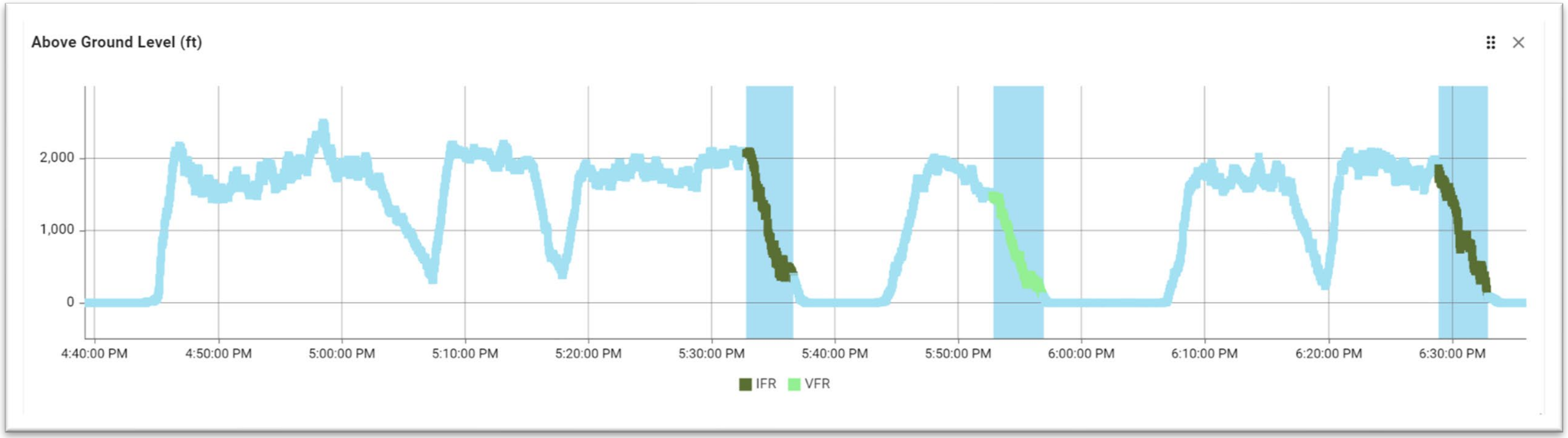
→ Inform safety decisions, pilot training, standard operating procedures, etc.

Current Unstable Approach metric algorithm



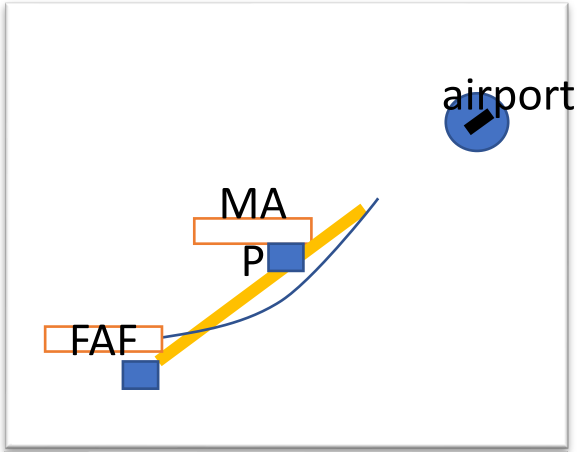
Detecting Approaches

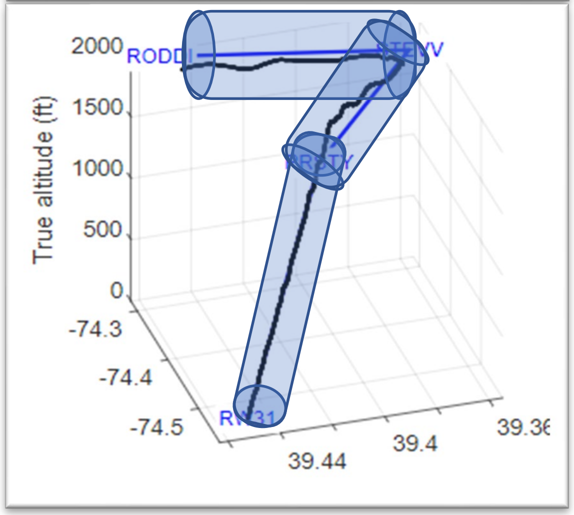
- VFR and IFR Approach Detection
  - Forms events from ground speed, vertical speed, altitude
  - Performs multiple passes to join neighboring events into single approach event



Instrument Approach Procedure Detection

- Locates nearest facility to flight path end
- Builds nominal paths of Instrument Approach Procedures in CIFP
- Compares nominal path to flight path based on:
  - Proximity to final approach leg (FAF to MAP) path
  - # of flight points within a buffer of the procedure’s path
  - # of missed waypoints per procedure
  - Proximity, laterally and vertically, to entire procedure’s path

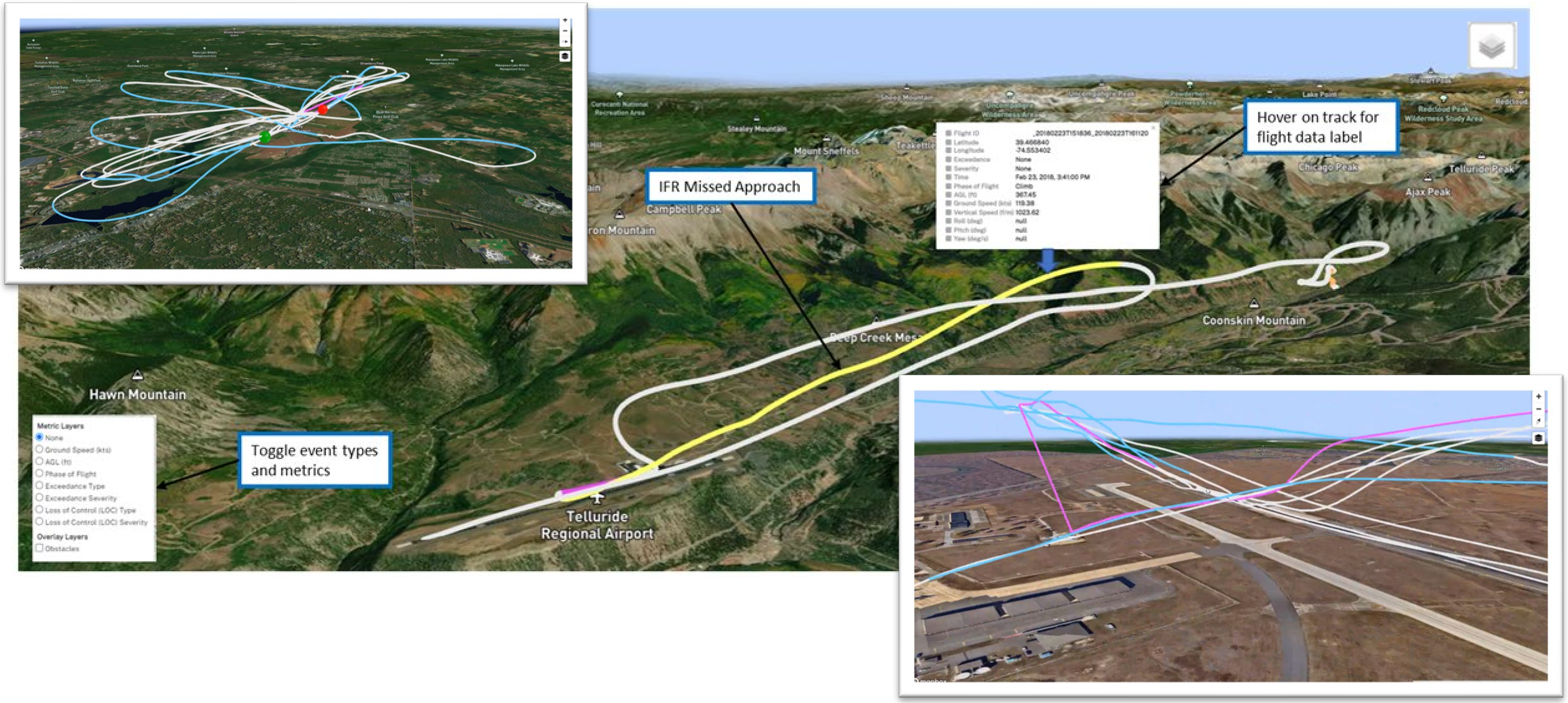




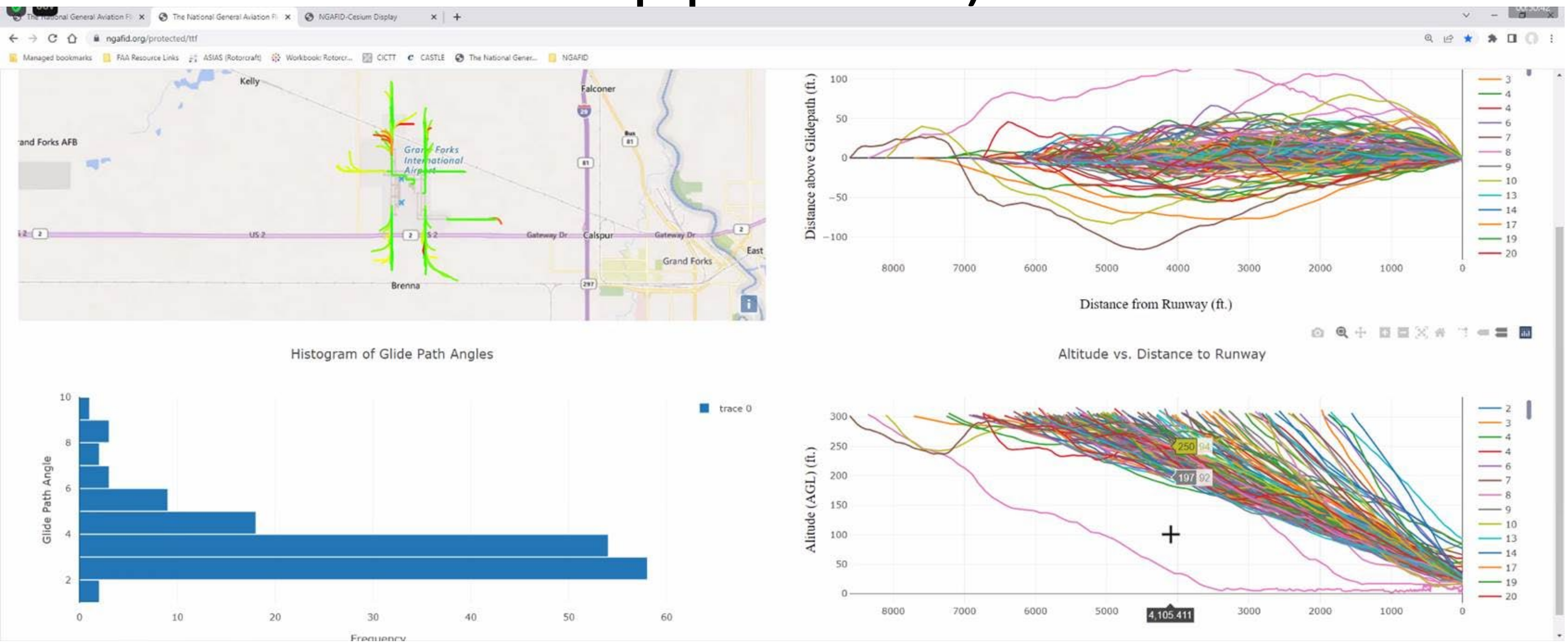
Visualizations

- What we have today
  - Operator: My Flights – Flight specific approach classification and stability analysis
  - Aggregate metrics – By time, time and rate , aircraft make/model, mission, LoC-I type
  - Operator Aggregate metrics – Benchmarks against time and rate , aircraft make/model, mission, LoC-I type
- Future: **Operator** Specific maps
  - 2D/3D Geospatial Map view of approaches
- Future: Aggregate and Flight Specific stability analysis
  - Approach within population mean and standard deviations
  - Stability Parameters by altitude gates (e.g. RoD at 250’ vs 500’ across aircraft types)
  - Missed approach rate
- Get feedback from group on visualizations

3D Approach Rendering

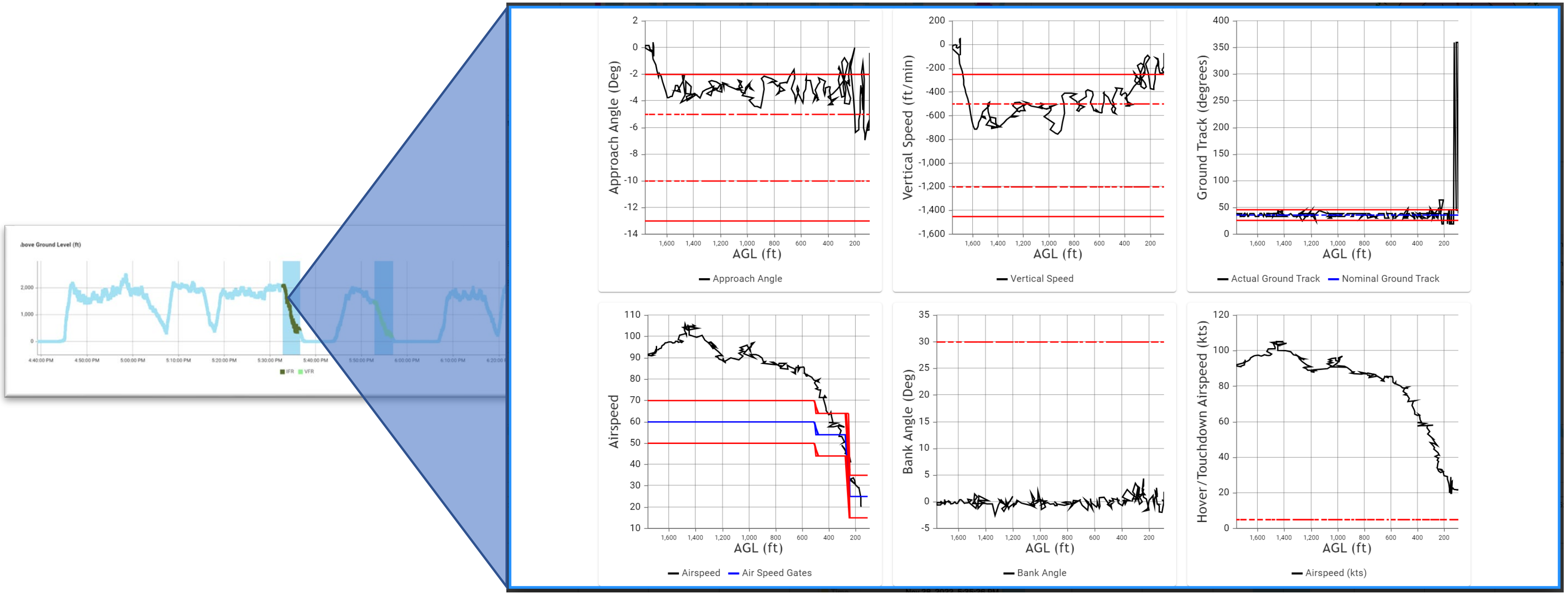


Aggregate Map View (Unstable Approach)



Deterministic Approach – Physics Based

- Deterministic Parameter Calculations
- Unstable if at least 20% of points are outside of the tolerances defined



Stability Criteria

- Deterministic Approach (Current State)
  - Identified Tolerances for key parameters (E.g. Approach Angle, Airspeed, etc…)
  - 80-20 rule (if 20% of points exceed tolerances)
- Statistical Approach – 1 (Recommended State)
  - Evaluate population statistics of key parameters by aircraft type, VFR/IFR
  - Unstable Approach if a parameter is outside of 2σ from its population
- Statistical Approach – 2
  - Evaluate variance within the flight of key params
  - Ensureconstant angle, descent rate, speed, etc…
- Statistical Approach – 3 (Future)
  - Build ML-based outlier detection
  - Receive labeled unstable approaches from operators and build model

Proposed Rotorcraft Stable Approach Criteria

- <u>Visual Approach</u>
  - Airspeed: IAS +/- 10 kts. of Vref, with +/- 10 kts. at altitude gates (i.e. 1,000’, 500’, 250’, 100’, 50’)
  - Approach Angle:
    - Normal: 10°
    - Steep: 15°
    - Shallow: 5°
    - Tolerance: (+/- 3°)
  - Vertical Speed:
    - Normal: 300 fpm - 1,200 fpm
    - Steep: >= 1,200 fpm
    - Shallow: <= 300 fpm
    - Tolerance: (+/- 250 fpm)
  - Ground Track: +/- 10° of final approach course
  - Hover/Touchdown: Airspeed <= 5 kts.
  - Bank Angle: <= 30°

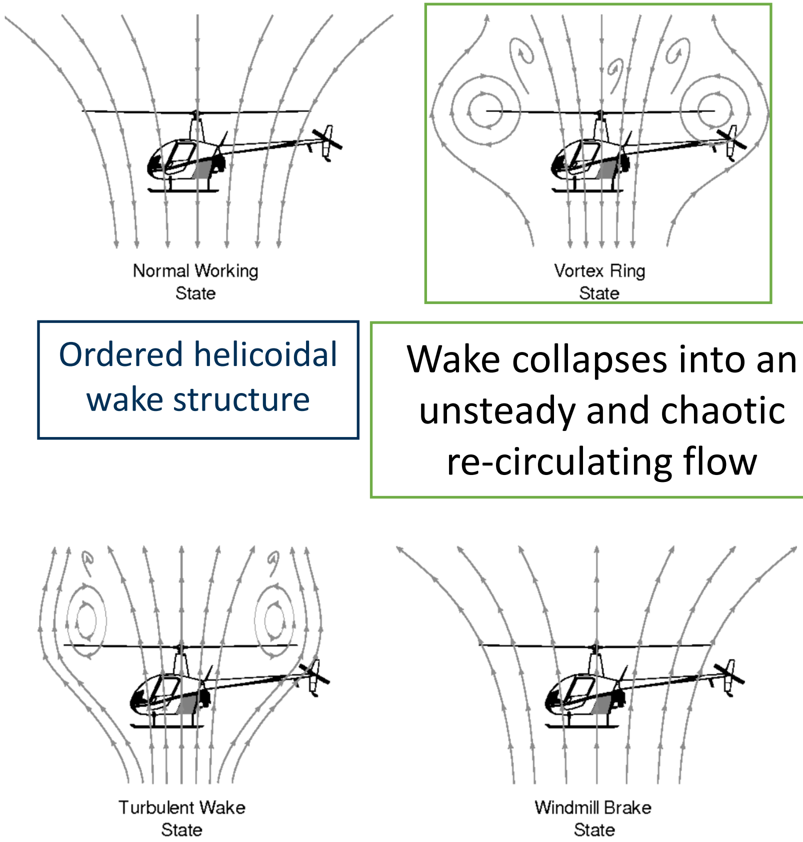
- <u>Instrument Approach</u>
  - Airspeed: IAS +/- 10 kts. of Vref, but not <= Vmini
  - Vertical Speed: <= 700 fpm (precision) or <= 1,000 fpm (non-precision) **unless approach dictates higher rate of descent*
  - Ground Track: +/- 5° of final approach course
  - Lateral Deviation: Within ½ scale deflection of localizer or localizer performance or 5° of VOR/NDB bearing
  - Vertical Deviation: Within one dot glideslope or glidepath
  - Bank Angle: <= 20°

?’s – Should proposed stable approach criteria be dependent on specific make/model/series of rotorcraft and/or mission segment? Altitude/Distance/Airspeed Gates? Torque? Bank Angle Limits?

