Intelligent Health & Mission Management Architecture for Autonomous and Resilient Distributed Space Systems

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Abstract: Distributed Space Systems (DSS) play a vital role in the success of multi-spacecraft missions, which are garnering considerable attention because of their affordability through lower costs of multiple smaller spacecraft, adaptability through reconfiguration, and resilience to failure through redundancy. These systems enable collaborative endeavours among spacecraft, thus amplifying exploration capabilities within such missions. Nevertheless, the presence of multiple satellites amplifies the system's complexity and raises the probability of fault occurrences. Consequently, an efficient health and mission management (HMM) system capable of accurately detecting and identifying faults within such a complex system is imperative to enhance mission success. In this study, we introduce an innovative Intelligent Agent-based HMM (IHMM) architecture for multi-spacecraft systems, leveraging Intelligent Agents (IAs) to seamlessly integrate mission success with satellite health and resilience. A thorough exploration and classification of diverse data sources suitable for integration into IAs is conducted, categorised according to their deployment type and intended roles. To evaluate and validate our proposed architecture, we conducted a preliminary analysis using one-time and continuous friction faults on a reaction wheel. The experiments show our approach outperforms traditional methods by proactively adapting control strategies in real-time and preventing saturation of other reaction wheels.

1 INTRODUCTION

Over the past decade, there has been a noticeable shift towards utilising distributed space systems, such as satellite constellations, as opposed to monolithic systems. This trend, bolstered by increased private investment and the launch of large constellations, is part of the "Space 4.0" or "New Space" movement (Iacomino, 2019). Educational institutions have also become key players in space exploration, particularly through the use of CubeSats, small satellites initially introduced by California Polytechnic State University in 1999. The advancement of commercial off-the-shelf (COTS) technologies has transformed CubeSats from educational tools to commercially viable platforms. Leading examples of this shift include satellite constellations like Starlink, OneWeb, and Lemur-2, some of which are expected to exceed 1000 satellites, highlighting a significant departure from traditional space approaches. While "mass production" of satellites is now feasible, the challenge remains in managing their "mass operations." This shift, driven by economic and strategic advantages of distributed systems over monolithic ones such as feasibility, redundancy, resiliency, and cost-effectiveness, requires new approaches. Traditional manual control by skilled operators, even with batched telecommands, becomes increasingly complex with larger numbers of spacecraft. This method is not scalable for large satellite constellations, necessitating new operational methods and greater automation (Ben-Larbi et al., 2021). Transitioning to large-scale constellations introduces significant challenges, including higher complexity of (i) basic communication tasks and ground resources allocation, (ii) coordination and higher probability of anomalies, (iii) mission objectives, and (iv) space situational awareness (SSA) functionalities (Krupke

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et al., 2019). In the dynamic realm of space exploration and satellite technology, ensuring the success and safety of space missions has become increasingly dependent on robust SSA capabilities and subsystems health. Intelligent Health and Mission Management (IHMM) represents a promising technological approach that integrates mission success with health of satellite's subsystems. To motivate research efforts in this area and pave the way for the automated management of large distributed satellite systems, this paper presents a resilience-oriented architecture for IHMM by considering the flow of pre-processed data as an input for IAs. In summary, this paper provides the following contributions:

- Proposes two distinct classifications of data sources based on sensor deployment type and their respective roles for IHMM.
- Proposes a novel resilience-oriented architecture for IA-enabled IHMM that integrates various AI-based technologies to increase mission success.
- Presents preliminary analysis to evaluate proposed architecture effectiveness considering reaction wheel friction faults as a use case scenario.

The paper is structured as follows: Section 2 reviews related concepts and approaches, focusing on resiliency in DSSs. Section 3 classifies data sources and sensors for IHMM. Section 4 details the resilience-oriented IHMM architecture and components. Section 5 presents preliminary analysis of the proposed architecture. Conclusions and future work are in Section 6.

