



Rolls-Royce

IMechE Seminar on Improving Aircraft Engine Health Management

“ASTRAEA II – Integrated System Health Management”

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ASTRAEA II Project Overview

- Autonomous
- Systems
- Technology
- Related
- Airborne
- Evaluation &
- Assessment



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ASTRAEA II Project Overview

- **To assist UK industry in creating a new global UAS business by:**
 - **Developing cross sector capable technologies**
 - **Providing confidence for further investment in UAS product development**
 - **Proving that it is technically feasible to introduce RPVs into non-segregated airspace**
- **Industry Consortium: AOS, BAE Systems, Cassidian, Cobham, QinetiQ, Rolls-Royce, Thales**

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ASTRAEA II Project Overview

- Provide a power management solution for an Integrated Power System (IPS) targeted at UAS applications
 - Power - Electrical, Thrust and Thermal Power
- Provide autonomous management of contingencies and arisings related to the IPS
- Focus Application:
 - Medium Altitude Long Endurance (MALE) platform
 - Twin engine turboprop
 - Typical mission duration > 35 hours

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EHM for Flight Management

- **Maximise the probability of mission success in response to in-flight arisings**
 - **Diagnostic fault isolation to allow effective in-flight mitigations**
 - **Prognostics to enable in-flight planning of power supply**
 - **In-mission tests to enable higher confidence in analysis**
 - **Autonomous decision making to provide advise on mitigating or contentment actions**

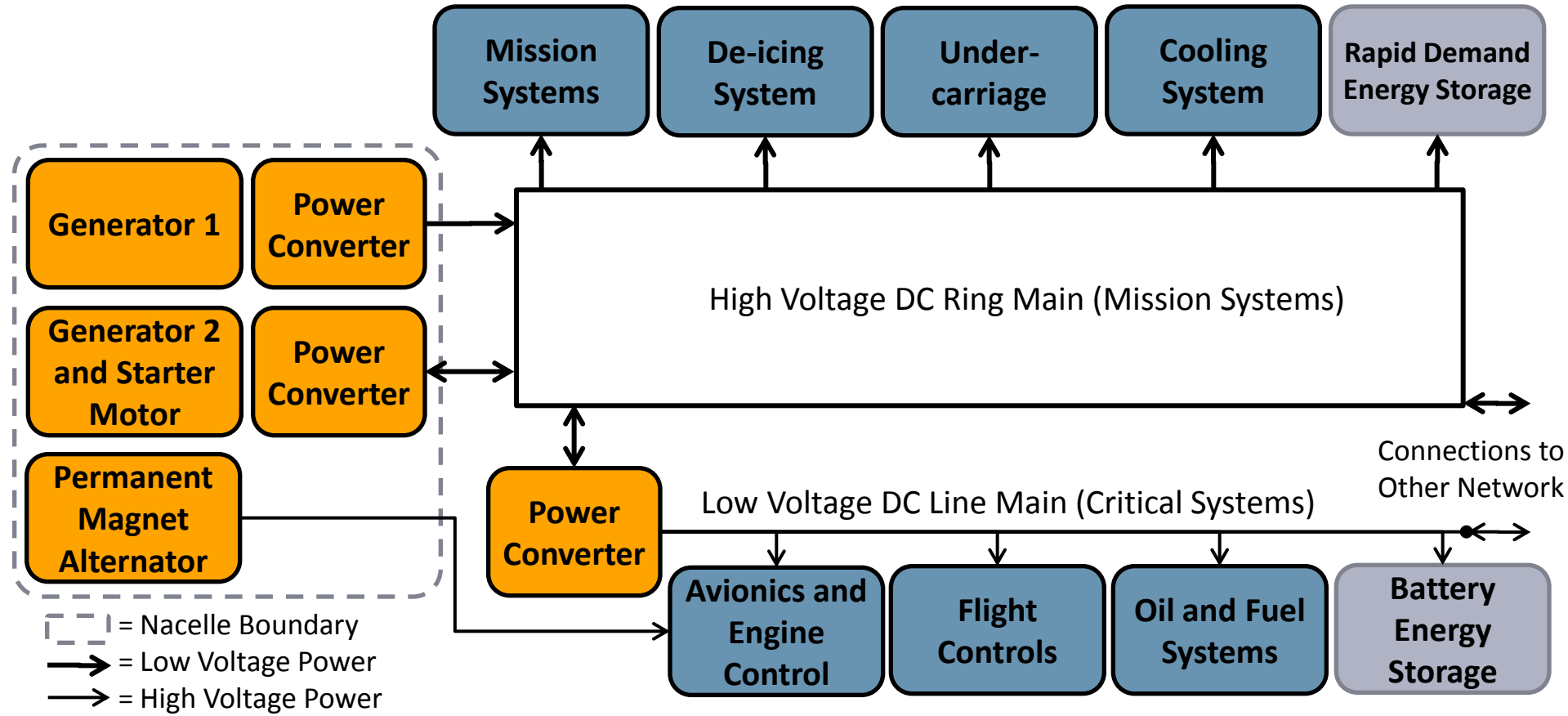
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EHM for Flight Management

- **Closing the loop on EHM outputs**
 - This infers novel integration of the EHM system with the IPS Power Manager
 - Result in in-flight changes to IPS power prevision optimisation and system configuration
 - Ultimately influence the operation of UAS
- **Separation of Powers**
 - Delegation of Power Manager and EHM System authority
 - EHM acts as an advisory system to the Power Manager which has authority over the IPS

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Health Management Beyond the Engine