Introduction: Vortex Ring State

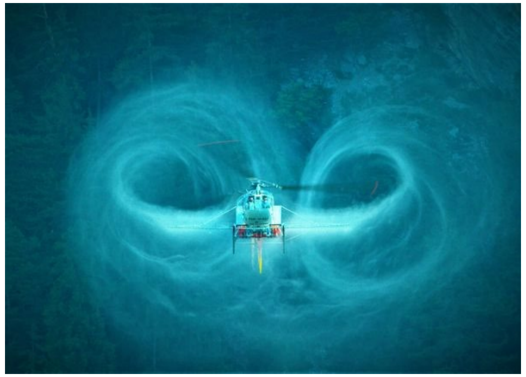
The 4 Working states of the rotor in axial flight [2]:

- **Introduction**
- VRS Recovery Metrics
- VRS Accident Analysis
- Scenario-Based Simulations
- Conclusion



Ordered helicoidal wake structure

Wake collapses into an unsteady and chaotic re-circulating flow



mvheli.com

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2. Leishman J. G. Principles of Helicopter Aerodynamics. Cambridge University Press, New York, NY, 2000. p.252-258.
3. Federal Aviation Administration. Helicopter Flying Handbook (FAA-H-8083-21B). 2019. Ch.11.
4. Brand A. Dreier M. Kisor R. and Wood T. "The Nature of Vortex Ring State". Journal of the American Helicopter Society, 56 (2), April 2011

Introduction: Vortex Ring State

VRS inducing characteristics:

- Low or zero true airspeed
- Collective input creating induced flow
- Sufficient Rate of Descent, depending on the Helicopter disk loading

Symptoms of VRS encounter:

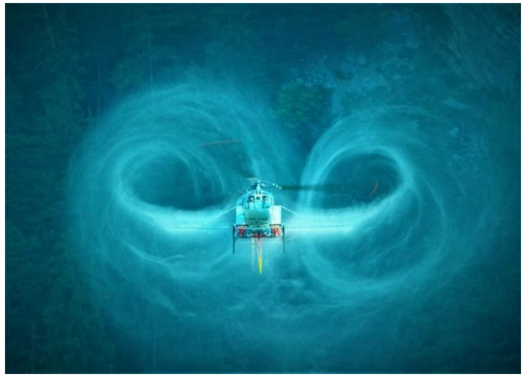
- Random uncontrolled pitch, roll and yaw
- Aircraft vibrations and stick shake
- Increasing rate of descent
- Less control authority

Intuitive reaction:

→ Increases rotor power

→ Feeds vortex motion without generating additional lift

→ Forces helicopter down



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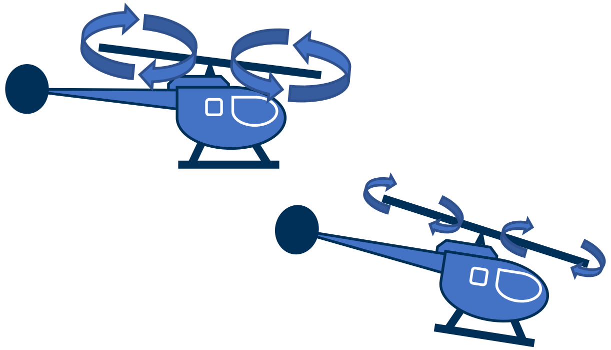
4. Brand A. Dreier M. Kisor R. and Wood T. "The Nature of Vortex Ring State". Journal of the American Helicopter Society, 56 (2), April 2011

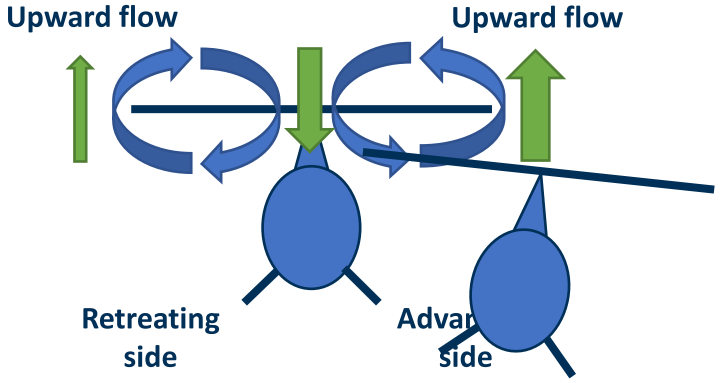
Introduction: Recovery Techniques

Three competing techniques are currently taught:

- **Traditional recovery:**
  - Establish forward flight speed by lowering collective and pitching down



- **Vuichard recovery:**
  - Bring advancing blade in the upward flow by banking to the right and adding power while maintaining heading



Airbus recovery:

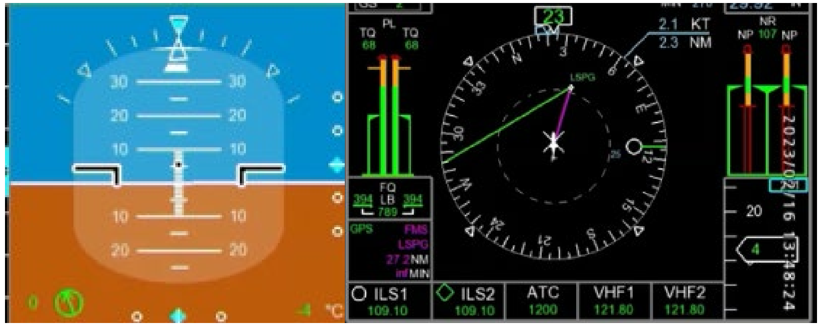
Establish forward flight speed by increasing collective and pitching down

- Recovery through autorotation is also possible → Very high loss of altitude

VRS Methodology

On-line Simulation

- Analyze VRS accident reports and discuss with subject matter experts
- Establish a list of VRS prone situations
- Write and Test scenario-based simulations for each situation
- Run scenarios with various pilots
- Identify pilots’ decision making process in each case
- Compare recovery techniques and determine best course of action



Preliminary Study Objectives

- Introduction
- Preliminary Study Results
- Current Study Plan
- Future Work

Scenario-based Simulations

- Recognizing and Avoiding VRS-prone Situations:
  - Do pilot recognize a VRS-prone situation?
  - What parameters do the pilots use to determine the risk of a possible VRS encounter?
- Detecting the early signs of VRS:
  - What early signs of VRS did the pilots identify?
  - If early signs are detected, what immediate corrective actions are taken by pilots (if any)?
- Exiting and Recovering:
  - Why do pilots use one recovery technique over the other (if any is used)?
  - What are the perceived and actual limitations of each recovery technique in these scenarios?

Recovery Techniques Comparison

- For the Traditional Recovery, what is the impact descent rate, pitch, and torque on the recovery metrics?
- For the Vuichard Recovery, what is the impact of descent rate, and roll on the recovery metrics?
- How do the recoveries compare for each metric?
- Is there a recovery that performs overall better?

VRS Accident Analysis: Results

Introduction

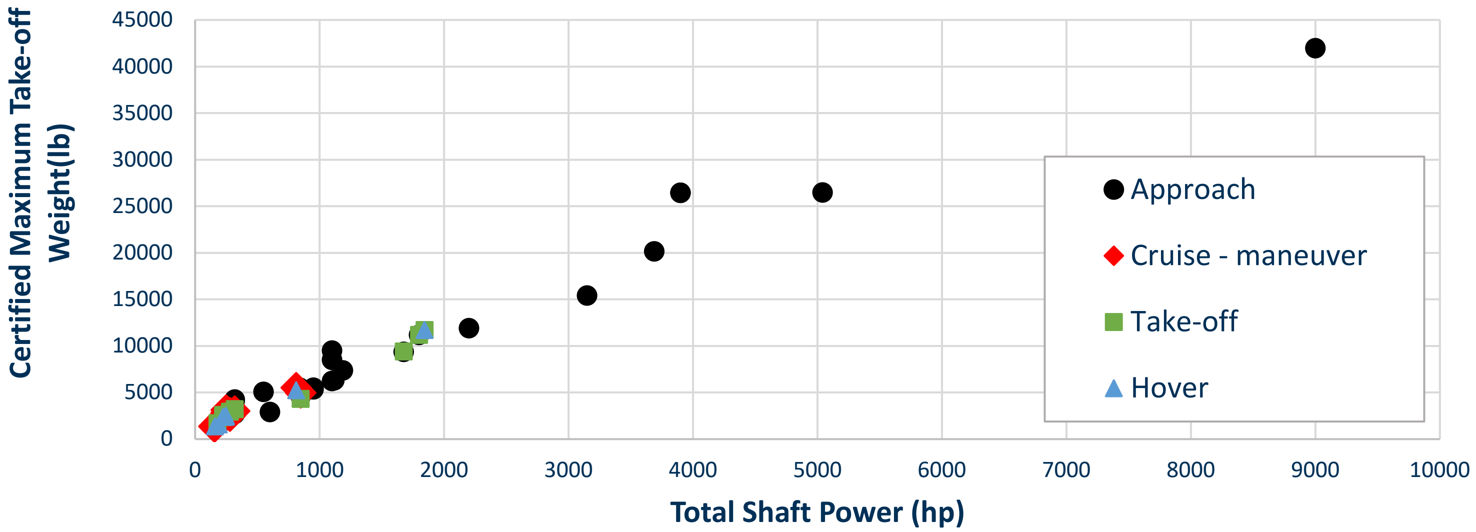
Preliminary Study Results

Current Study Plan

Future Work

Contributing Factors									
Phase of Flight	# of accidents	High Weight	High Density Altitude	Tail Wind	Gust/ Turbulence	External load	IMC/ Night	Obstacle	Traffic
Approach	46	4	5	12	4	1	4	2	2
Cruise-Maneuver	17	1	0	6	1	1	0	0	0
Take off	11	2	2	3	2	0	0	0	0
Hover	8	3	1	1	1	1	0	0	0

VRS-related Accidents by Phase of Flight, Weight and Power



- **VRS accidents occur predominantly during approaches and concerns all helicopter sizes**
- **Tail wind is the main contributing factor reported**

Scenario-Based Simulations: Approach Scenario

Introduction

Preliminary Study Results

Current Study Plan

Future Work

Scenario:
- Settings: Low weight, 20 kt tail wind
- Objective: Enter and recover from VRS with terrain on the right
- Description: Fly to a helipad on the side of the mountain and come for a straight in landing

Test subjects:
- 16 pilots
- All pilots had experience flying the Traditional Recovery
- 7 pilots had received Vuichard Recovery training

Simulations Outcome:
- 3 pilots did not enter VRS during the simulation
- 1 pilot did not recognize that he entered VRS
- 4 pilots decided to use the Vuichard recovery
- 8 pilots performed Traditional recoveries, 3 because of the mountain to the right

Conclusions:
- Identifying the VRS onset is still a critical and complex component for pilots, even with training
- The lateral excursion when escaping to the side must be measured to determine whether there is an actual risk of collision with obstacles

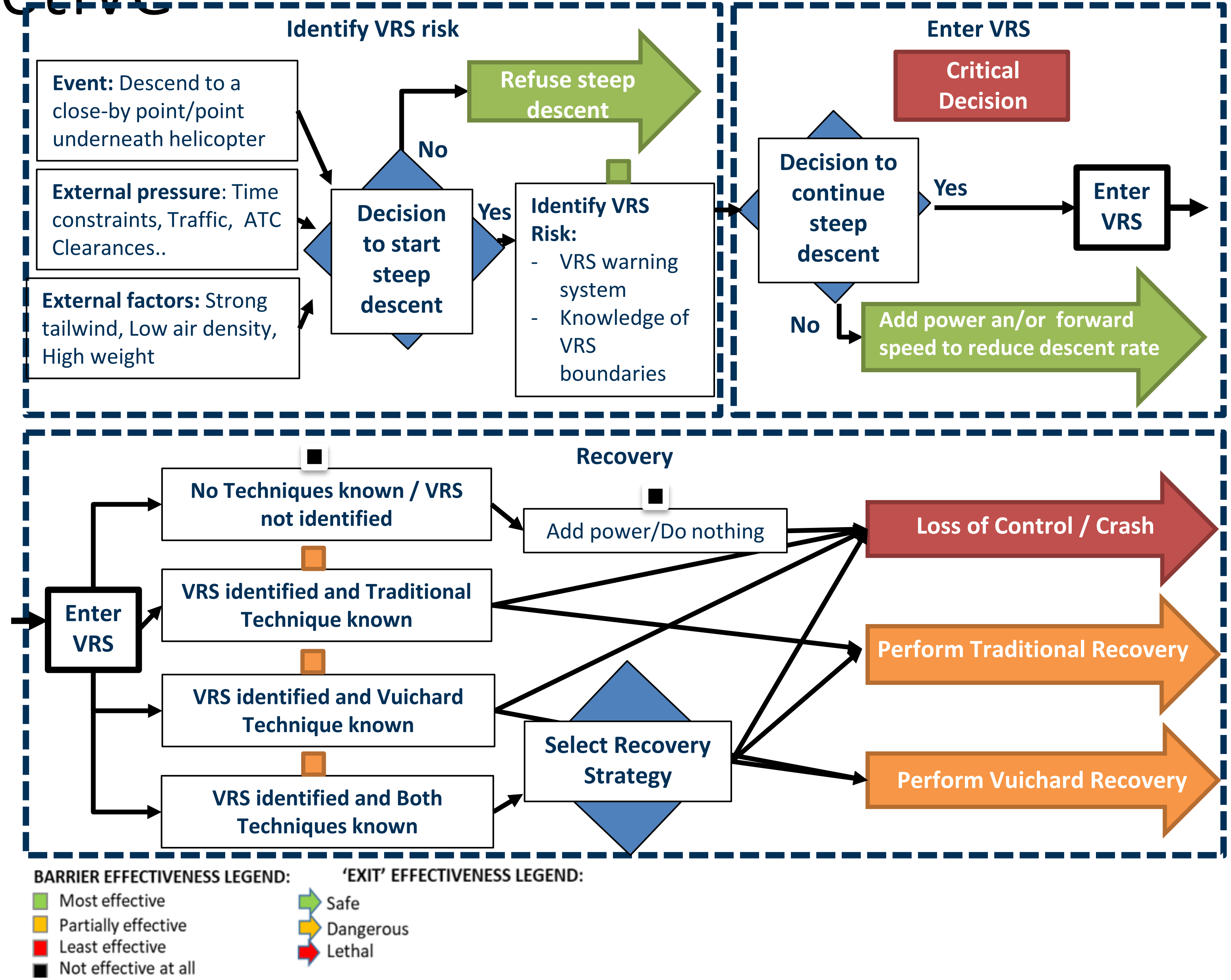
Scenario-Based Simulations: Objective

Introduction

Preliminary Study Results

Current Study Plan

Future Work



VRS Recovery Metrics

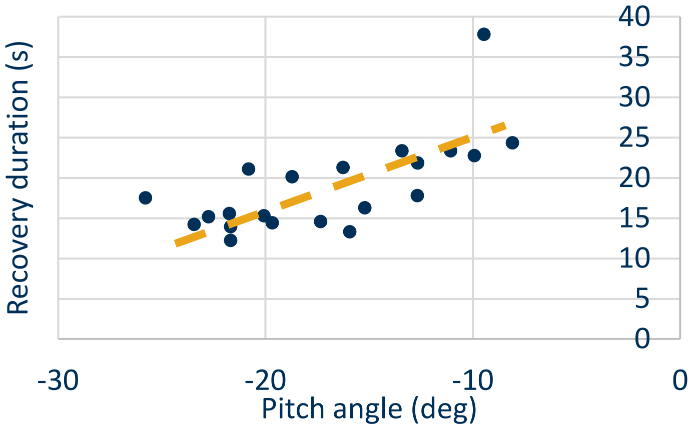
Introduction

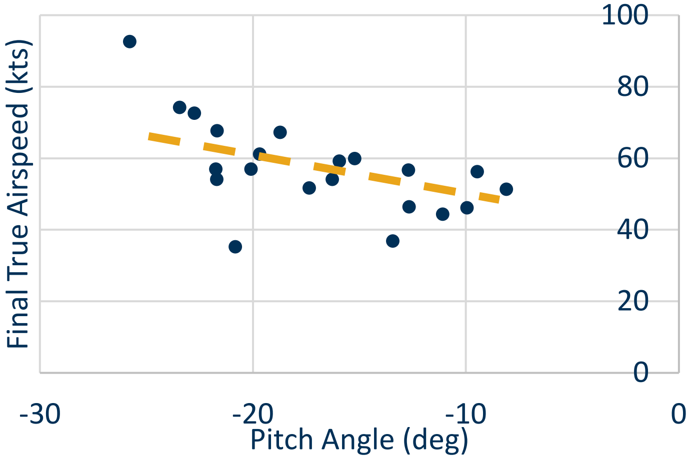
Preliminary Study Results

Current Study Plan

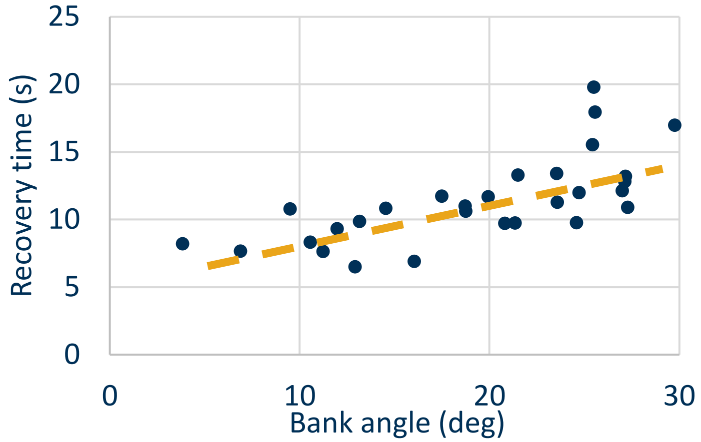
Future Work

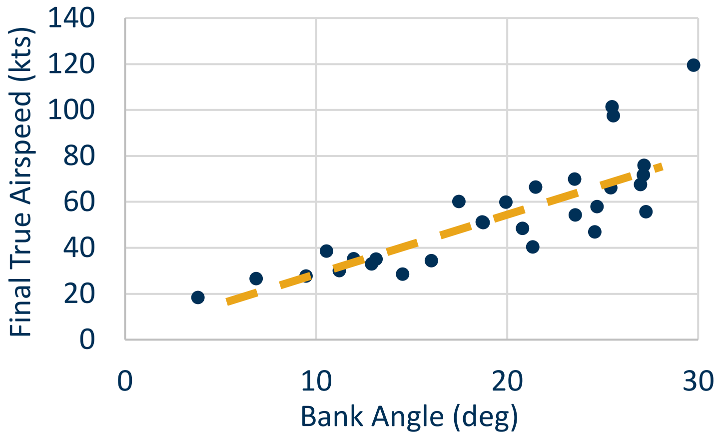
Traditional Recovery





Vuichard Recovery





Overall the Vuichard recovery was faster with less altitude lost, however there is a wide standard deviation for all metrics