2 LITERATURE REVIEW

Spacecraft face numerous challenges during missions, such as harsh environments and the inability to repair or replace malfunctioning equipment. Extreme conditions in space, such as temperature cycling, vacuum, and radiation, degrade critical instruments and systems, especially in Low-Earth Orbit (LEO) and Geosynchronous satellite operations. Components like Telemetry, Tracking and Command (TTC) transponders, Attitude Determination and Control Systems (ADCS), Solar Arrays and Electrical Power Systems (EPS) are particularly susceptible. Integrated System Health Management (ISHM) represents a promising technological approach that integrates sensor data from different sources with historical records of component and subsystem health status (Figueroa et al., 2006). This fusion facilitates the generation of actionable insights, empowering intelligent decision-making concerning satellite constellation operation, maintenance, and resilience. ISHM primarily depends on evaluations and forecasts of system health, which encompass early fault detection and the estimation of Remaining Useful Life (Jennions, 2011). Various AI techniques have been applied to space ISHM systems, with a notable link between the advancement of AI technology and its integration into space health management. Many AI technologies initially developed within the aerospace industry have matured and found application in space health management systems. In the 1970s and 1980s, rule-based expert systems were prevalent, coinciding with NASA's Integrated Vehicle Health Management (IVHM). Subsequently, the focus shifted towards advancing technologies like decision support systems and emerging fields like Machine Learning (ML).

NASA developed the Remote Agent, the first fully autonomous AI system for spacecraft, featuring the Livingstone model-based reasoning system and decision support. It was used in NASA's X-37 program, where Vehicle Management Software (VMS) diagnosed and predicted faults. Although the X-37 IVHM experiment concluded, it advanced real-time ISHM for space missions. In 1992, NASA prioritized IVHM for future space systems. By the 2000s, AI development expanded to deep learning, robotics, and autonomous vehicles, while aerospace ISHM emphasized model-based reasoning. Systems like MAPGEN enabled constraint-based planning for Mars missions (Ai-Chang et al., 2004). Recently, focus has shifted to onboard autonomy in diagnostics, prognostics, and navigation using AI

The next advancement in the ISHM paradigm, known as Intelligent Health and Mission Management (IHMM) (Ranasinghe et al., 2022), has emerged to seamlessly integrate mission success with spacecraft health. IHMM systems bring forth the ability to forecast declines in the operational performance of subsystems, allowing for timely identification of suitable corrective or reconfiguration measures. This ensures that the system maintains an acceptable level of operational capability well in advance of any potential failure event (Ranasinghe et al., 2022). Our proposed resilience-oriented IHMM architecture which integrates different AI-based technologies for HMM is discussed in the section 4.

3 DATA CLASSIFICATION

The effectiveness of IHMM relies on diverse data from space-based and ground-based assets, providing vital insights into satellite health, resilience, and mission facilitation. Advanced sensors and technologies enhance safety, efficiency, and security in space operations while supporting exploration and resource utilization. Given the critical role of satellite health in mission success, sensors are categorized by deployment (space or ground) and function in health management, mission success, or both (see Table 1), clarifying their role in satellite operations.

3.1 Deployment-Based Classification

Ground-based sensors are vital for satellite operations but have limitations such as line-of-sight obstructions and atmospheric interference. With growing mission complexity, integrating space-based sensors is essential. These sensors provide continuous, unobstructed observations, enabling precise monitoring, early anomaly detection, and real-time space weather monitoring. They enhance SSA, improve communication with GSs, and mitigate risks, making them critical for optimising mission success in space exploration.

3.2 Role-Based Classification

Satellite health is critical for space missions, requiring effective monitoring and maintenance (Ranasinghe et al., 2022). Beyond health, mission success involves meeting objectives and handling space complexities, aided by various sensors. Some focus on health, others on mission goals or space navigation, while certain sensors serve dual roles. This section classifies sensors by their roles—health management, mission success, or dual-purpose—helping operators optimize decisions for mission success and satellite longevity.

