Improving Flight Test Safety Through Enhanced Safety Risk Management

Workshop

- Exploring effective safety risk management (SRM) to include contemporary definitions and available references that may or may not be familiar to test teams.
- Reinforce understanding and provide opportunity to refine competence in identifying test hazards, the causes for those hazards, and mitigations to ultimately reduce risk to as low as reasonably practicable.
- Practicing effective SRM will offer a tangible benefit for attendees in conducting test hazard analyses (THA) back at their host organizations.
- THAs developed during the tutorial may be hosted on the Flight Test Safety Database (FTSD) as a resource for the flight test community.

Technical Session

- To complement the theme, we will hear from test teams on their SRM process
- Did it have the safety effect they anticipated.

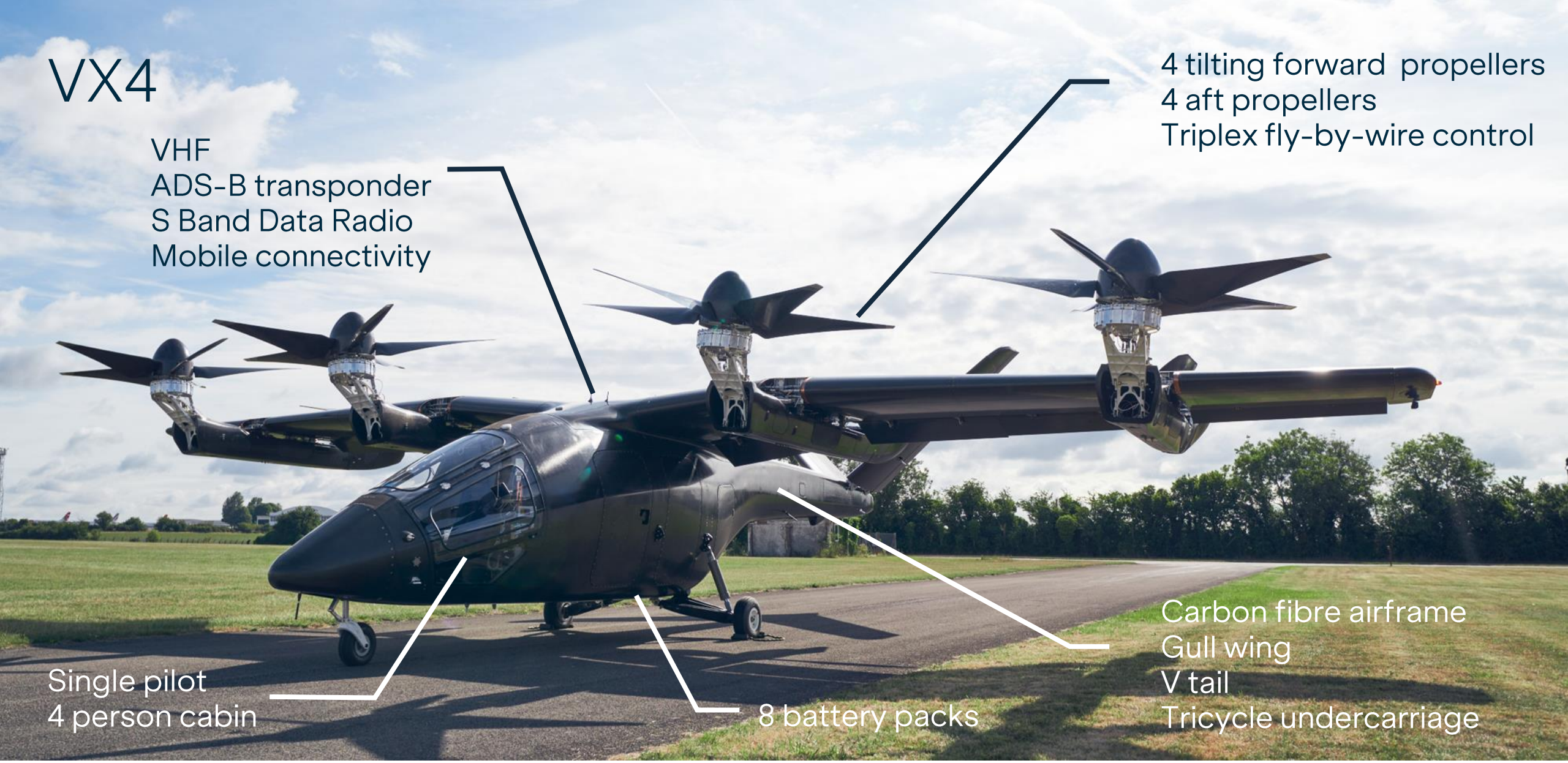
Developing Flight Test Safety in a Startup