VRS Human in the Loop Study Overview

- Introduction
- Preliminary Study Results
- Current Study Plan
- Future Work

Simulators:
- S76 static Simulator
- H125 Loft Dynamics simulator
- R22 Loft Dynamics simulator

Test subjects:
- 15 pilots of varied experience level

Study Organization:

Part 1: Scenario-Based simulations
- 5 pilots per simulator
- 6 VRS-inducing scenarios

Part 2: Recovery Comparison
- 1 hour/pilot/simulator

Simulator Scenarios

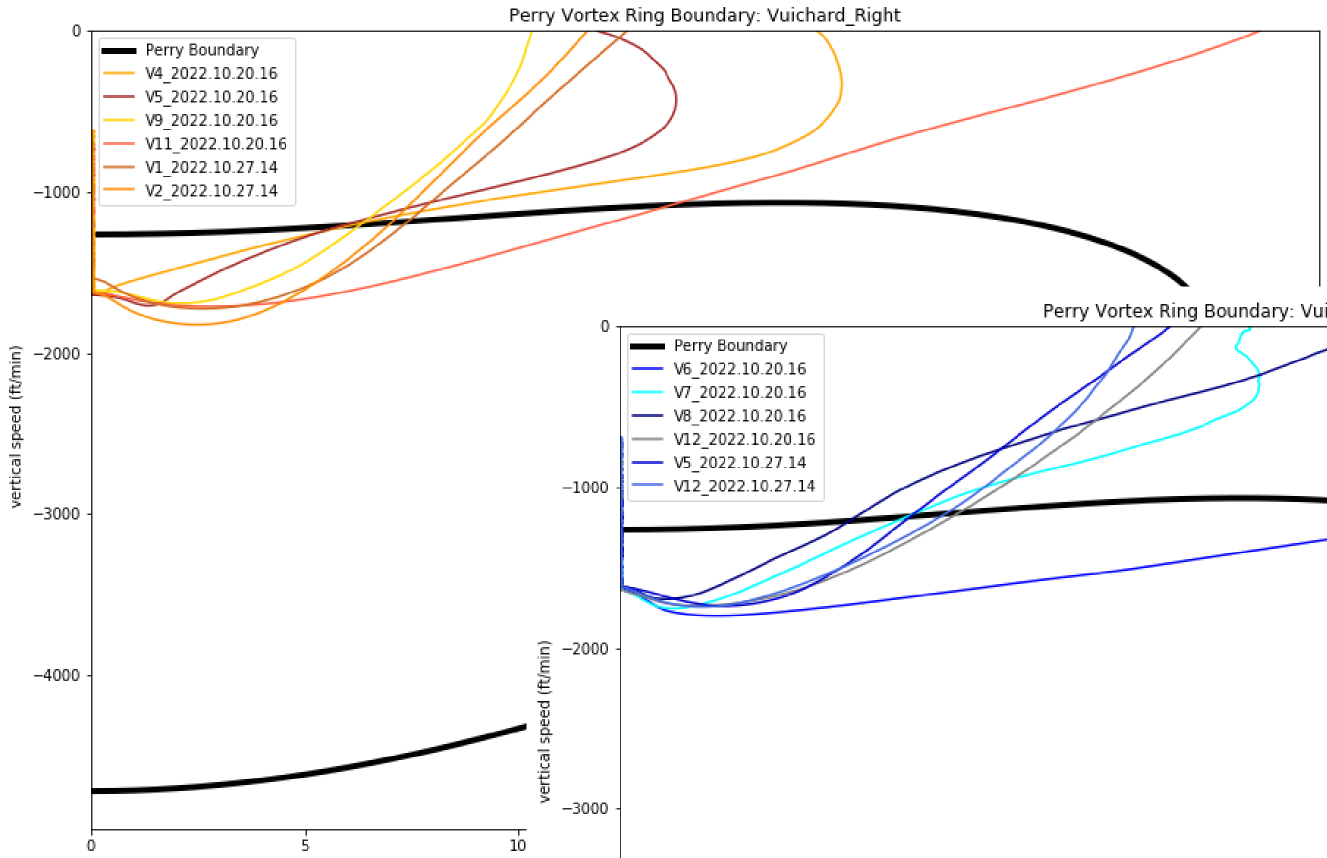
- **VRS metrics:**
  - Time required to identify VRS
  - Altitude drop
  - Rate of descent

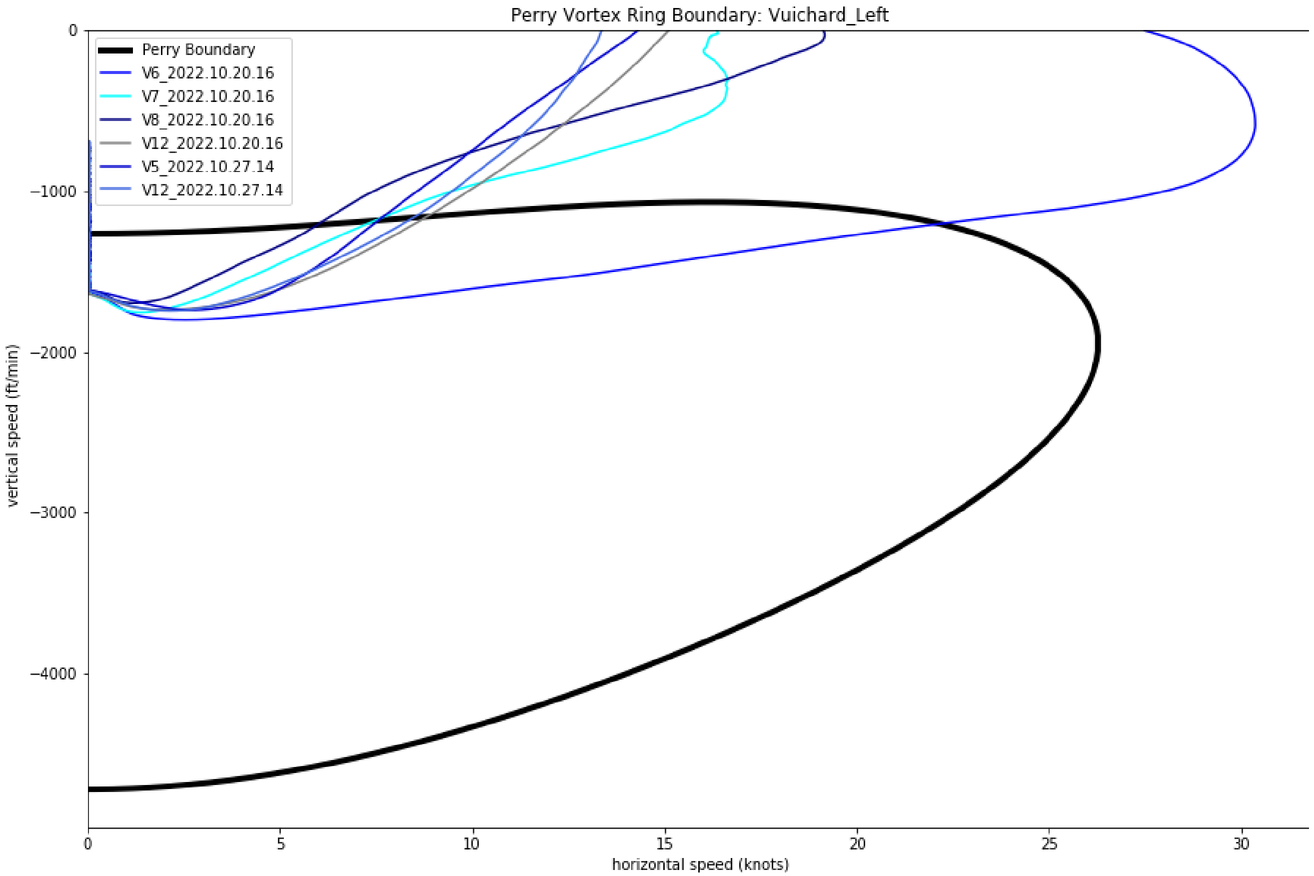
- **Recovery metrics:**
  - Recovery technique chosen and justification
  - Identification and Recovery time
  - Altitude drop
  - Rate of descent
  - Forward airspeed
  - Maximum normal acceleration during recovery
  - Maximum torque and overtorque occurences
  - Pitch, bank and heading variations
  - Order and amplitude of control inputs during recovery

Example VRS Scenario: Steep Approach

- In September 2022, 16 pilots flew segment 2 of the scenario. Only 7 indicated that they had been trained to perform a Vuichard Recovery prior to the simulation. All pilots were shown both techniques.
- Pilots were asked to perform a steep approach to a helipad with a mountain on their right side
- Even pilots who had training in the Vuichard recovery were hesitant to use it as they feared hitting the terrain
- So **the lateral excursion when escaping to the side must be measured to determine whether there is a risk of collision with obstacles**
- This is done through a comparison of Vuichard recovery on both sides

Vuichard Recovery Advancing vs Retreating Side





Vuichard Recovery Advancing vs Retreating Side

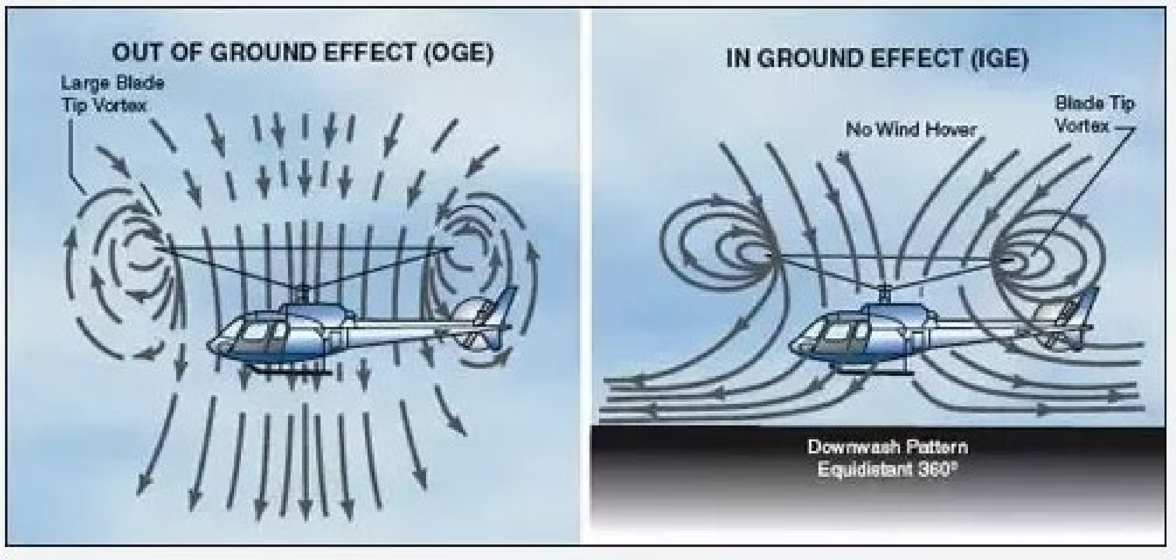
Recovery Type	Recovery time (s)	Altitude Drop (ft)	Initial Descent rate (ft/min)	Initial TAS (kts)
Vuichard Left	11.8	-177.0	-1634.4	16.8
	15.9	-106.9	-1643.2	17.1
	8.8	-92.2	-1618.3	16.5
	6.1	-74.8	-1644.8	16.8
	6.6	-94.6	-1621.9	16.6
	8.3	-113.8	-1623.8	16.8
AVERAGE	**9.6**	**-109.9**	**-1631.1**	**16.8**
Vuichard Right	8.1	-162.4	-1622.3	16.3
	8.7	-126.8	-1642.1	16.5
	8.1	-123.8	-1611.2	16.2
	6.9	-56.9	-1627.4	16.6
	7.2	-125.2	-1542.6	15.9
	6.3	-89.3	-1628.6	16.7
AVERAGE	**7.5**	**-114.1**	**-1612.4**	**16.4**

The advancing and retreating side results are fairly similar which indicates a limitation in the helicopter model since recovering on the retreating side should be longer with more altitude loss

Preliminary Results: Underpowered Takeoff

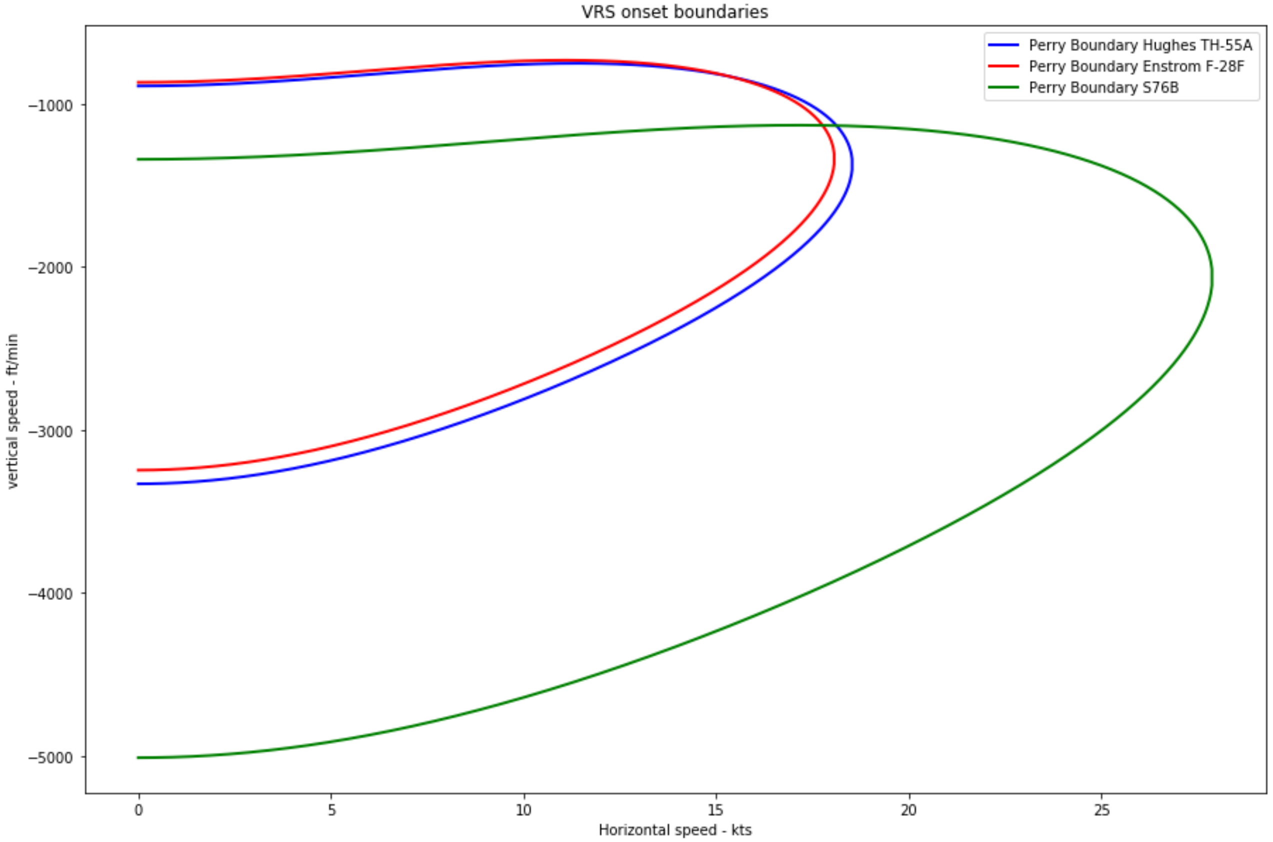
<u>Settling with insufficient Power scenario description:</u>