4 PROPOSED ARCHITECTURE

The objective of IHMM is to develop an operational management solution using AI to monitor system conditions and provide real-time health assessments for safety-critical and mission-essential systems. It anticipates faults or performance degradation, enabling timely recovery actions and adjustments to maximise mission performance. IHMM enhances safety and reliability through precise real-time insights into system health and situational capabilities. It considers mission objectives, operational conditions, and environmental indicators for informed decision-making. The system forecasts performance declines, identifies components needing reconfiguration, and adjusts mission profiles to maintain operational capability, reducing the risk of failure or mission aborts. Main drivers of IHMM system are discussed this section. Moreover, a generic architecture of IHMM system by considering pre-processed data flow as an input for IA is proposed at the end of the section.

4.1 Health and Usage Monitoring System (HUMS)

A HUMS collects, processes, and analyzes critical system component data using onboard sensors to monitor key systems and environmental indicators. These sensors enable early fault detection and proactive measures to prevent disruptions, as discussed in previous sections. Sensor data is sent to a central unit for logging and storage, processed onboard or at a GS, and critical information is transmitted to GS operators as needed. Pre-processing involves filtering, fusion, and analysis to remove noise, ensuring accurate normal behavior representation (Gregory and Liu, 2021). Data fusion integrates diverse sources, extracting features for ML models. Fault condition indicators are monitored by analyzing anomalies against a trained model, updated continuously to adapt to operational changes, ensuring accurate diagnostics and prognostics. Reasoning methods include knowledge-based, model-based, and data-driven approaches. Data-driven methods, such as ML (Neural Networks, SVMs, Clustering, Fuzzy Logic) and statistical techniques (Gaussian Process Regression, least squares regression, Hidden Markov Models), are preferred for their independence from physical models, lower costs, and faster processing times.

4.2 Fault Detection, Isolation, and Recovery (FDIR)

FDIR is vital in aerospace and spacecraft operations, monitoring sensory data or computed variables against nominal values derived from normal operations. Monitoring parameters are identified by analysing failure mechanisms. Significant deviations are tested to exclude false positives and input into an inference module with a fault model covering potential faults. This enables real-time adjustments or repairs to maintain performance until full maintenance is feasible (Holland, 2010).

Failure Mode, Effects, and Criticality Analysis (FMECA) is widely used to understand fault mechanisms and identify critical failure paths. By analysing system parameters (e.g., temperature, mass, voltage), FMECA aids in pinpointing the fault's nature and location.

Table 1: List of Sensors and Data Sources by considering 2 Classifications.

Sensors	Deployment-based		Role-based	
	Space	*Ground*	*Health*	*Mission*
Infrared Cameras	✓	✓	✓	
Star Trackers	✓		✓	
Solar Array Sensors	✓		✓	
Battery Sensors	✓		✓	
Thermal Infrared Sensors	✓		✓	✓
Gyroscopes	✓		✓	
Accelerometers	✓		✓	
Magnetometers	✓	✓	✓	
Telemetry Data	✓		✓	
Inertial Measurement Units (IMUs)	✓		✓	
GPS/ GNSS Receivers	✓	✓	✓	✓
Antenna Pointing Sensors	✓		✓	
Transponder Sensors	✓		✓	
Central Processing Unit (CPU) Load Sensors	✓		✓	
Memory Utilisation Sensors	✓		✓	
Thruster Status Sensors	✓		✓	
Fuel Level Sensors	✓		✓	
Error Logs	✓		✓	
Onboard Clock Sensors	✓		✓	
High-Resolution telescopes & Optical Cameras	✓	✓	✓	✓
multi-spectral (MSP) and hyper-spectral (HSP) optical sensors	✓			✓
Radar Sensors (e.g., Synthetic Aperture Radar (SAR))	✓	✓	✓	✓
Automatic Identification System (AIS) Receivers/ Transponders	✓	✓		✓
RF Sensors	✓	✓		✓
Satellite Communication Systems (Laser or RF)	✓	✓		✓
EO/IR (Electro-Optical/Infrared) Cameras	✓	✓		✓
LIDAR (Light Detection and Ranging)	✓	✓		✓
Radiation Detectors (Dosimeters, Particle Detectors, Spectrometers)	✓	✓	✓	✓
Solar Observatories	✓	✓	✓	

4.3 Predictive Fault Analytics

Fault prediction is vital for ensuring the reliability of complex engineering systems, including aerospace and manufacturing. By leveraging advanced data analytics, ML algorithms, and predictive modeling, fault prediction anticipates failures or anomalies before they occur. This proactive strategy enables timely maintenance, reduces downtime and costs, and enhances system performance and resilience. System integrity reflects trust in performance based on standards, with integrity flags signaling unmet criteria. Traditional health monitoring is reactive, lacking immediate prevention of critical issues or smooth degradation of safety-critical systems. Therefore, fault prediction is crucial for predictive reliability.