Presentation to the Flight
Test Safety Committee
13 Oct 2022

Developing Flight Test Safety in a Startup

- VX4
- How it started
- Developing Safety Culture
- Experimental eVTOL hazards
- Eliminating hazards
- Mitigating hazards
- What's an acceptable risk
- How its going

VX4

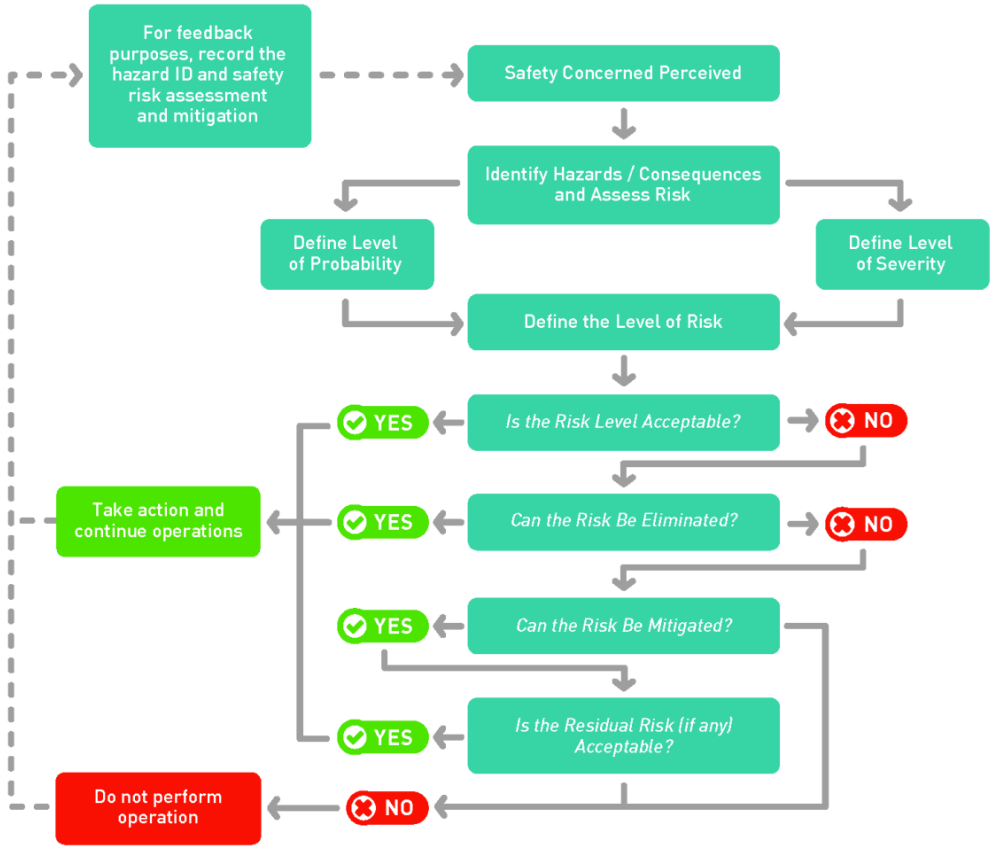

VHF
ADS-B transponder
S Band Data Radio
Mobile connectivity
4 tilting forward propellers
4 aft propellers
Triplex fly-by-wire control
Single pilot
4 person cabin
8 battery packs
Carbon fibre airframe
Gull wing
V tail
Tricycle undercarriage