- Take off at high enough weight from airport to ensure insufficient power when hovering out of ground effect
- Climb in hover until OGE when helicopter starts to settle:
  - let it descend without attempting to recover
  - or increase collective



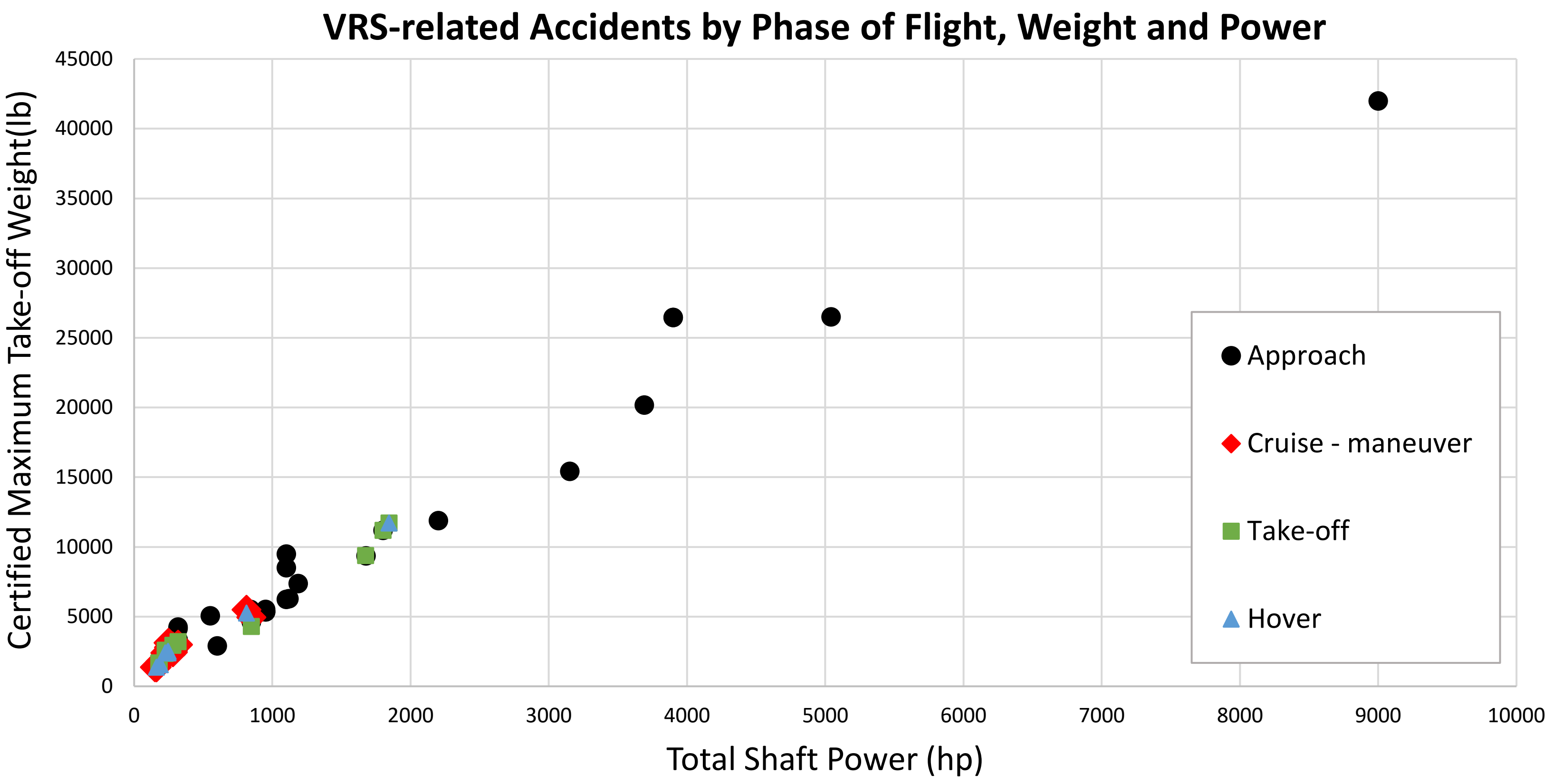
IGE Hover Segment

Accident #	Helicopter	Max Take off gross weight (lbs)	Rotor Diameter (ft)
CEN14CA082	S-76B	11700	44
CEN15LA224	Enstrom F-28F	2600	32
ERA13CA283	Hughes TH-55A	1670	25



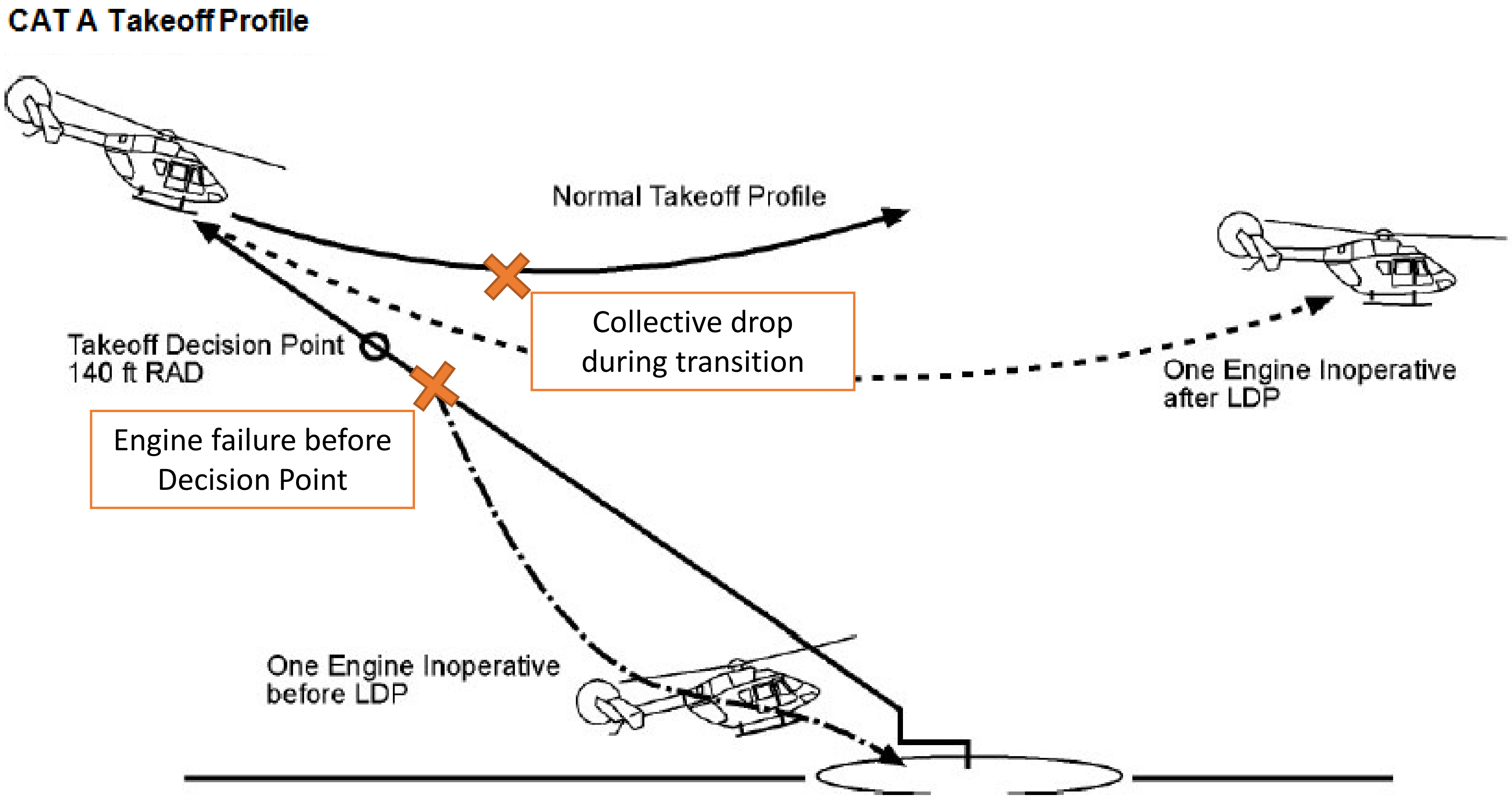
According to Perry's model, VRS onset Boundary is higher and at lower horizontal speeds for smaller helicopters

VRS on Takeoff Accidents



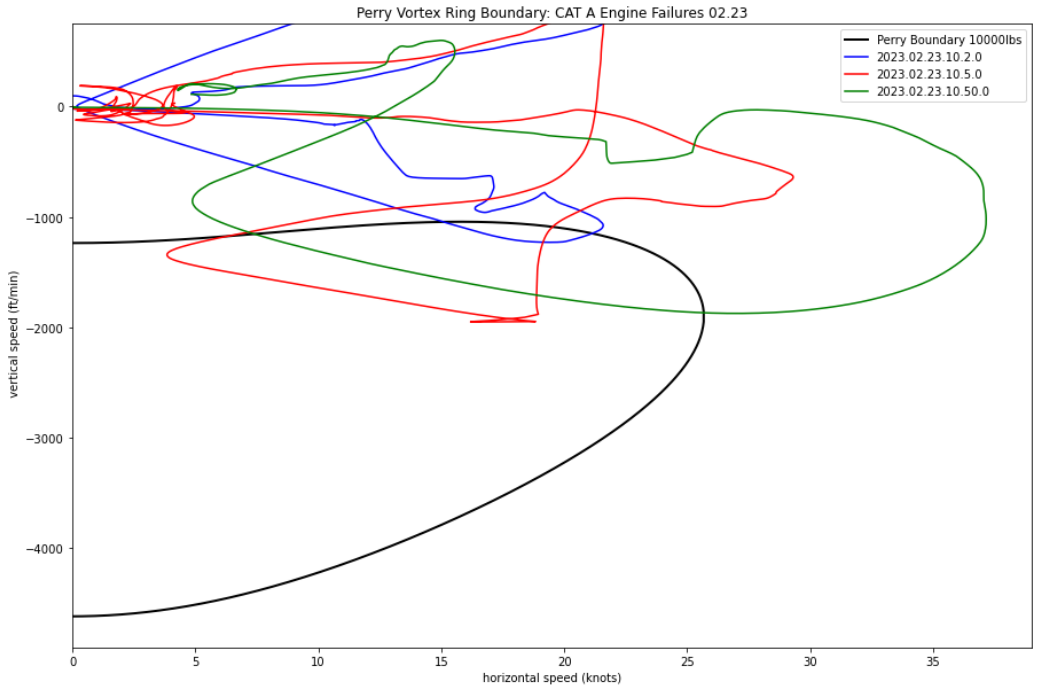
Unlike accidents during approach, VRS-related accidents during Take-off concern mostly the lighter helicopters.

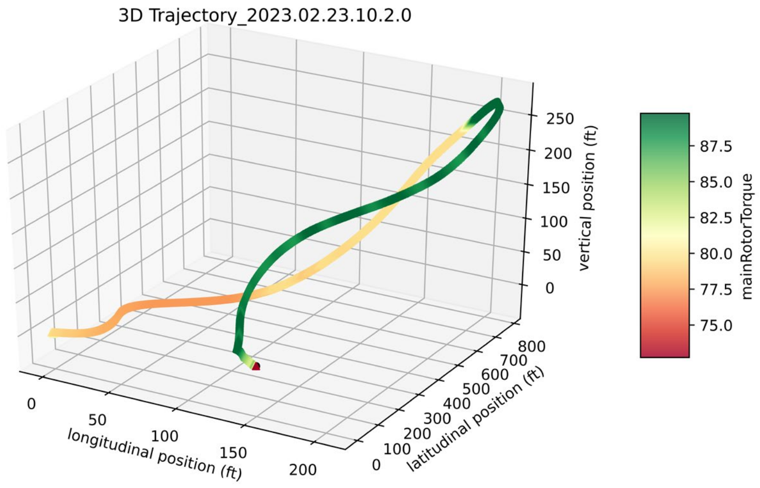
Preliminary Results: CAT A Takeoff

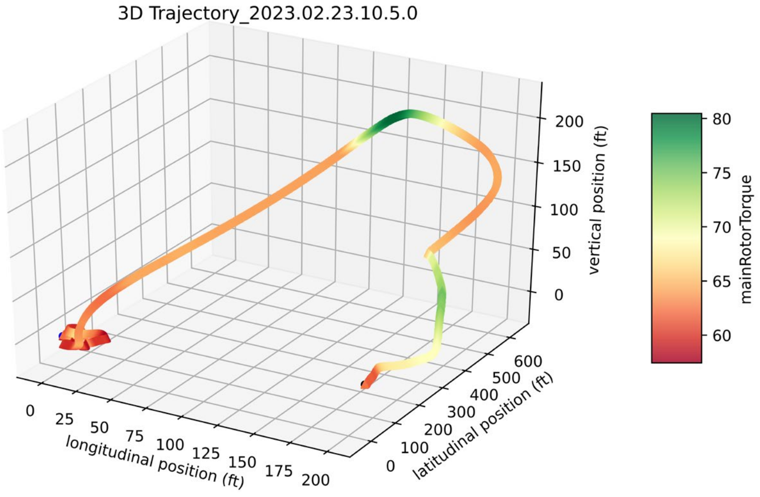


We are investigating two failures during backwards CAT A Takeoff that could potentially lead to VRS encounters

Preliminary Results: CAT A Takeoff Engine Failure

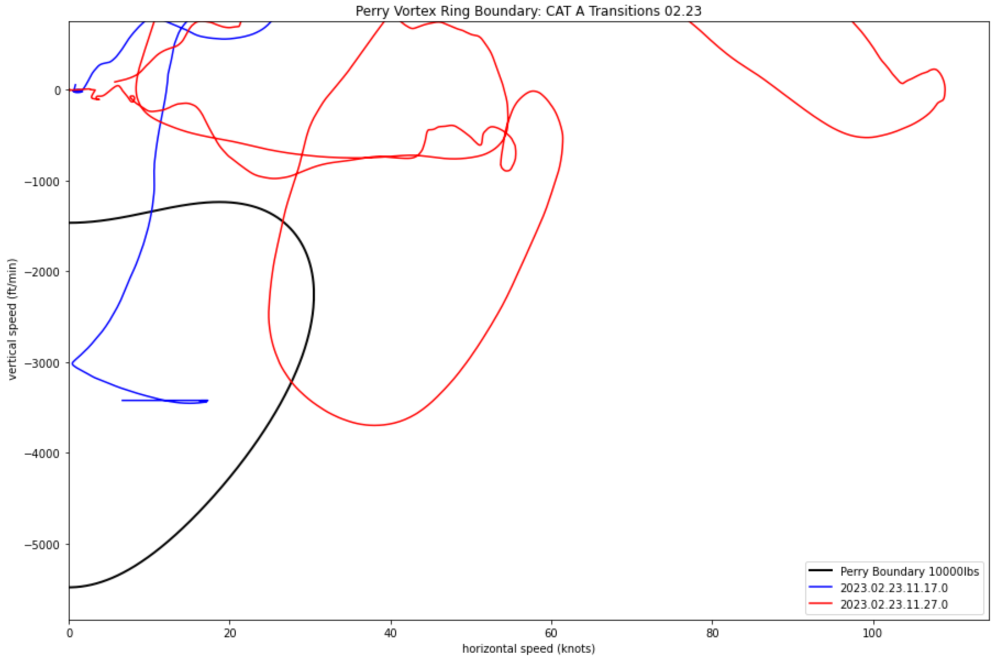


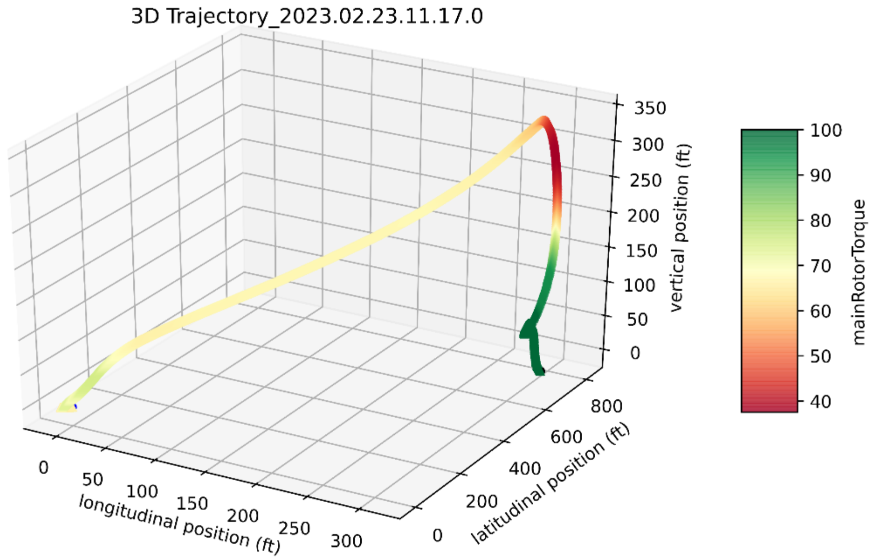


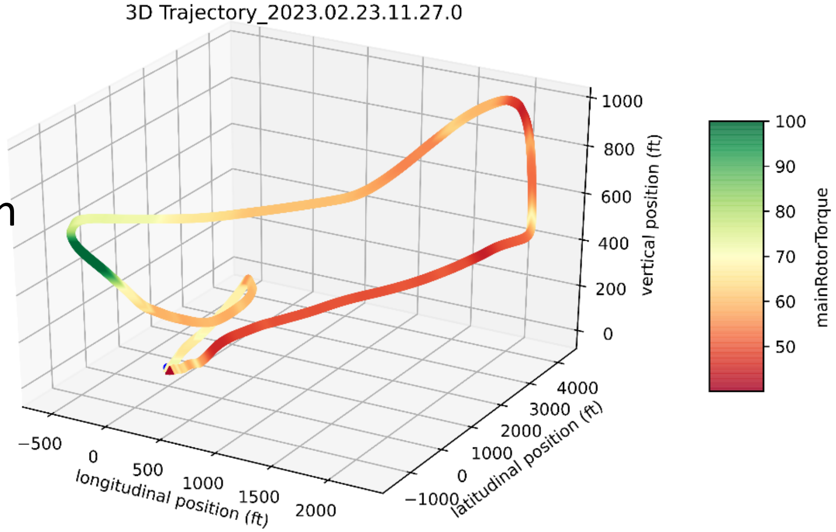


CAT A backwards takeoff with one engine failure before decision point has led in some cases to a VRS encounter. In these situations pilots were not able to land back on the helipad.