The need for methods combining reactive and predictive approaches is especially important for complex autonomous missions (Thangavel et al., 2024). Predictive integrity, derived from Avionics-Based Integrity Augmentation (ABIA), was developed for safety-critical GNSS applications.

4.4 Resilience-Oriented IHMM Architecture

Satellite avionics oversee critical operations, including housekeeping, task execution, resource allocation, payload handling, and information security. With the growing sophistication of small satellites, their software complexity has increased, driven by a shift of functionalities from ground-based systems to onboard computers, enhancing autonomy and mission capabilities. To address this complexity, agent-based architecture is proposed for its unique features, such as decentralisation, modularity, robustness, scalability, flexibility, adaptability, and resiliency, among others.

The resilience-oriented IHMM architecture, incorporating AI-based technologies for data preprocessing and input to intelligent agents (IA), is depicted in Fig. 1. Fault detection, the initial and critical phase of FDIR systems, enables spacecraft to autonomously handle issues without ground operator support. Built-in testing (BIT), a widely used fault detection and isolation method, identifies and isolates faults without external equipment. FDIR systems assess fault severity using fault models, monitored parameters, and BIT outputs, providing inputs to IA for further action.

The TT&C subsystem serves as the primary communication link between a satellite and GS, facilitating control and monitoring operations. It accomplishes this by gathering telemetry data from all satellite subsystems and transmitting it to the GS, while also receiving commands from the ground. TT&C is responsible for three key tasks (Anyaegbunam, 2014):

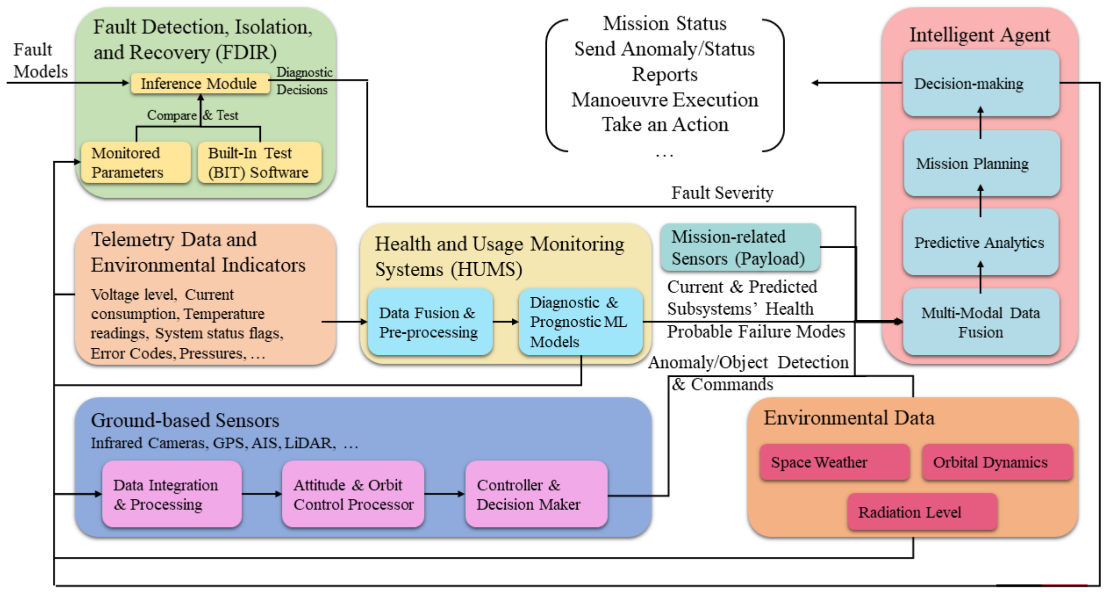

Figure 1: Resilience-oriented IHMM Architecture.

