Health and Usage Monitoring System (HUMS) for hybrid and electrical VTOL – a conceptual approach for future flight safety

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Health and Usage Monitoring System (HUMS) for hybrid and electrical VTOL –

A conceptual approach for future flight safety

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The traditional HUMS-model for helicopters

- Allocation of sensor data for condition monitoring
- Monitoring of e.g. engines, shafts, gear-box, bearings, rotors, and structure
- Post-flight download and assessment/analytics
- In some cases, utilization of prognostic algorithms
- Improvement of safety due to better SA for maintenance personnel
- Better prevention of catastrophic failures

Helicopter compared to EVTOL

Reference: Airbus Helicopters, DLR, Volocopter

Status quo in EVTOL aviation – Nov 2021

- Number of startups building E-VTOL is still growing
- Influx of capital and investor expectations
- technical capabilities outpace the regulatory framework

- No comprehensive certification or airworthiness framework
- No certification or legal basis for autonomous operations

Development of business models for E-VTOL

- Starting with piloted vehicles
- Models for cargo and passengers

- Push to automation, making all inhabitants passengers
- Autonomous fleets and operations, increasing the profitability and revenue passenger mile (RPM)
- High connectivity and electronic conspicuity

What makes EVTOL different?

- Much less parts – especially moving parts
- Highly automated flight stabilization
- Battery-electric or hybrid (fuel-cell electric)
- Similar configurations as in the small UAS design (multi-copter, fixed-wing, transition-hybrid)
- Multiple engines and drivetrains
- Flight envelope and range limited by battery performance
- Completely dry – no liquids

HUMS for E-VTOL

- Components of interest are flight controller, batteries, propeller, motors, payload and the data links.
- Parameters of interest: vibration, temperature, voltage, frequency, noise, current, and many more
- Number of sensors is higher
- Highly connected
- Options for cloud-based processing and storage
- Artificial intelligence and machine-learning can be used for pattern recognition and to recognize time-dependent degradation of systems

Benefits of HUMS for EVTOL

- Optimization of maintenance events
- Reducing unscheduled maintenance
- Lower maintenance and operations costs
- Keeping footprint and weight add-on to a minimum

Reference: GPMS, Foresight system

The batteries – a new maintenance paradigm

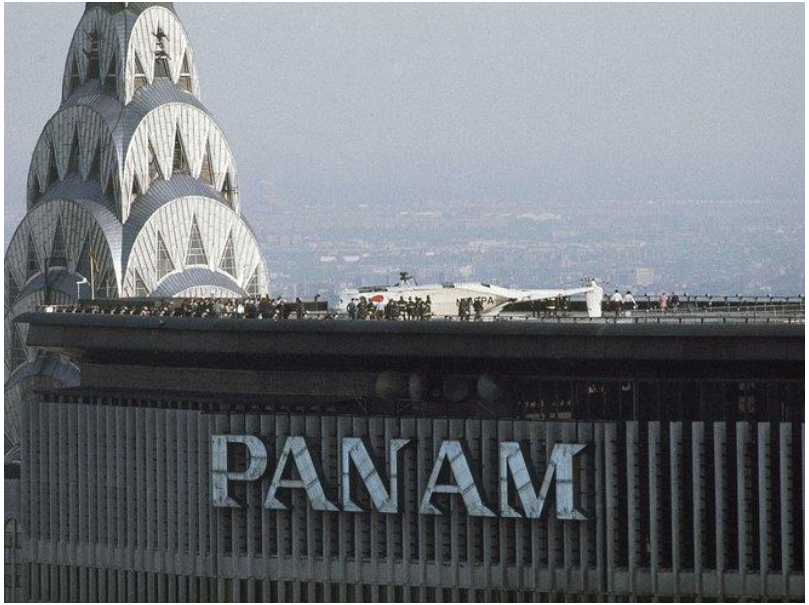
- Number of battery units and cell count – how much redundancy is needed?
- How does battery life develop?
- Battery age as developing factor - capacity degradation
- Putting limits on the mission

Challenges 1

- Potential thermal challenges for larger electric motor layouts, especially in T/O mode power draw
- No historical data about fatigue and degradation in EVTOL
- No proof and evidence for condition monitoring to extend longer intervals due to less wear and tear/fatigue

- Mishaps will happen
- Modern risk culture will influence perception and growth
- Different perception helicopter accidents vs. EVTOL accidents

Helicopter crash, PanAm building, NYC 1977



Challenges 2

- Develop regulations for fully autonomous platforms
- Insurance and potential liability

- Highly connected vehicles and platforms
- To include Cyber Security aspects in the development of EVTOL

Potential for the future

- Standardization of flight log data
- Standardization of links for data transmission
- Improvement of coverage and infrastructure for real-time connectivity
- Real-time diagnosis solution integrated into UTM environment

Reference: Whitepaper, Enabler for safe operations - Health Condition Monitoring SafeDrone by Lufthansa Technik, April 2018

Actions needed 1

- Traditional aviation regulation foundation is based on Safety Management Systems, Flight Data Monitoring Systems and HUMS
- Integrate awareness for Safety Management, Risk Assessment, Just Culture, etc. into the EVTOL economy
- Manufacturers, operators and MRO provider need to adopt aviation principles

Actions needed 2

- Develop and transform education – both vocational and academic
- Combine aeronautical science, maintenance, computer science and mechatronics

- Adopt technology development in curricula
- Start early in schools - STEM education with small drones

Actions needed 3

- Further research and analysis of data
- Extensive testing for fatigue, battery life and system safety

- Industry-wide collaboration
- Prevent parallel structures and analysis
- Transparency
- **Safety data cannot be an IP – collaboration is needed for industry protection and risk-reduction**

eVTOL supply chain

Reference: Agility Prime, 2020.

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Thank you!

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