How it started

- Risk Management integral part of the organisation Safety Management System (SMS)

- Developing SMS for more complex aircraft and test operation
- Safety Culture
  - Rapidly growing company with diverse experience (including non aviation)
  - Ambitious timelines

- ICAO Safety Management Manual decision aid



Developing Safety Culture

An informed culture

- Leadership commitment to safety
- Regular communications – positive reinforcement

A reporting culture

- Small start-ups just deal with issues
- As the business grows formal reporting needed to raise issues to management to take the action needed
- Encouragement to report at all levels in the business – understand the near misses before they become an accident

A learning culture

- There are no new flight test accidents – educate with case studies
- Train for human factors in the flight test environment with simulator and telemetry system

A just culture

- Just Policy was in place
- Need to educate staff
- Encouragement for near misses to be raise openly & honestly

A flexible culture

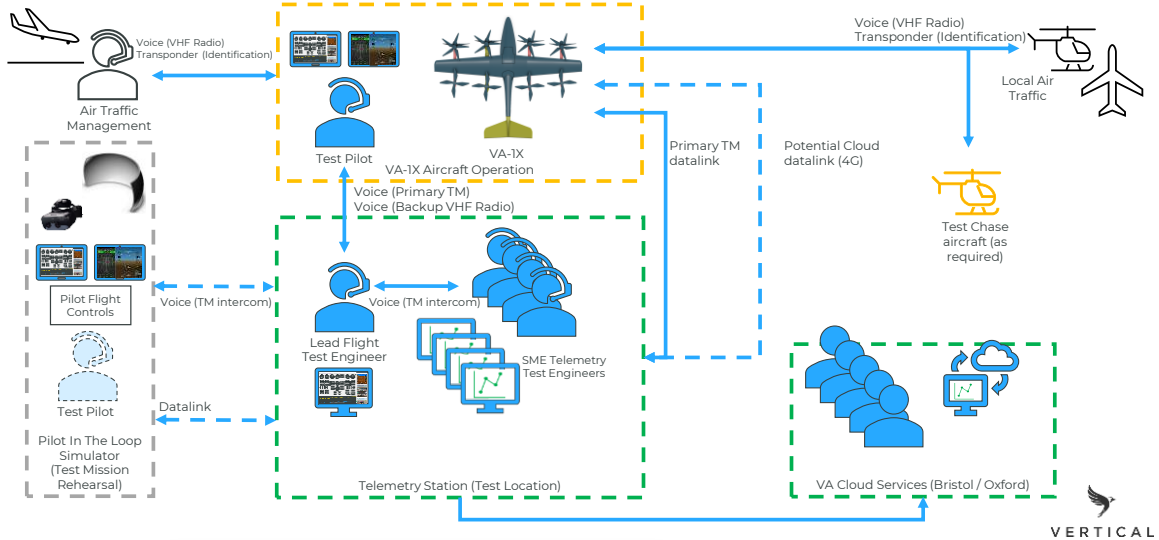
- No issue here
- Almost too flexible

Experimental eVTOL hazards

- High Voltage
  - Significant energy stored & distributed
  - Training & processes
  - Emergency services awareness
- Thermal Management
  - Motor & Inverters
  - Batteries charging & discharging
- Structural Vibration
  - Relatively stiff structure
  - Systems harmonics
- Loss of Control
  - Unified control
  - Novel effectors
  - Understand what the black boxes are doing
- Normal flight test hazards