1. Health monitoring, achieved by analysing received telemetry data via AI algorithms at the GS to assess the satellite's condition.
2. Satellite tracking to determine its location.
3. Satellite control by executing commands received from the GS.

These functions are vital for satellite operations, enabling system health monitoring and abnormal behavior detection (Abdelghafar et al., 2020). Ground-based sensors such as infrared cameras, GPS, AIS, and LiDAR can be integrated into ground stations (GS) to offer valuable inputs for intelligent agents (IA). Thus, anomaly detection and command signals from GSs can serve as IA inputs.

Telemetry data supports HUMS (space-based or ground-based) in assessing subsystem health and identifying failure modes (Chen et al., 2022). Environmental factors like space weather, radiation levels, and communications from neighboring satellites can be processed directly by IA or at a GS, contributing relevant information. Payload data from mission-related sensors is another critical input for IA, linking spacecraft health to mission success (Sibilla, 2022). Consequently, pre-processed data from AI-based units can replace raw data as IA inputs, enhancing mission capabilities and objectives.

5 PRELIMINARY ANALYSIS

In order to evaluate and validate our proposed architecture, a preliminary analysis is conducted in this section. According to (Perumal et al., 2021) the attitude and orbit control system (AOCS) contributes to 32% of small satellite failures. Reaction wheels (RWs) are critical components for AOCS which are used for satellite attitude control. By spinning the reaction wheel at different speeds, the satellite can change its orientation without using fuel. This is based on the principle of conservation of angular momentum. RWs are prone to various failure and degradation, among them friction fault is the one which is considered in this paper. A friction fault in the reaction wheels of a satellite refers to an increase in the internal friction within the reaction wheel assembly, which can impede the wheel's ability to spin freely. This friction can lead to reduced performance or complete failure of the reaction wheel, compromising the satellite's ability to control its orientation (attitude) in space.

Two different friction faults are considered for evaluation purpose:

1. Defines an event that injects a large, one-time static friction fault.
2. Defines an event that is always active, and adds a smaller static friction fault with small probability

Basilisk (Kenneally et al., 2020), an Astrodynamics Simulation Framework, is utilised for simulation environment. The simulated scenario involves

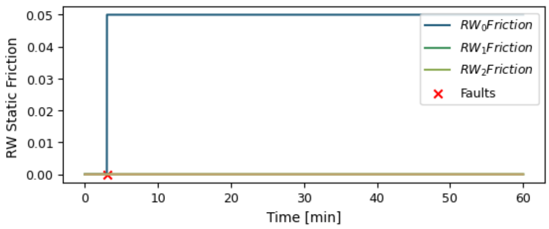

Figure 2: One-time static friction fault.

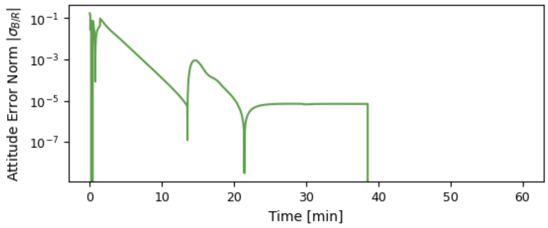

Figure 4: Impact of one-time static friction fault on attitude.

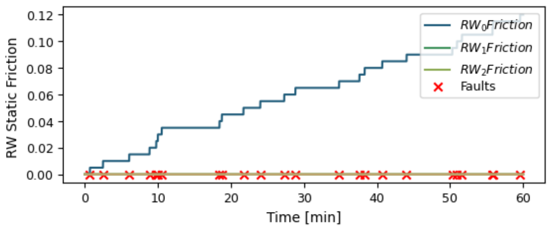

Figure 3: Continuous smaller static friction fault.