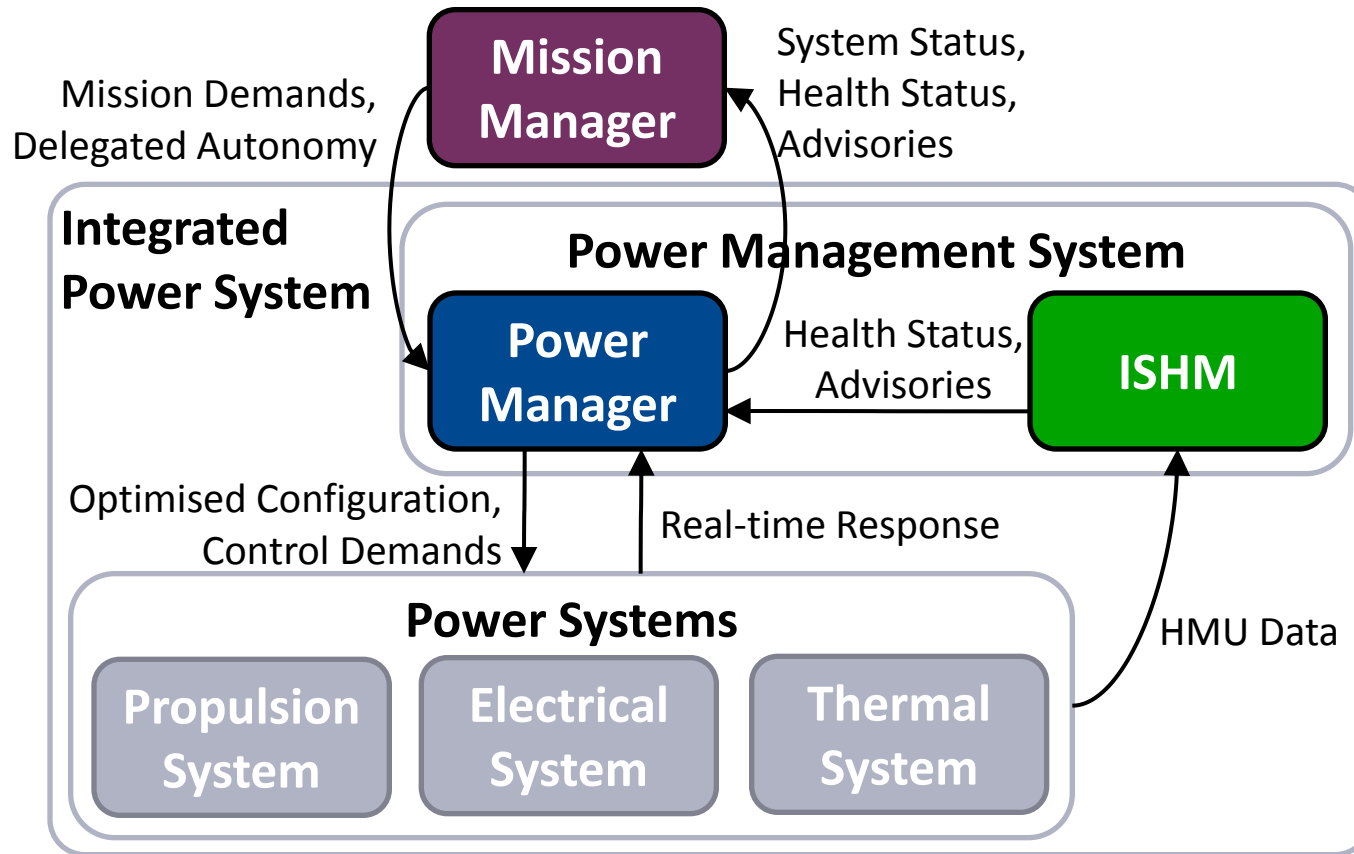
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Health Management Beyond the Engine

- **Inclusion of Electrical System components**
 - Increasing dependency on electrical power
 - Power electronics for power conversion and switching
 - Energy storage devices
- **Complexity of fault isolation due to system interactions**
- **Inclusion of Thermal System components**

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Integrated System Health Management

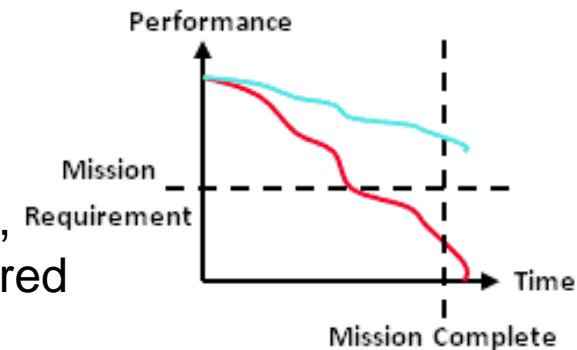


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Integrated System Health Management

● CONOP - Power System Degradation

- **Objective:** To enable the PMS to prognose system degradation and to accommodate in order to meet mission goals.
- **Precondition State:** Long endurance mission commenced, mission goals ongoing.
- **Post interaction State:** Mission goals achieved, degradation isolated and accommodated. Required maintenance informed.
- **System Interaction:** During a long endurance mission an incipient failure in the port engine is detected that will lead to a functional failure, which would put mission goals at risk.



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Integrated System Health Management

- ❑ **System Interaction (continued...):** Insufficient data is available to calculate an accurate prognosis.
- ❑ An in-mission test on the port engine requested to enable prognosis is requested by the ISHM.
- ❑ The PMS assesses the impact of the test to mission goals to be acceptable and conducts the test.
- ❑ With the resulting data the ISHM determines that there is a high probability of the functional failure occurring before mission goals achieved.
- ❑ ISHM advises that a restriction to engine operation is enforced by the PMS to reduce the probability of failure during the mission.
- ❑ PMS re-plans the mission and reconfigures IPS to accommodate the operating restriction.
- ❑ RPV continues mission and completes goals.

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Thanks for your attention

Any Questions??



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