Eliminating hazards

- Flight Test lead on Concept of Operations for the test aircraft
  - Establishing use cases and user needs to feed requirements
- Test aircraft operation as a control system with telemetry
  - System-Theoretic Process Analysis step 2
  - Develop requirements for telemetry & training
- Leading creation of flight crew publications; Aircraft Flight Manual and Checklists
- Trying things out in the Pilot In the Loop Simulator
- Proving equipment on rigs



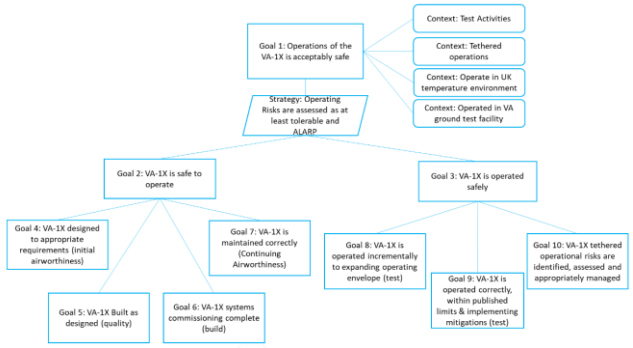
Mitigating hazards

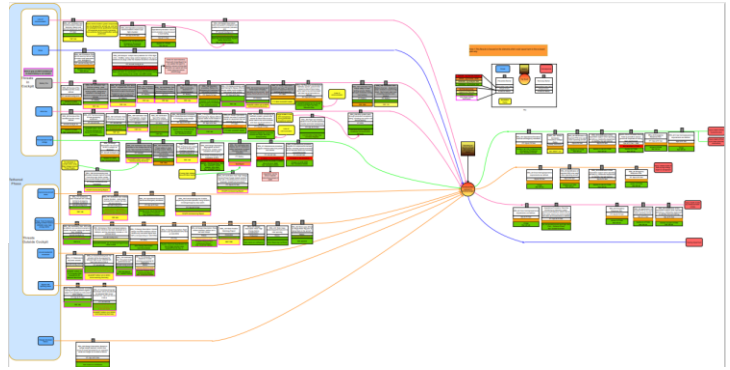
- Train the team in a realistic environment
- Initial whole aircraft running in a big hangar
- Tethered operation first
  - Build confidence in new technology
  - Use ground power to run motors for longer
- Incremental envelope expansion & fail fast
  - Thrustborne – most demanding on power train
  - Wingborne
  - Transition – eVTOL concept hangs on this
- Take things as slow as you can
  - Pressure to deliver
- Test away from the company pressures, but close enough to get engineering advice quick
- Having experience in key areas

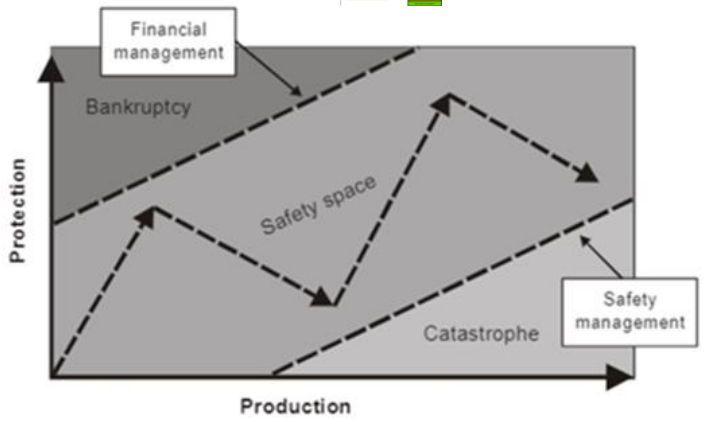
What's an acceptable risk

Impact \ Probability	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

- Is the Risk tolerable
- Have we taken all practicable measure
- Developing the safety argument – BowTie & Goal Structured argument
- First Flight Readiness Review
- Independent CAA Permit to Fly review
- Remote versus crewed
  - Going from remote mentality to pilot on board
  - Balancing loss of situational awareness of on board pilot with confidence in novel systems
- Human element to Risk appetite
  - Need to progress
  - Personnel experience & exposure to risk ownership