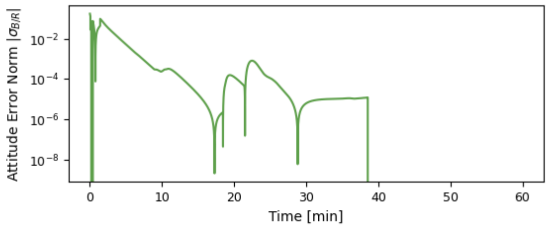

Figure 5: Impact of continuous smaller static friction fault on attitude.

a 6-degree-of-freedom (6-DOF) small satellite's attitude control over a 60-minute period while orbiting Earth in LEO, focusing on maintaining orientation during an eclipse and handling a reaction wheel fault. The satellite uses "Honeywell HR16" reaction wheels controlled by a PD controller to align with the desired attitude. The eclipse module simulates the Earth's shadow, temporarily affecting the sun's visibility and the satellite's sensors. A friction fault is injected in one of the reaction wheels, testing the system's resilience. The simulation logs various parameters, including attitude error, reaction wheel torque, and speed, and generates plots to illustrate the satellite's performance in maintaining orientation despite the injected fault.

Figures 2 and 3 show one-time and continuous static friction faults in RW_1, respectively. In Figure 2, RW_0 experiences a friction fault at the 3rd minute of the simulation, with static friction sharply increasing and stabilizing at a higher level—indicating potential mechanical issues like bearing wear. RW_1 and RW_2 maintain low, stable friction, showing normal operation. The early fault in RW_0 could impair its attitude control efficiency.

Figure 3 depicts a continuous fault in RW_0, with static friction rising stepwise over 60 minutes. Frequent faults, such as RW_0 saturation, suggest ongoing degradation, while RW_1 and RW_2 remain unaffected. This fault could also reduce the spacecraft's attitude control performance.

Each of above mentioned faults can be happened due to the following events, respectively. For each event, the cause & effectare discussed as follows.

1. Bearing Wear
   - Cause & effect: Reaction wheels are mounted on bearings that enable smooth spinning. However, prolonged use can cause the bearings to wear, leading to increased friction and resistance, which hinders the wheel's ability to spin at the desired speed.
2. RW saturation:
   - Cause & effect: Reaction wheel saturation happens when wheels reach their maximum spin rate, preventing additional torque. Persistent saturation can strain bearings and mechanical parts, leading to increased friction.

The effects of on-time and continuous friction faults on satellite attitude are shown in Figures 4 and 5, respectively. These figures depict the attitude error norm, indicating the deviation from the desired orientation over simulation time. Figure 4 shows initial fluctuations due to a friction fault, while Figure 5 exhibits more frequent corrections and fluctuations with continuous faults.

In the traditional architecture (without IA), at both cases, the PD controller adjusts control torque to minimize attitude error, while other reaction wheels (RWs) compensate by increasing torque to stabilize the spacecraft. This method allows for quick stabilization but overlooks broader factors like overall satellite status, mission goals, and long-term consequences. Consequently, this leads to increased stress on the remaining RWs, risking saturation and reducing the satellite's ability to maintain precise pointing, which can compromise the mission.

Figure 6 illustrates the RWs' speeds over time. The blue line, representing the affected wheel's speed, remains nearly constant, showing it is no longer effectively contributing to attitude control due to increased

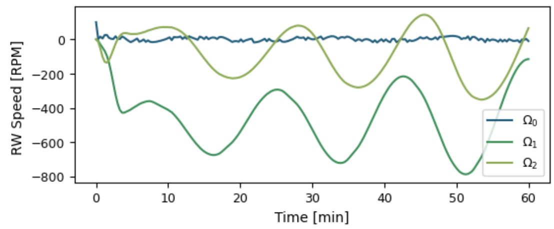

Figure 6: Reaction Wheels speed with PD controller.

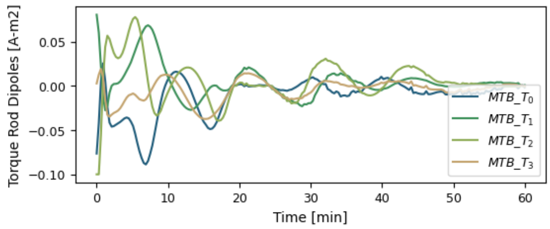

Figure 7: Dipole moment for the torque rods.

