SafeDrone by Lufthansa Technik

Enabler for safe operations - UAV Health Condition Monitoring

SafeDrone by Lufthansa Technik - Whitepaper
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Summary

This Whitepaper addresses the recent research results from the SafeDrone project of Lufthansa Technik. UAV Health Condition Monitoring (HCM) addresses the risk-based approach and the regulatory requirement to allow operations that need specific levels of assurance, integrity, and robustness of the platform and the mission.

HCM can act as a risk-mitigating process to enable approval of operations with higher potential risk level. It applies the concept of Continuous Airworthiness, mandatory in commercial manned aviation, to UAS. With the described results, the team of SafeDrone was able to significantly increase operational integrity, decrease downtime and henceforth contribute to flight safety.

Introduction
What is necessary to enable a safe and reliable integration of UAS into airspace?

The market for services and platforms in Unmanned Aircraft Systems (UAS) is steadily growing. Due to increasing demand in the industry and growing technological capability and performance of UAS, the number of operations, density and flight hours will increase. Also, when operations will become more autonomous, operational reliability and stability become increasingly important. With the correlating increase in risk for incidents and accidents, conditions and regulations need to adapt.

According to recent studies, 64% of UAS incidents are caused by technical and equipment problems. (Wild, G., Murray, J., & Baxter, G., 2016, Exploring civil drone accidents and incidents to help prevent potential air disasters; Aerospace)

An EASA study identified three technical safety issues from the analysis of occurrences, which are the guidance and control system, propulsion system and power sources. (EASA Report, UAS Safety Risk Portfolio and Analysis, 2016)

This research results clearly indicate, that greater emphasis on technical issues such as the airworthiness of UAV and the integrity of the communication links will produce greater safety dividends.

Authorities and regulatory bodies, e.g. JARUS (Joint Authorities for Rulemaking on Unmanned Systems) have developed several models for risk mitigation, such as the risk-based approach. It defines measures and processes that can increase safety and enable specific operations. One of those measures is a reliable condition monitoring and situational awareness regarding the airborne platform.

While commercial aviation has become the safest means of transportation on earth over the past decades, Unmanned Aviation is still in a very early phase. There are not yet any universal or adequate maintenance concepts for UAS in place – the same goes for data and documentation standards for performed flights. Improper or reactive maintenance in the UAS branch has already led to unsuccessful missions or even losses.

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HCM can act as risk-mitigating process to enable approval of operations with higher potential risk level. It applies the concept of Continuous Airworthiness, mandatory in commercial manned aviation, to UAS.

For complex UAS operations, a technical fleet management and a standardized maintenance process need to be applied, allowing scalable and commercial sustainable operations. This can enable smart maintenance to reduce unnecessary repairs, therefore down-time of UAS fleets and loss of revenue.

What is Health Condition Monitoring (HCM) and how does it work?

Health Condition Monitoring is a diagnostic process of data allocation from a complex technical system or platform (turbine, engine, UAV) to determine the status (health) of the system.

Pre-installed sensors, distributed over the whole system, are used to measure the status of the several sub-systems and elements. The collected data is used to make best-informed decisions about operations, safety, and maintenance.

How can HCM be applied to UAS?

HCM data can be retrieved from the UAV platform after the operation or flight (Black Box Principle) or, pending on connectivity and circumstances, with real-time data transmission to the measuring instance.

All elements of the UAV and the whole system with their operational integrity contribute to a safe operation. These can be e.g. the flight controller, batteries, propeller, motors, payload and the data linkage. Parameters of interest can be temperature, voltage, vibration and many more.

Additionally, machine-learning is used for pattern recognition and to recognize time-dependent degradation of systems.

Due to missing standardization and market segmentation, each UAS manufacturer collects flight and maintenance data only inhouse and is therefore limited to his missions and variety. Also, no overarching database collects actionable and reliable data for statistical analysis, quality management, and pattern recognition.

A transparent and trustworthy data management with results from all manufacturers will increase flight safety and help the market to develop.

SafeDrone UAV HCM research experiences and results

The SafeDrone team conducted intense flight tests and data allocation with several hardware manufacturers from different UAV market segments.

For each flight up to 800 signals from dozens of sensors were gathered, some of those already installed and some bespoke and modified for the HCM project.

After collection of raw sensor data, several stages of converting and cleansing, reducing noise and extracting relevant features, were implemented. This resulted in more than 350 analyzed KPIs, checked against more than 750 thresholds and values.

During the last project phase of SafeDrone, failure detection and health monitoring for ongoing UAV operations were successfully demonstrated. The diagnostic results revealed expected and unexpected correlations and were used for the optimization of future UAV operations.

The results of the project so far clearly indicate the commercial benefits for UAV operators and the validation for failure detection before the occurrence of catastrophic events. Precise and clear maintenance recommendations will improve operations and enhance asset availability, which can be critical in times of increased demand. The team gained actionable technical data from the UAV operations, relating to the quality of components and their actual meantime between failures (MTBF) and meantime between repairs (MTBR).

In addition to the data standard, Lufthansa Technik also developed a new serial number scheme for components and parts of UAV´s. In comparison to the civil aviation industry, there are no standardized schemes for the part number (P/N) and serial number (S/N) generation available today. This naming scheme is a fundamental requirement for the HCM platform to not just allow unique identification per component but also tracking of component lifetimes and behavior, which enables benchmarking between same part numbers and prediction.

SafeDrone HCM developed this approach as a neutral instance and vendor-neutral entity, with significant experience in maintenance, repair, and overhaul.

Additional advantages of UAV HCM

The compliance with regulatory requirements is made easier; mitigation of operational risk for specific missions and individual waivers is enhanced. UAV HCM can act as threat barrier because it decreases several hazards of UAV operations. Given a sufficient cellular or alternative connectivity, UAV HCM can be an integral part of a future UTM.

Not only operators but also UAV manufacturers can benefit from the tremendous diagnostical opportunities for their product development and test-flight campaigns, e.g. on the way to certification.

With the described results, the team of SafeDrone was able to significantly increase operational integrity, decrease downtime and henceforth contribute to flight safety.

Offering a solution to detect context-sensitive failures and launching a platform for post-flight analysis is only the very first step in enhancing asset availability and safety. The platform will be continuously developed over the coming months, thereby expanding the range of supported UAV brands and allowing for preventive warning measures as well as improved failure identification. Increased reliability and reduced maintenance efforts may result in pre-flight checks for unmanned aircraft becoming unnecessary in the long term.

Future development

The described results of the project indicate further need for development and collaboration of all stakeholder involved. Areas of interest can be:

- Standardization of flight log data
- Standardization of links for data transmission
- Improvement of coverage and infrastructure for real-time connectivity
- Integration of HCM data into a future UTM
- Real-time diagnosis solution, executable directly on the UAV, integrated into UTM environment