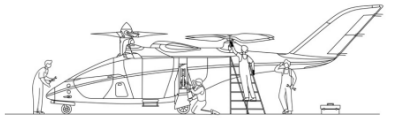
Source: James Reason

How its going

- VX4 prototype built
- Tethered ground runs completed
- Tethered hover
  - Prove the structure and power train
  - Prove VX4 can fly
- Low speed envelope expansion
  - Focus on transition corridor
- Aircraft enhancements
  - Propeller efficiencies
  - Crew escape system
- Wingborne
- Transition

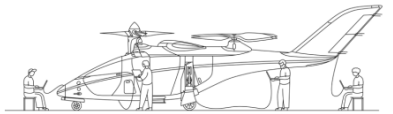
Step 1 – Build and Commissioning

The VX4 Prototype was built through Q1 at our partner GKN's Global Technology Centre where 90% of the build was completed and low voltage systems commissioned. The Prototype was then dismantled and transported to our test facility in Q2 where it was reassembled and the remaining 10% build completed, ready for ground tests and final commissioning.



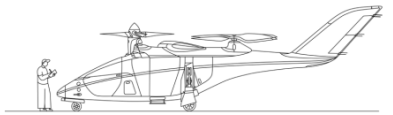
Step 2 – Ground Tests

The VX4 Prototype has completed a series of rigorous ground based tests, a requirement for permit to fly, including vibration tests, lift load tests and propeller thrust tests to validate the build meets the design specification.



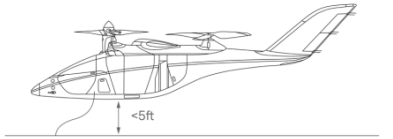
Step 3 – Piloted Permit to Fly

The CAA has visited our design HQ in Bristol as well as our Cotswold Airport Test Facility, inspecting engineering design and process documentation, test data, and the aircraft itself. Once satisfied, the CAA will issue a piloted permit to fly, moving us to Step 4.



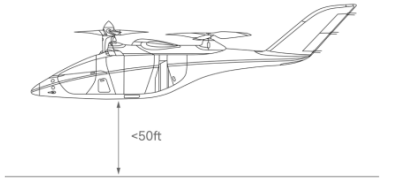
Step 4 – Tethered Hover

The first flights are a series of taut and loose tethered hovers. This important first phase of airborne testing proves aircraft stability in take-off and landing, flight control systems, vibration, noise, ground effects and battery performance. Once satisfied with performance we move to Step 5.



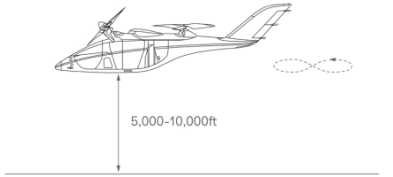
Step 5 – Low Speed Flight

We will perform a series of untethered tests at heights of up to 50ft and speeds of up to 40kts. These multi-axis manoeuvres continue to expand the flight envelope, testing stability and control, the flight control system, propeller to propeller interactions, loads, vibrations and system operation during low speed transition.



Step 6 – Transition and Envelope Expansion

Following Step 5, and a key milestone, transition involves moving from hover to wing-borne cruise and back at heights of between 5,000ft and 10,000ft at speeds of up to 145kts, expanding the flight envelope fully and proving the simulation work on aerodynamics, structure, powertrain and flight control systems.



Developing Flight Test Safety in a Startup

- VX4 set to deliver electric advanced air mobility
- Holistic view of Safety Risk Management as part of SMS to support Flight Test
- Developing Safety Culture for maturing technology in a rapidly growing and dynamic environment
- Flight Test developing the Concept of Operations
- Understanding the hazards; eliminating in design or developing mitigations
- Balancing Risk to Life and need to deliver; shaped by the collective experience of the team & working environment
- VX4 prototype is built and flight test underway

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