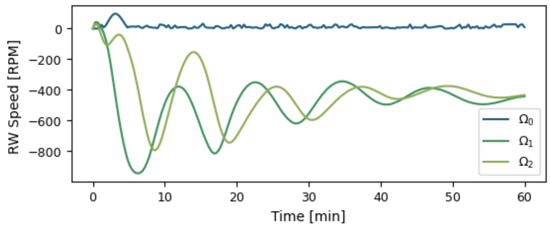

Figure 8: Reaction Wheels speed using magnetic torquers.

friction. The other two lines display significant speed variations, indicating they are compensating for the degraded wheel's performance loss. These fluctuations highlight the increased effort needed to maintain stability as the control system adjusts. Consequently, current FDIR methods and PD controllers are mainly reactive, offering only short-term responses.

In contrast, The IA assesses the friction fault considering the satellite's overall status, including subsystem health, mission phase, and environmental factors like space weather. This enables the IA to evaluate fault severity beyond immediate attitude errors. By combining real-time HUMS data with historical trends, the IA can predict if the fault will result in a total reaction wheel failure. If so, it can take preemptive measures to reduce impact. Additionally, the IA considers the mission phase and objectives: prioritizing precise attitude control during critical phases (e.g., imaging or communication alignment) or opting to conserve resources by reducing control effort during less critical periods.

In our scenario, the IA dynamically adjusts its control strategy in real-time to account for the reduced effectiveness of the faulty reaction wheel (RW). To avoid saturating the remaining RWs, it switches to an alternative control algorithm better suited to the situation. The IA proactively employs magnetic torquers alongside the remaining RWs to distribute the control load, reduce the control burden, and sustain their effectiveness during the mission-critical phase. This approach is validated in the literature, including (Avanzini et al., 2019) and (He et al., 2023). The dipole moment for the torque rods is shown in Figure 7. Initial spikes indicate the activation of torque rods for attitude control and desaturation of the other RWs. The observed reduction and stabilization of the dipole moment over time demonstrate that the initial intervention effectively mitigated the effects of RW degradation, allowing other RWs to regain control.

Figure 8 shows the effectiveness of magnetic torquers in controlling the speed of reaction wheels. The rotational speeds fluctuate initially, but these fluctuations diminish over time, particularly after 20 minutes. Compared to using only the PD controller (see Figure 6), the reaction wheels' speeds are significantly reduced, indicating lower stress and reduced risk of saturation.

In summary, the IA's proactive and predictive capabilities enhance response to friction faults in a reaction wheel by leveraging satellite status, historical data, and mission objectives. By integrating predictive analysis and adaptive control with the traditional PD controller, it offers a more resilient, mission-aware fault management strategy. This approach stabilizes the satellite more effectively, extends operational life, and ensures mission success. The proposed architecture resolved these faults promptly, primarily due to centralized decision-making and recovery by a single IA that processes all relevant data. This centralization minimizes conflicts, ensures system-wide consistency, and reduces errors common in decentralized systems. Additionally, it enables faster response times by streamlining decision-making and improving resource management through optimized allocation of processing power, memory, and communication bandwidth. Maintaining a holistic view of the satellite's status improves fault detection and supports proactive interventions. Consequently, the architecture enhances resiliency and significantly boosts the mission success rate, offering a robust solution for complex space missions.

6 CONCLUSION AND FUTURE WORK

In this article, we explored the factors driving the rise of DSS in multi-spacecraft missions and emphasised the necessity of a resilience-oriented architecture that integrates satellite health and mission success. By classifying diverse data sources and investigating mission-based DSS literature, we proposed a novel resilience-oriented IHMM architecture using AI-based approaches for enhanced fault detection and mission success. IAs in small satellites are primarily responsible for health management and mission success, relying on lightweight, onboard-executable algorithms. Key measures to enhance DSS resilience include onboard health management, cluster-based mission planning, and self-recovery mechanisms. A preliminary analysis with one-time and continuous friction faults on the reaction wheel validated our architecture. The system efficiently addressed these faults using proactive adjustments and centralised decision-making, preventing reaction wheel saturation and maintaining stability. Future work will involve implementing and validating the architecture in a simulated constellation space environment to demonstrate its effectiveness.