Preliminary Results: CAT A Takeoff Transition







Dropping the collective too low during a transition to forward flight has led in some cases to a VRS encounter. In these situations, pilots attempted Traditional and Vuichard recoveries.

Off Line Simulation

FLIGHTLAB

- FLIGHTLAB is an aircraft and rotorcraft design and simulation software developed by Advanced Rotorcraft Technology (ART).

Capabilities:

- FLIGHTLAB Model Editor (FLME): Graphical Interface to model each vehicle subsystem
- Control System Graphical Editor (CSGE): Graphical Interface to design flight controls
- Analysis Workspace and Utilities (Xanalysis): Trim, Handling qualities, linear and non-linear simulations

Use:

- Used by manufacturers for design and analysis of vehicles

VRS Methodology

Off-line Simulation

- Develop helicopter models from low-fidelity to high-fidelity

⬇

- Develop a controller to tune off-line flight controls

⬇

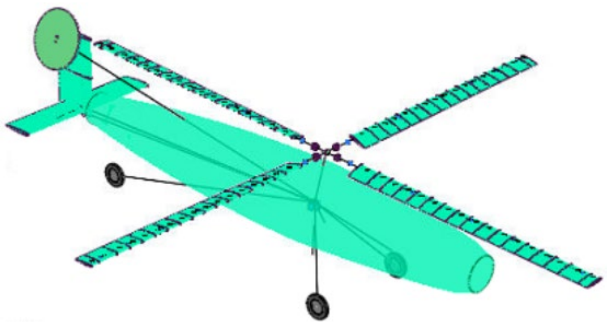
- Create descent trajectory in VRS

⬇

- Compare and validate helicopter models' behavior in VRS

⬇

- Simulate both recovery techniques from VRS



Next Steps

On-line Simulation

- **Analyze VRS accident reports and discuss with subject matter experts**
- **Establish a list of VRS prone situations**
- **Write and Test scenario-based simulations for each situation**
- Run scenarios with various pilots
- Identify pilots' decision making process in each case
- Compare recovery techniques and determine best course of action

Off-line Simulation

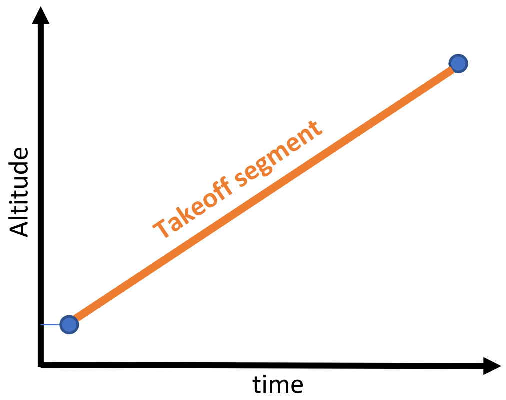
- **Develop helicopter models from low-fidelity to high-fidelity**
- **Develop a controller to tune off-line flight controls**
- **Create descent trajectory in VRS**
- Compare and validate helicopter models' behavior in VRS
- Simulate both recovery techniques from VRS

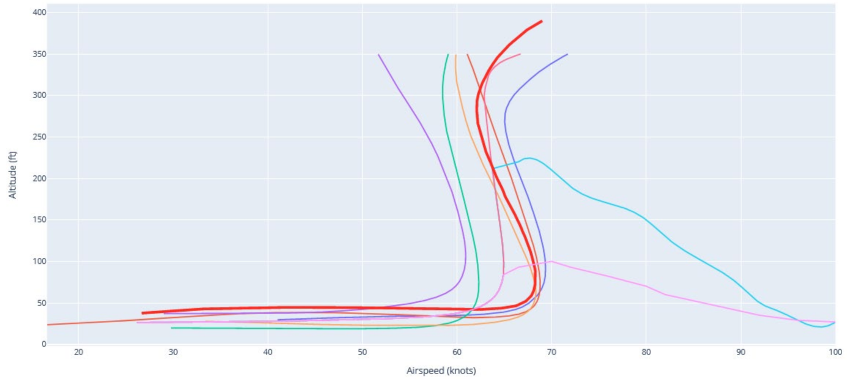
Takeoff Outlier Detection – Goal and Approach

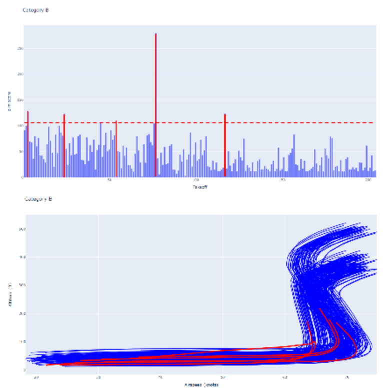
- **Goal**: Establish safety metrics for rotorcraft takeoffs by identifying outliers from the flight data
  - Multi-dimensional time series data recorded in Flight Data Monitoring (FDM) programs used as input data

Approach:

1. Takeoff segment identification
2. Takeoff classification from airspeed and altitude
3. Outlier detection
   - Neural Network models
   - Modified z-score computation
   - Threshold methods analysis

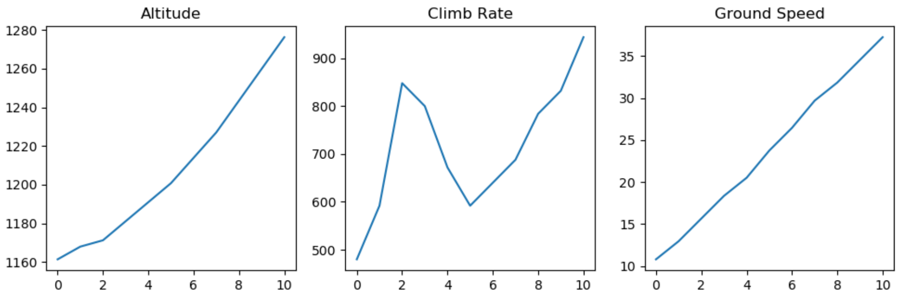


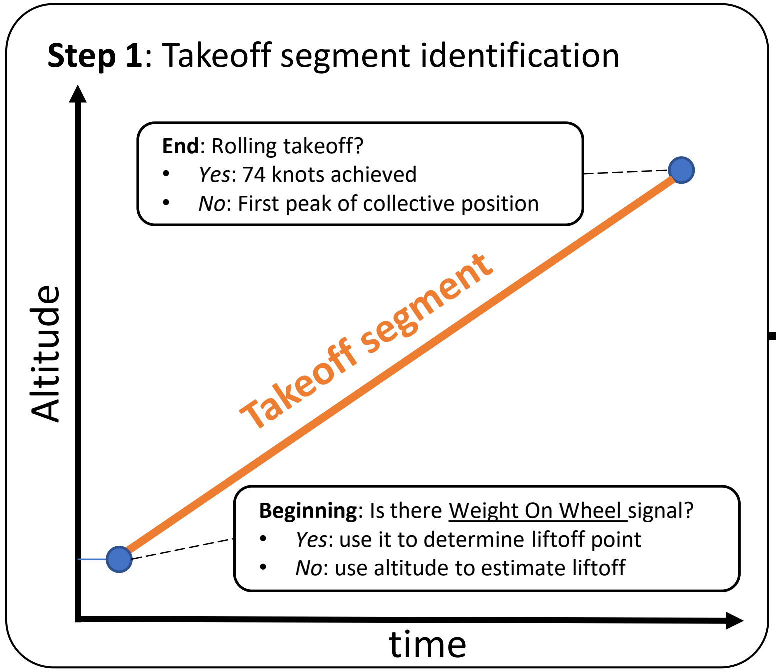


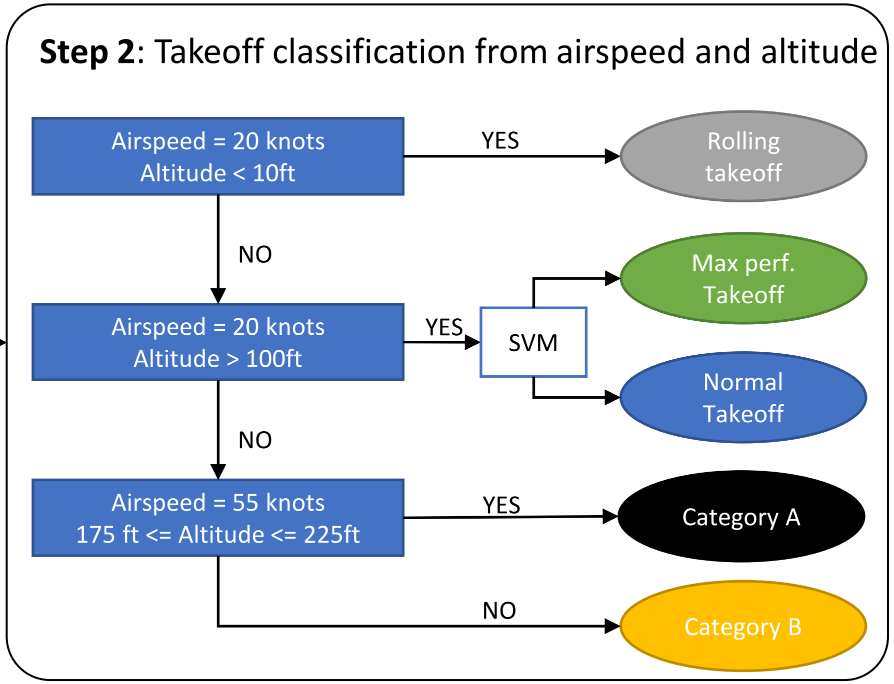


Takeoff Segment Identification and Classification

- **Input**: multi-dimensional







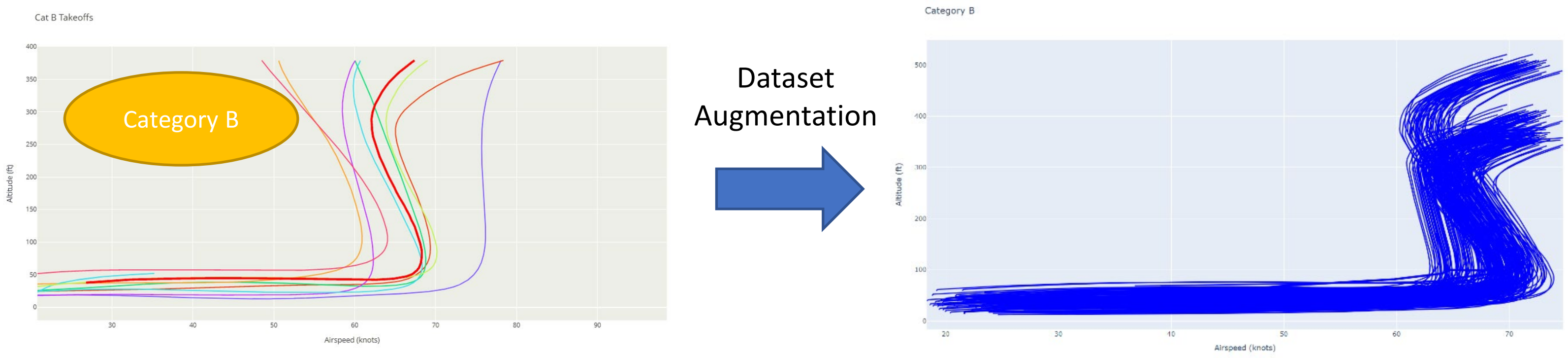
Neural Network model

- **Generate takeoff neural network models**
  - Recurrent Neural Network - Long Short-Term Memory (LSTM) was implemented and trained to create models of each takeoff category

Raw data *(80 features)* → Feature Selection *(Extra Trees Classifier)* → Dataset Augmentation → Model Training *(LSTM)*

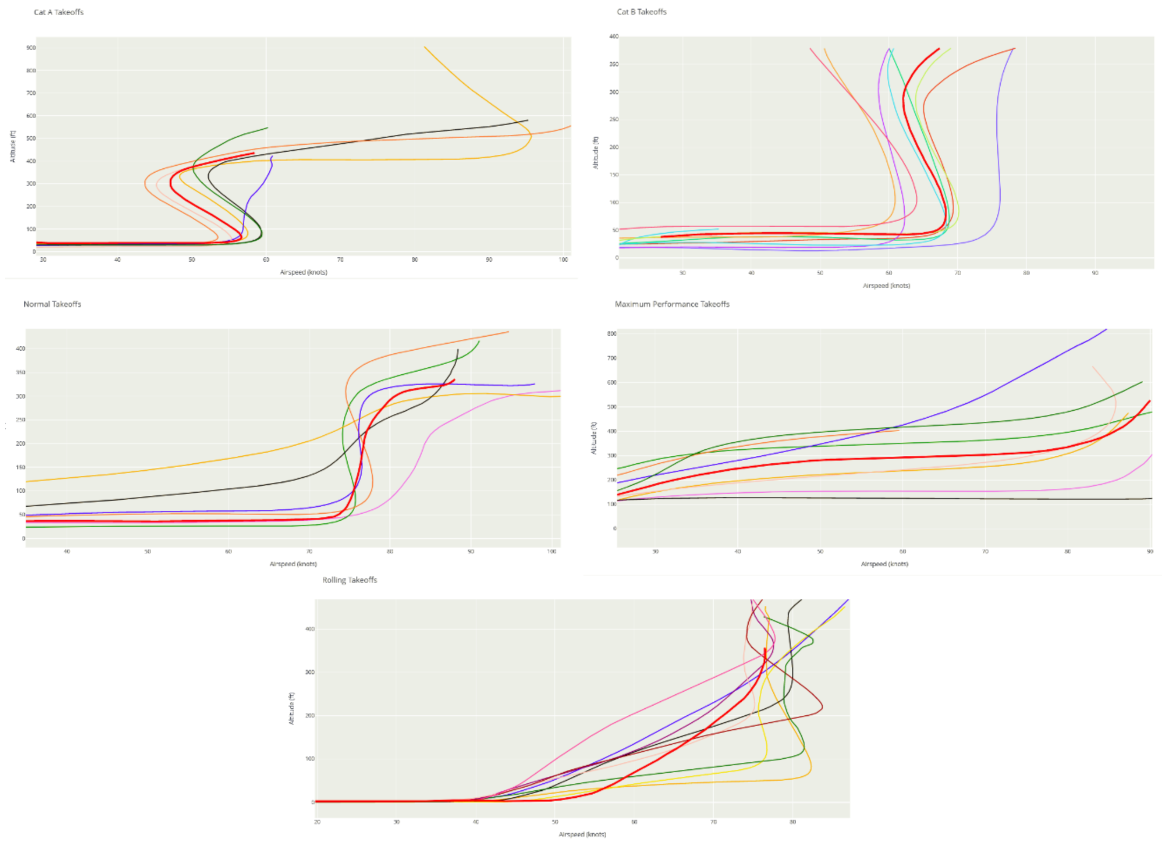
For each takeoff category

- To prevent overfitting, machine learning applications are very dependent on a large amount of training data
- To improve the models created by the RNN runs on the takeoff analysis, synthetic data was created (~ 250 takeoffs for each category) based on the takeoff datasets available for each type



Modified Z-Score Computation

- RNN models were generated for each takeoff category, serving as representatives of the <u>typical takeoff behavior</u>
- These RNN models were then used to compute the modified **Z score (z-m score)** for each takeoff available in the datasets (measures how far a data sample is from the value of typical observation)



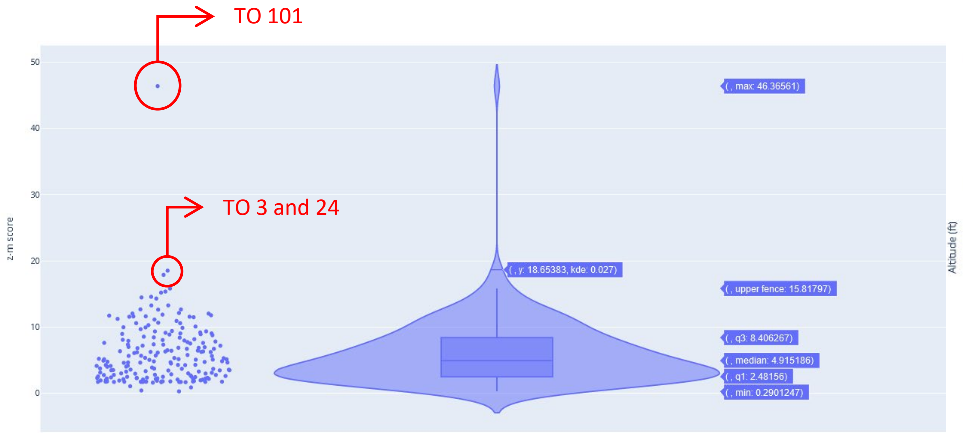
Threshold Definition

- Three threshold methods were evaluated
  - Standard Deviation (SD)
  - Median Absolute Deviation (MAD)
  - Clever Standard Deviation (Clever SD)
- One of the case study was done using a dataset of 200 category B takeoff and one outlier takeoff was added, the z-m score for the 201 takeoffs and the thresholds are shown in the figure below

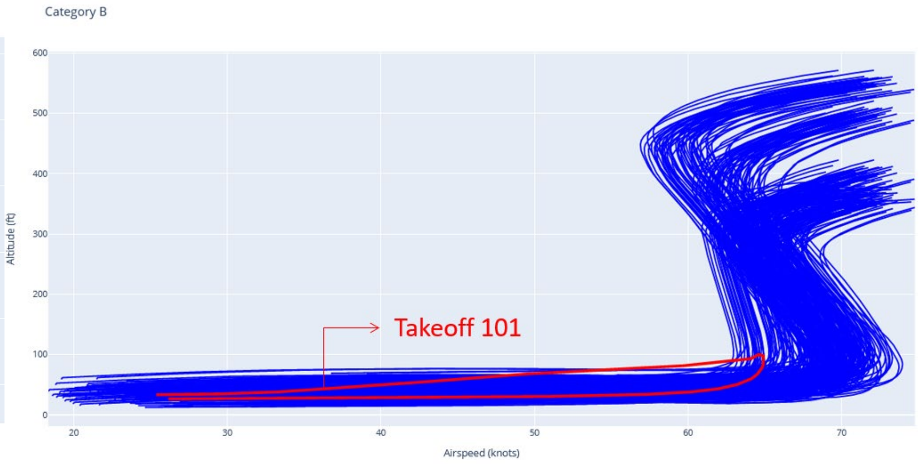
Outliers Detection: case studies

- In this case, using all the three methods, the outlier takeoff (101) was identified, however the SD and Clever SD methods presented false positive outliers results
- The MAD method detected only the takeoff 101 as an outlier without false positive results

Method	Outliers detected
SD	TO3 and TO101
MAD	TO101
Clever SD	TO3, TO24, and TO101

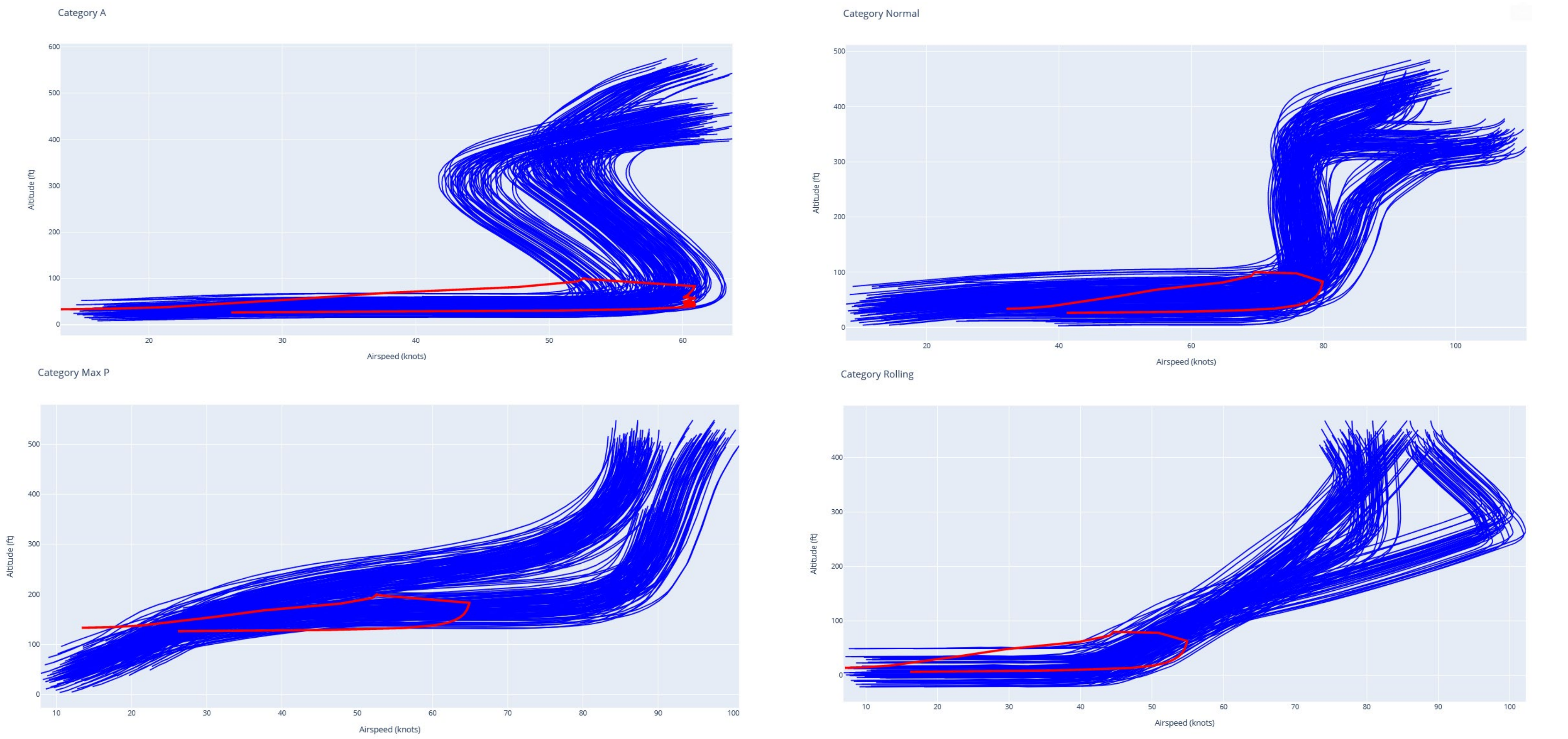


Z-m score Violin plot



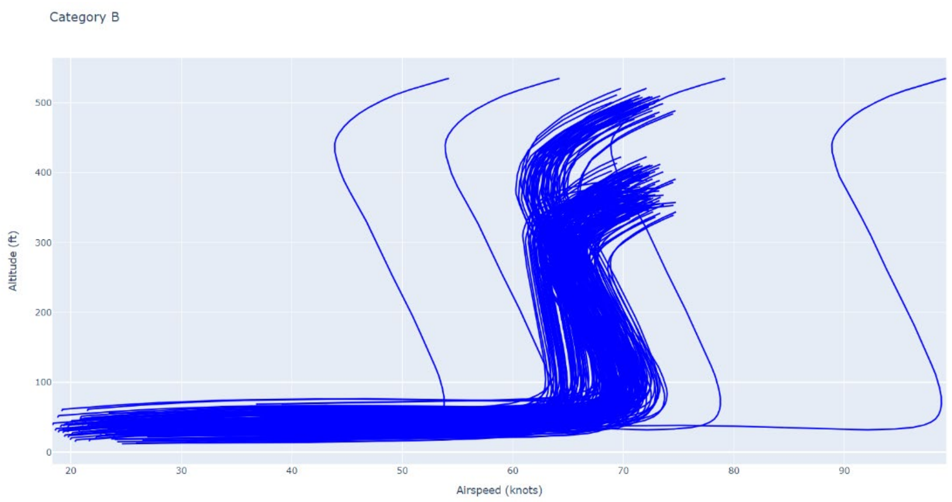
Outliers Detection: case studies

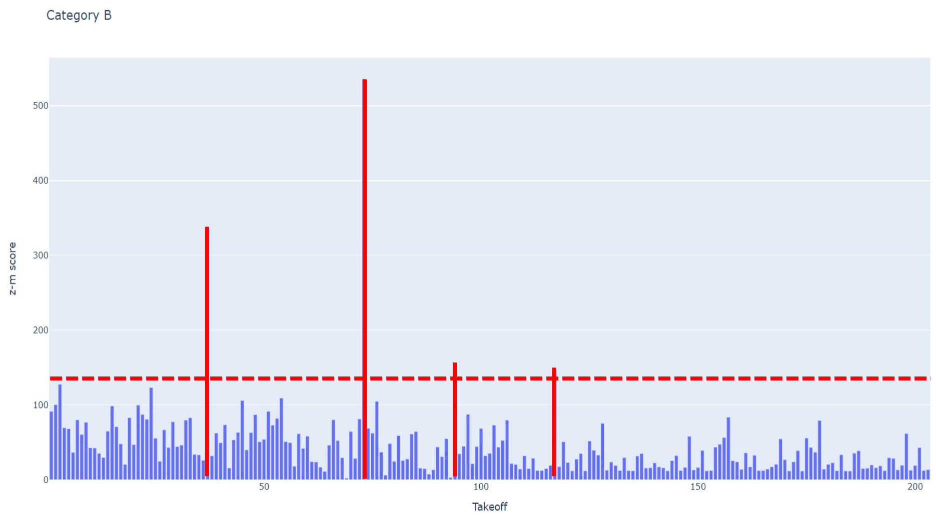
- The same test was done for all other takeoff categories and the MAD was the only method capable to detect the outlier takeoff without false positives



Threshold Definition

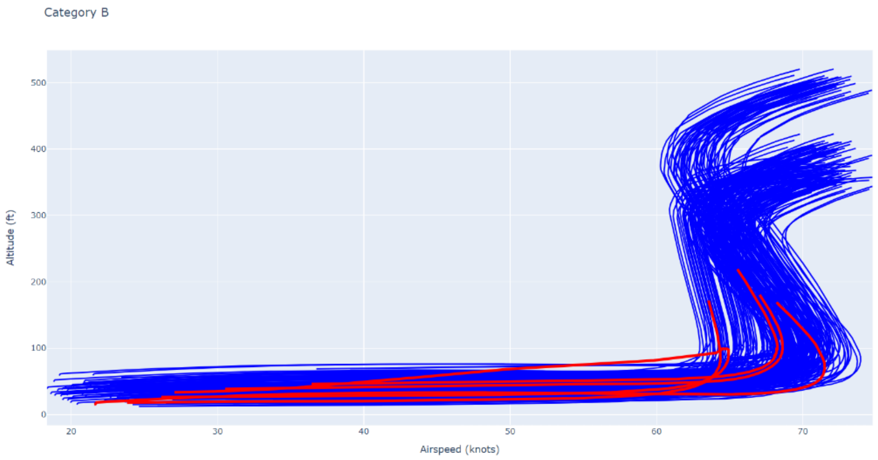
- Other study cases were conducted based on FAA pilot's suggestions of possible unusual takeoff situations
- One example implemented was considering airspeed variations based on the S-76D manufacturer’s recommendations (4 takeoffs)
- Using the MAD threshold definition, all the 4 outliers were detected

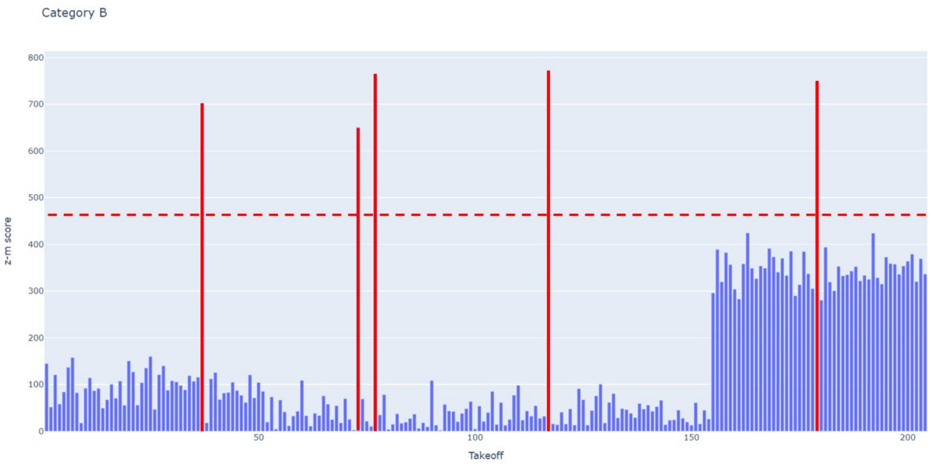




Outlier Detection

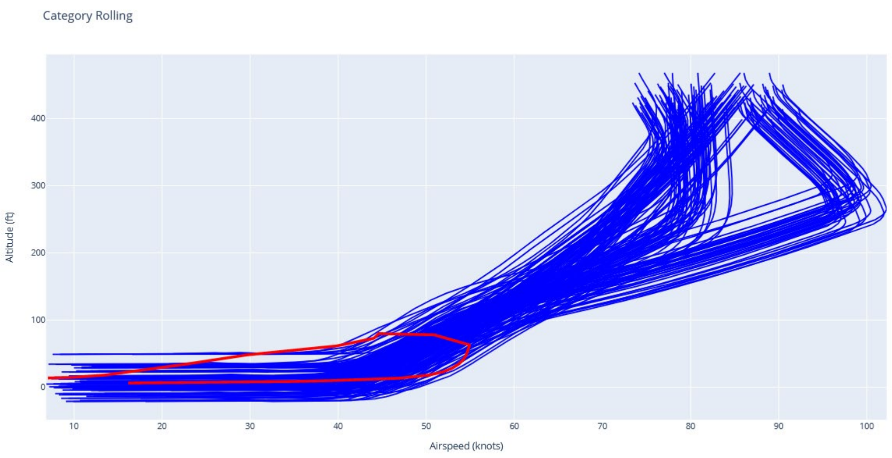
- Other case study was done adding five outlier takeoffs and four of them were confined area takeoff cases
- In this case, as the confined are takeoff presented significant differences with respect to final altitude that is limited due to the takeoff area limitations
- So, the outliers were detected only using the altitude feature and not the airspeed

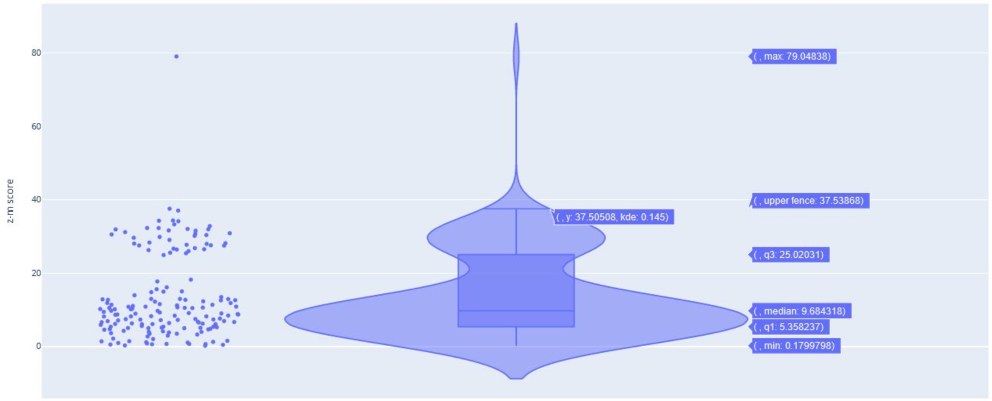




Outlier Detection

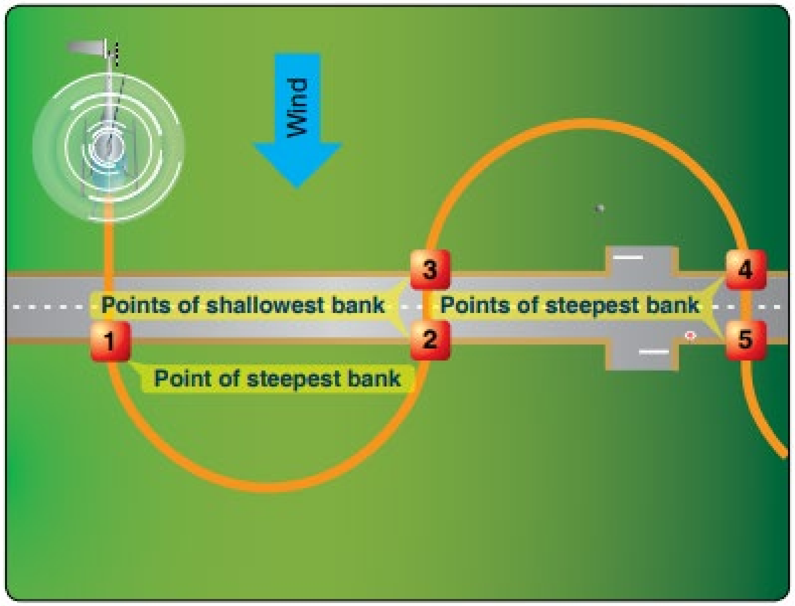
- Based on the results, the modified z-score and MAD threshold is a useful method to identify outliers in takeoff datasets
- The method presented satisfactory results for all the takeoff categories
- The method must be applied to the available features (altitude and airspeed) to avoid ’miss’ outliers that do not present significant differences in one of the reference parameters in some cases





Future Work

- Collect more takeoff data to run the Neural Networks and improve the model's fidelity
- Test other alternatives of dataset augmentation
- Test the methodology to different helicopter phases
- Explore other outlier detection techniques



Questions?