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REFERENCES

Abdelghafar, S., Darwish, A., and Hassanien, A. E. (2020). Intelligent health monitoring systems for space missions based on data mining techniques. *Machine learning and data mining in aerospace technology*, pages 65–78.

Ai-Chang, M., Bresina, J., Charest, L., Chase, A., Hsu, J.-J., Jonsson, A., Kanefsky, B., Morris, P., Rajan, K., Yglesias, J., et al. (2004). Mapgen: mixed-initiative planning and scheduling for the mars exploration rover mission. *IEEE Intelligent Systems*, 19(1):8–12.

Anyaegbunam, B. (2014). Design elements of satellite telemetry, tracking and control subsystems for the proposed nigerian made satellite. *Int. J. Eng. Sci. Invention*, 3(1):5–13.

Avanzini, G., de Angelis, E., Giulietti, F., and Serrano, N. (2019). Attitude control of low earth orbit satellites by reaction wheels and magnetic torquers. *Acta astronautica*, 160:625–634.

Ben-Larbi, M. K., Pozo, K. F., Haylok, T., Choi, M., Grzesik, B., Haas, A., Krupke, D., Konstanski, H., Schaus, V., Fekete, S. P., et al. (2021). Towards the automated operations of large distributed satellite systems. part 1: Review and paradigm shifts. *Advances in Space Research*, 67(11):3598–3619.

Chen, C., Yin, Y., Liu, Y., Wang, D., Chen, R., and Jia, Y. (2022). Design and discussion of on-orbit autonomous health management system for mission-constrained spacecraft.

Figueroa, F., Holland, R., Schmalzwel, J., and Duncavage, D. (2006). Integrated system health management (ishm): systematic capability implementation. In *SAS 2006: 2006 IEEE Sensors Applications Symposium*, number SSTI-2200-0066.

Gregory, J. W. and Liu, T. (2021). *Introduction to flight testing*. John Wiley & Sons.

He, Y., Yang, S., Lin, S., He, W., and Yang, Z. (2023). Satellite attitude control for emergency mode using reaction wheels and magnetic torquers. In *2023 6th International Conference on Robotics, Control and Automation Engineering (RCAE)*, pages 207–211. IEEE.

Holland, S. (2010). *Integrated vehicle health management in the automotive industry*. Citeseer.

Iacomino, C. (2019). *Commercial space exploration: potential contributions of private actors to space exploration programmes*. Springer.

Jennions, I. K. (2011). *Integrated vehicle health management: perspectives on an emerging field*. SAE International.

Kenneally, P. W., Piggott, S., and Schaub, H. (2020). Basilisk: A flexible, scalable and modular astrodynamics simulation framework. *Journal of aerospace information systems*, 17(9):496–507.

Krupke, D., Schaus, V., Haas, A., Perk, M., Dippel, J., Grzesik, B., Larbi, M. K. B., Stoll, E., Haylock, T., Konstanski, H., et al. (2019). Automated data retrieval from large-scale distributed satellite systems. In *2019 IEEE 15th international conference on automation science and engineering (CASE)*, pages 1789–1795. IEEE.

Perumal, R. P., Voos, H., Vedova, F. D., and Moser, H. (2021). Small satellite reliability: A decade in review. In *35th Annual Small Satellite Conference*.

Ranasinghe, K., Sabatini, R., Gardi, A., Bijjahalli, S., Kapoor, R., Fahey, T., and Thangavel, K. (2022). Advances in integrated system health management for mission-essential and safety-critical aerospace applications. *Progress in Aerospace Sciences*, 128:100758.

Sibilla, M. (2022). *Autonomous Onboard Health and Usage Management System for Smart Satellites*. PhD thesis, Politecnico di Torino.

Thangavel, K., Sabatini, R., Gardi, A., Ranasinghe, K., Hilton, S., Servidia, P., and Spiller, D. (2024). Artificial intelligence for trusted autonomous satellite operations. *Progress in Aerospace Sciences*, 144:100960.