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609-485-8429 (Lacey)

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Lacey.Thompson@faa.gov

Website: rotorcraft.npn.faa.gov

asias

Participation

Rotorcraft ASIAS Web Portal

https://www.rotorcraft.asias.info

Ways to Participate

- Third Party Cooperative Agreements – DTOs
- Cooperative Agreements – Operators
- Statements of Intent – R-IAT members or non-data providing organizations who meet the criteria for participation
- All participants must adhere to ASIAS Procedures and Operations (P&O) Plan

Rotorcraft ASIAS Points of Contact

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Mobile: (202) 251-0871

tim.nguyen@gdit.com

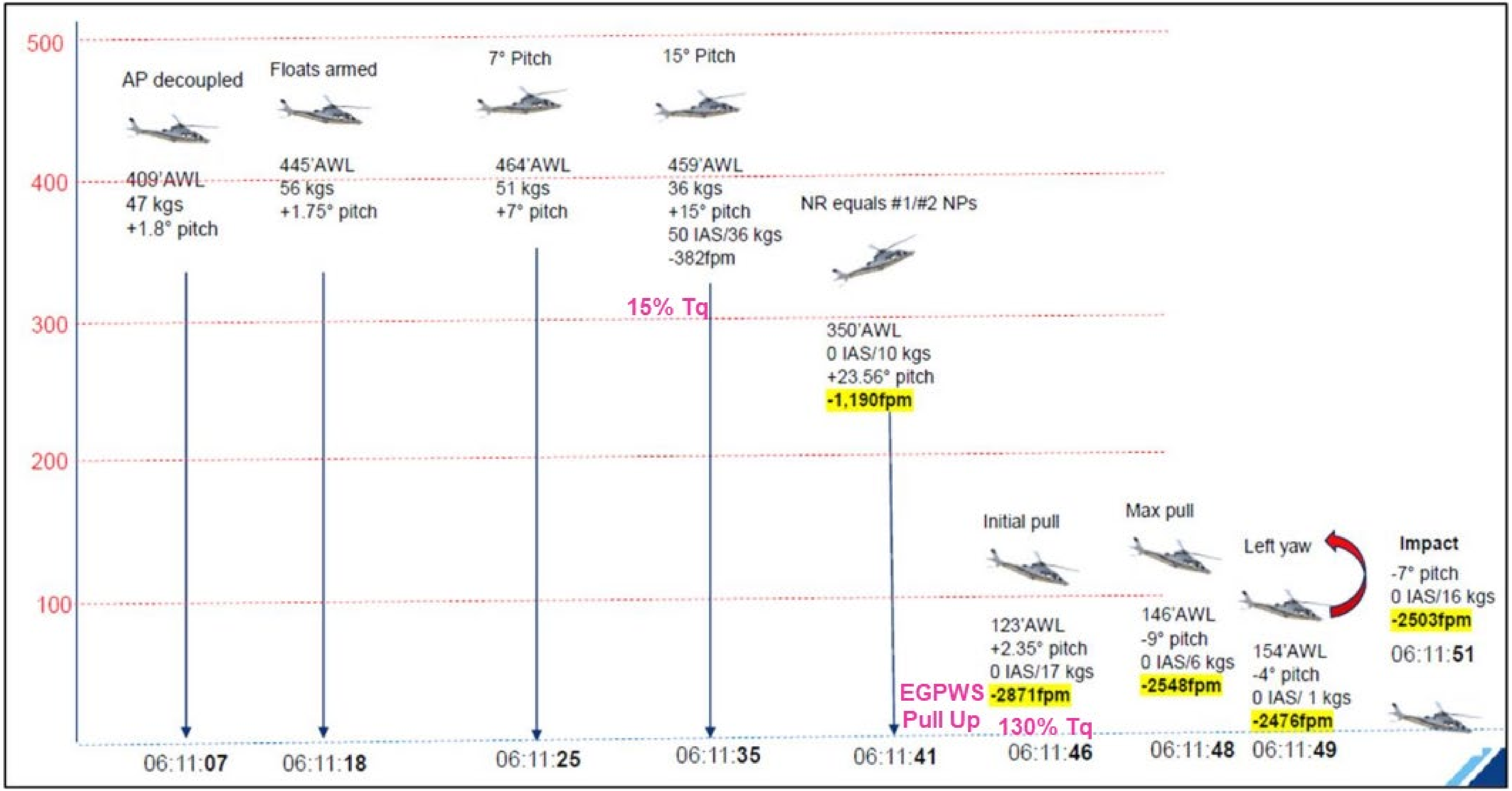
FDM Working Group

Agenda

- Anti Trust Statement
- Welcome
- VT-PWI Mumbai Offshore Accident
- Cliff Johnson and Lacey Thompson, FAA
- General Discussion

HSAC
Safety Through Cooperation

VT-PWI



500
400
300
200
100
AP decoupled
409'AWL
47 kgs
+1.8° pitch
Floats armed
445'AWL
56 kgs
+1.75° pitch
7° Pitch
464'AWL
51 kgs
+7° pitch
15° Pitch
459'AWL
36 kgs
+15° pitch
50 IAS/36 kgs
-382fpm
15% Tq
NR equals #1/#2 NPs
350'AWL
0 IAS/10 kgs
+23.56° pitch
-1,190fpm
EGPWS
Pull Up
Initial pull
123'AWL
+2.35° pitch
0 IAS/17 kgs
-2871fpm
130% Tq
Max pull
146'AWL
-9° pitch
0 IAS/6 kgs
-2548fpm
Left yaw
154'AWL
-4° pitch
0 IAS/ 1 kgs
-2476fpm
Impact
-7° pitch
0 IAS/16 kgs
-2503fpm
06:11:51
06:11:07
06:11:18
06:11:25
06:11:35
06:11:41
06:11:46
06:11:48
06:11:49

VT-PWI

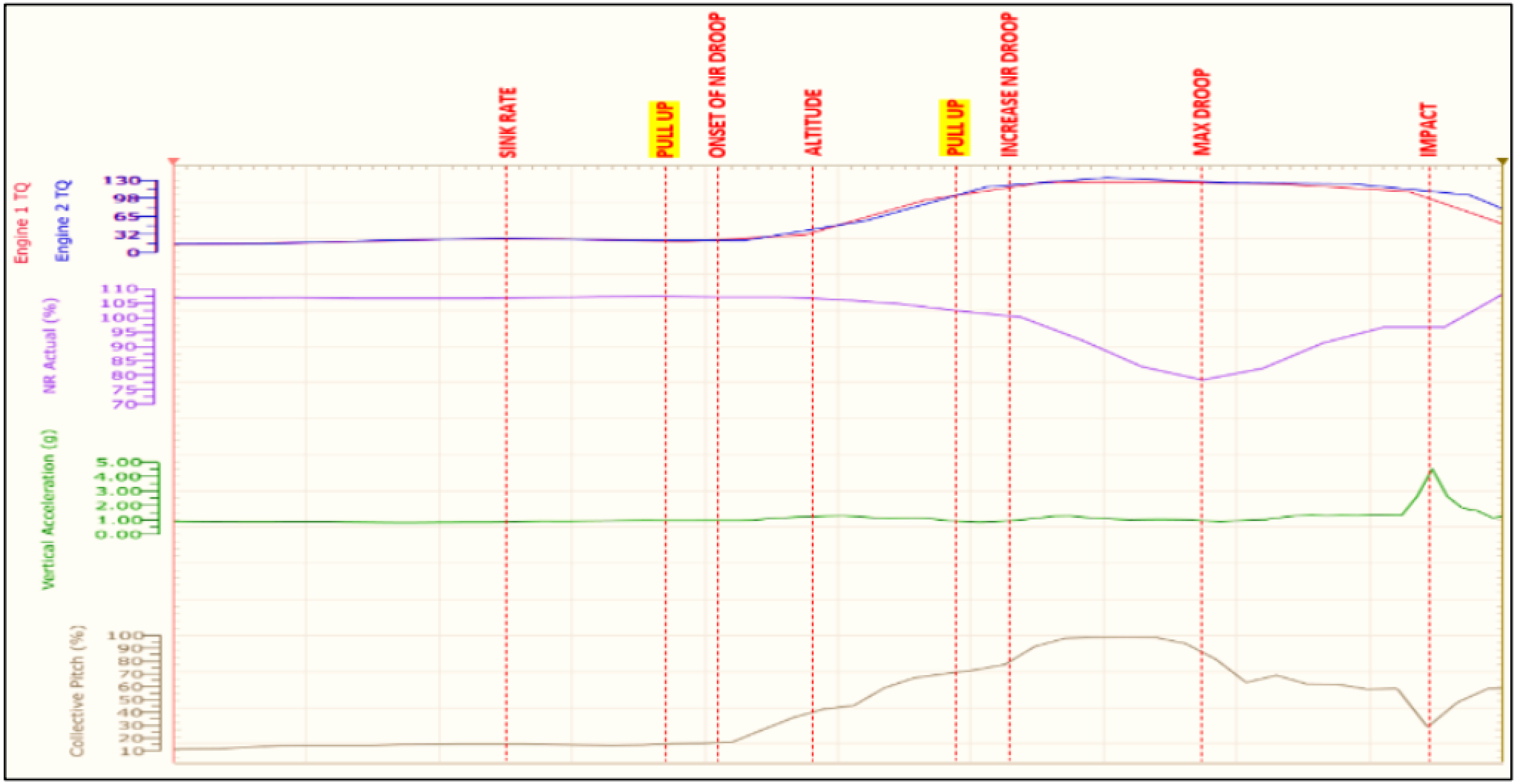


Figure 21: Graphical representation of flight data parameters with events identified in CVR recording

Links

- GPSJam GPS/GNSS Interference Map
- VT-PWI AAIB Report

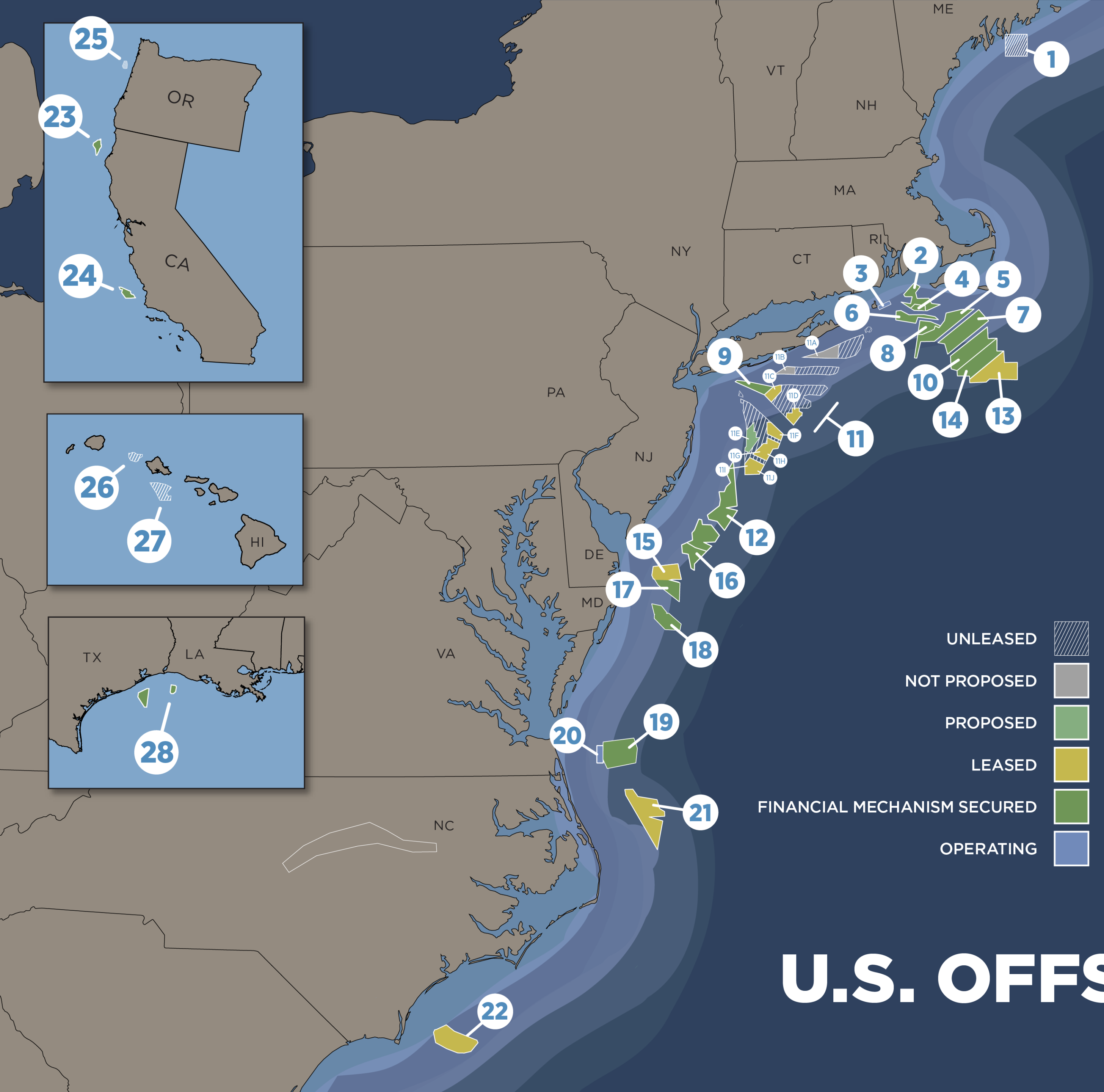
Offshore Wind

•

HSAC Aviation Support to Offshore Wind Assessment –ACP Offshore Windpower

Helicopter Safety Advisory Conference 11 & 12 October 2023

BUSINESS NETWORK for OFFSHORE WIND

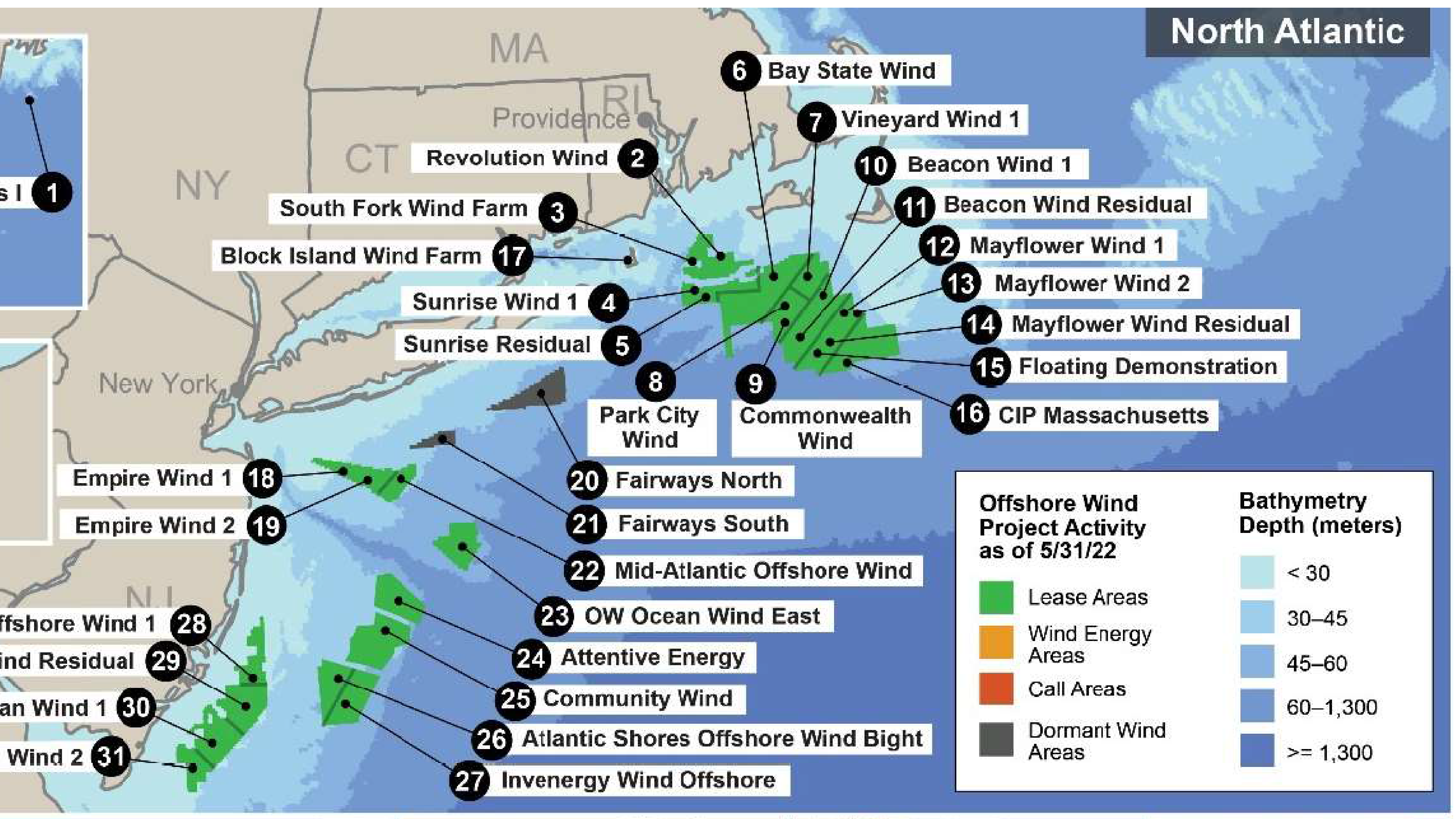


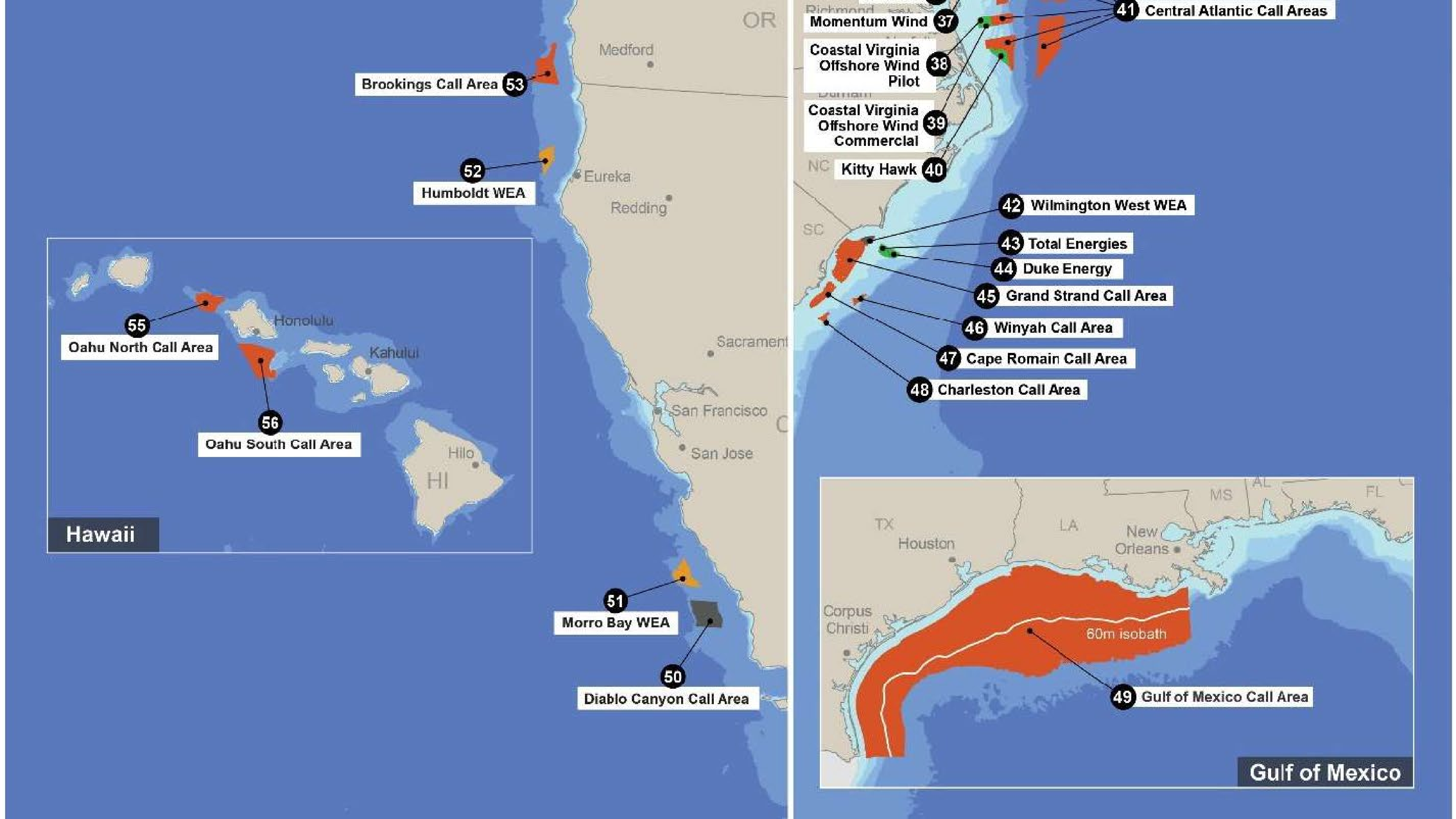
1. **Maine Aqua Ventus I**
   (New England Aqua Ventus) [11 MW]
2. **Revolution Wind**
   (Ørsted / Eversource) [704 MW]
3. **Block Island Wind Farm**
   (Ørsted) [30 MW]
4. **South Fork Wind Farm**
   (Ørsted / Eversource) [132 MW]
5. **Bay State Wind**
6. **OCS-A 0486**
7. **Vineyard Wind / Park City W. / Commonwealth W.**
   (CIP / Avangrid) [800/804/1,232 MW]
8. **Sunrise Wind**
   (Ørsted / Eversource) [880 MW]
9. **Empire Wind 1 & 2**
   (Equinor / bp) [816/1,260 MW]
10. **Beacon Wind**
    (Equinor / bp) [1,230 MW]
11. **NY Bight Call Area**
    • **A** (Fairways N) • **B** (Fairways S) • **C** (OCS-A0544) • **D** (OCS-A0537)
    • **E** (OCS-A0543) • **F** (OCS-A0538) • **G** (OCS-A0540) • **H** (OCS-A0539)
    • **I** (OCS-A0541) • **J** (OCS-A0542)
12. **Atlantic Shores Offshore Wind**
    (EDF / Shell) [1,510 MW]
13. **Liberty Wind**
    (CIP / Avangrid)
14. **Mayflower Wind**
    (EDPR / Shell) [1,204 MW]
15. **Garden State Offshore Energy**
    (Ørsted)
16. **Ocean Wind 1 & 2**
    (Ørsted / PSEG) [1,100/1,148 MW]
17. **Skipjack I / II Wind Farm**
    (Ørsted) [120/846 MW]
18. **MarWin / Momentum Wind**
    (US Wind) [270/808.5 MW]
19. **Coastal Virginia OSW - Commercial**
    (Dominion Energy) [2,640 MW]
20. **Coastal Virginia OSW - Pilot**
    (Dominion Energy) [12 MW]
21. **Kitty Hawk Offshore Wind**
    (Avangrid)
22. **Carolina Long Bay**
23. **Humboldt Wind Energy Area**
24. **Morro Bay Wind Energy Area**
25. **PacWave South**
26. **Oahu North Call Area**
27. **Oahu South Call Area**
28. **Draft Gulf of Mexico WEAs**

BUSINESS NETWORK FOR OFFSHORE WIND

U.S. OFFSHORE WIND MARKET

 10.26.22


North Atlantic
MA
RI
Providence
CT
NY
New York
NJ
1
6 Bay State Wind
7 Vineyard Wind 1
2 Revolution Wind
10 Beacon Wind 1
11 Beacon Wind Residual
3 South Fork Wind Farm
12 Mayflower Wind 1
17 Block Island Wind Farm
13 Mayflower Wind 2
4 Sunrise Wind 1
14 Mayflower Wind Residual
5 Sunrise Residual
15 Floating Demonstration
8 Park City Wind
9 Commonwealth Wind
16 CIP Massachusetts
18 Empire Wind 1
20 Fairways North
19 Empire Wind 2
21 Fairways South
22 Mid-Atlantic Offshore Wind
23 OW Ocean Wind East
28
24 Attentive Energy
29
25 Community Wind
30
26 Atlantic Shores Offshore Wind Bight
31
27 Invenergy Wind Offshore
Offshore Wind Project Activity as of 5/31/22
Lease Areas
Wind Energy Areas
Call Areas
Dormant Wind Areas
Bathymetry Depth (meters)
< 30
30–45
45–60
60–1,300
>= 1,300



OR
Medford
Brookings Call Area 53
52
Humboldt WEA
Eureka
Redding
55
Oahu North Call Area
Honolulu
Kahului
56
Oahu South Call Area
Hilo
HI
Hawaii
Sacramento
San Francisco
San Jose
51
Morro Bay WEA
50
Diablo Canyon Call Area
41 Central Atlantic Call Areas
Momentum Wind 37
Coastal Virginia Offshore Wind Pilot 38
Coastal Virginia Offshore Wind Commercial 39
NC
Kitty Hawk 40
42 Wilmington West WEA
SC
43 Total Energies
44 Duke Energy
45 Grand Strand Call Area
46 Winyah Call Area
47 Cape Romain Call Area
48 Charleston Call Area
TX
Houston
LA
MS
AL
FL
New Orleans
Corpus Christi
60m isobath
49 Gulf of Mexico Call Area
Gulf of Mexico

Standards Committees

There are 3 groups of Standards Committees within ANSI/ACP

- **Wind Technical Standards Committee** – focuses on design and technical standards
- **Workforce Standards Committee** – prepares consensus standards documents to facilitate uniform workforce competencies
- **Environmental, Health, and Safety Standards Committee** – prepares consensus standards, and related documents to facilitate EHS process and procedures relevant to worker safety

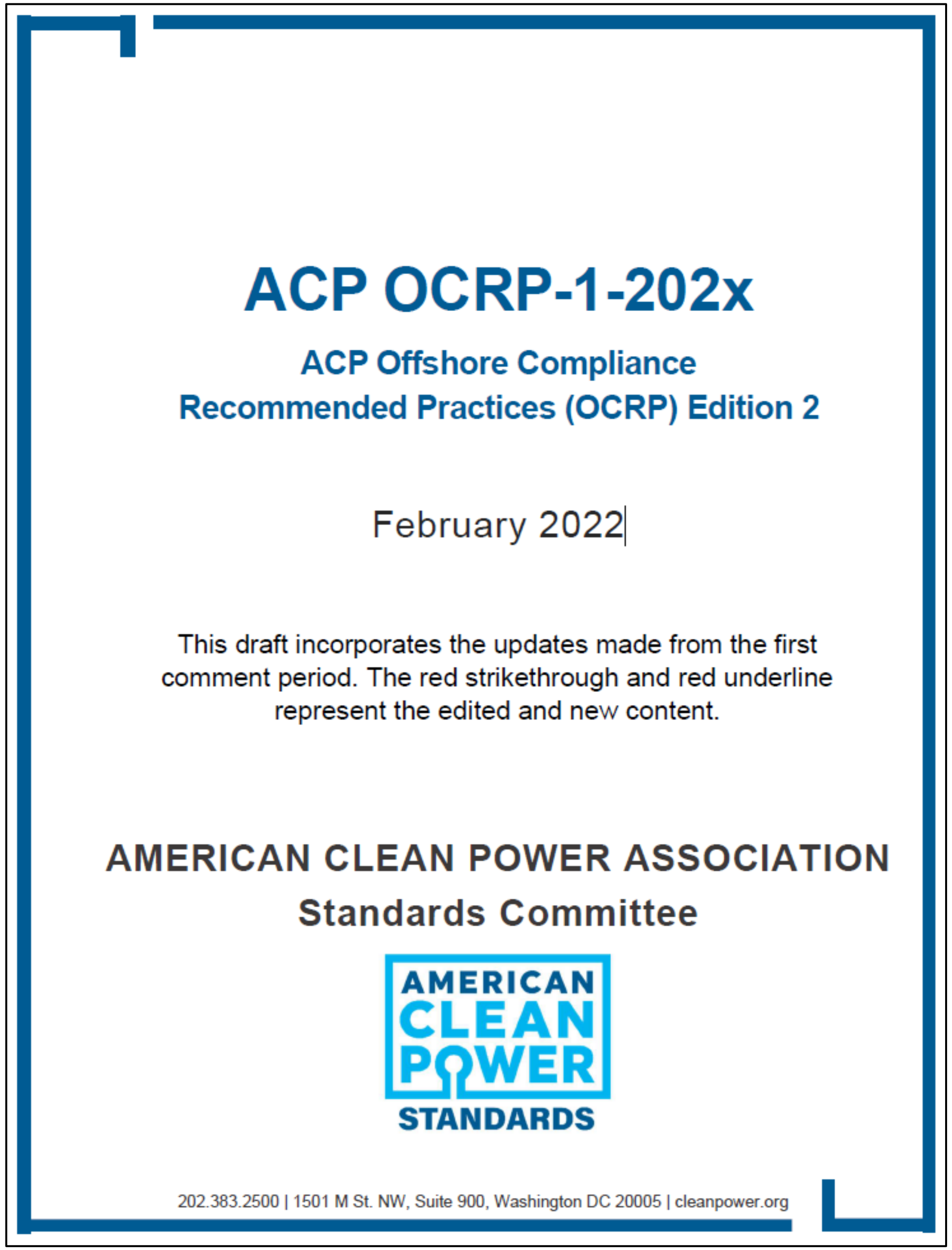
Wind Technical Standards Sub- Committee : ACP OCRP's

There are 5 OCRP Working Groups to cover different areas in Offshore Wind:

- ACP OCRP-1-2022 *Offshore Compliance Recommended Practices (OCRP) Edition 2*
- ACP OCRP-2 ACP U.S. *Floating Wind Systems Recommended Practices*
- ACP OCRP-3 *ACP US Offshore Wind Metocean Conditions Characterization Recommended*
- ACP OCRP-4 ACP *US Recommended Practices for Geotechnical and Geophysical Investigations and Design*
- ACP OCRP-5 ACP *US Recommended Practices Submarine Cables*

ACP OCRP-1-2022

- American Clean Power Association Standards Committee Recommended Practices Edition 2
  - February 2022
  - The first of five documents to be published
  - Written by a consensus-based group of more than 100 offshore wind energy industry members
  - Includes helideck section in which we had them agree to revise it and rescind API 2L as an industry standard and acknowledge that HSAC RPs have taken the place of API 2L
  - We also had them change vocabulary from "helipads" to helidecks



ACP OCRP-1-202x

ACP Offshore Compliance
Recommended Practices (OCRP) Edition 2

February 2022

This draft incorporates the updates made from the first comment period. The red strikethrough and red underline represent the edited and new content.

AMERICAN CLEAN POWER ASSOCIATION
Standards Committee

AMERICAN CLEAN POWER STANDARDS

202.383.2500 | 1501 M St. NW, Suite 900, Washington DC 20005 | cleanpower.org

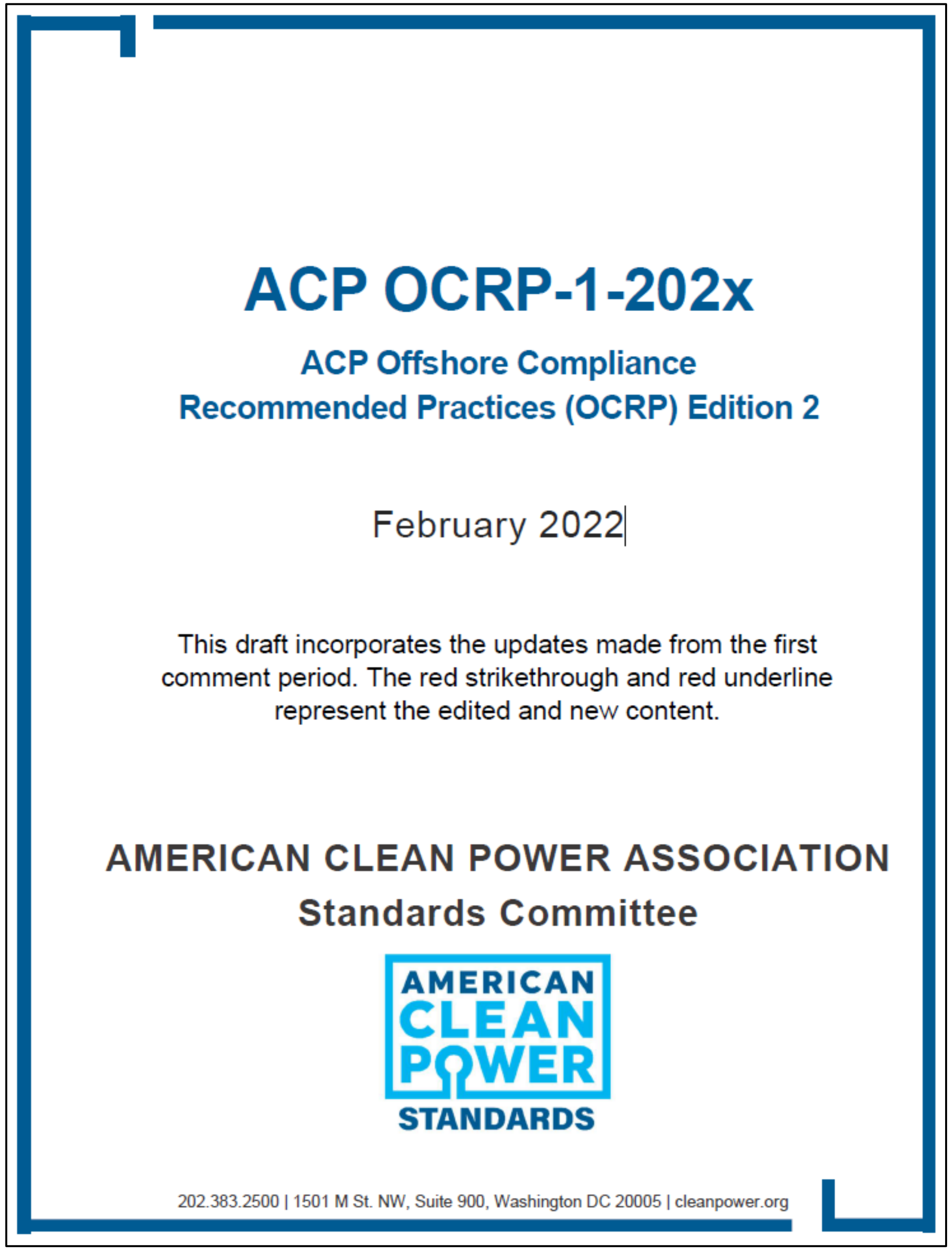
ACP OCRP-1-2022

- The Text of Section 5.7.5.3 will read as follows:

  Helidecks shall be designed according to accepted industry standards:

  - The FAA and USCG publish regulations for helicopter landing areas.
  - FAA AC150/5390-2C (needs to be updated to 2D) provides regulations governing the design, marking, and lighting of helicopter landing decks.
  - Coast Guard 46 CFR 108.231
  - Additional information can be found in the below guidelines:
    - HSAC RP 161 New Build Helideck Design Guidelines

API 2L was rescinded



ACP OCRP-1-202x

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Environmental, Health, and Safety Standards Sub Committees : ACP RPs

- ACP 1000-2.2-202x Draft: Rescue & Evaluation Subcommittee
- ACP RP 1001.2- 202x Draft: Recommended Practice for Offshore Safety Training and Medical Requirements
- ACP RP 1002.2-202x Recommended Practice for Offshore Safety Standards

TBD:

- Repower Sub-Committee
- Service Lift Task Force
- Wind Safety Standards Subcommittee -adopting European Standards (EN 5008 and others) that impact wind energy worker safety & health

ACP RP 1002 Recommended Practice for Offshore Safety Standards

This group will identify and publish a standard of the adopted occupational health and safety practices and standards to be applied for offshore wind farms

- This RP will cover health and safety from an operational standpoint
- The draft is in its infancy
- A question was brought up about flight operations and what guidelines to reference
- Dan Verda and I discussed collaborating with ACP to

Observations

There needs to be a concerted effort to include OSW organizations into HSAC

There needs to be a concerted effort for HSAC committee members to become participants in OSW organizations

US Regulatory Documents that address offshore wind turbine generators focus on height, lighting, and visibility markings, but do not make any specific mention of hoist platform requirements

A need to educate the OSW community on HSAC RPs as an accepted industry standard by IOGP, HeliOffshore, and USCG

International Association of Oil & Gas Producers

HeliOffshore
Safety Through Collaboration

Resources

- HSAC RPs 161-164
- UK CAA CAP 437 ed. 8 amend. 02/2021 dated July 2021
- G+ Global Offshore Wind: *Good Practice Guidelines for Safe Helicopter Operations in support of the Global Offshore Wind Industry Sections A&B*
- HeliOffshore *Wind Farm Recommended Practice (WinRep) Version 1.0*
- Bureau of Ocean Energy Management *Guidelines for Lighting and Marking of Structures Supporting Renewable Energy Development*, dated 28 April 2021
- U.S. Federal Aviation Administration (FAA) Advisory Circular AC 70/7460-1M *Obstruction Marking and Lighting*, dated 16 Nov 2020
- ACP OCRP-1-202x: ACP Offshore Compliance Recommended Practices (OCRP) Edition 2 February 2022