Detailed Solution Plan

Project Title: AI for Satellite Power Anomaly Detection
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Track: Conceptual Design
Date: July 2025

1. Overview

In space, power isn't just important — it's everything. A small dip in battery voltage or a rise in temperature could be the first clue that something's wrong. Our solution? An AI-based "power lookout" that watches over satellites in real time and spots these small warning signs before they grow into serious problems.

2. How It Works

Our system is made up of four main parts:

◆ **Data Ingestion**

We gather satellite telemetry data like:

- Battery voltage and current
- Solar panel performance
- Internal temperature
- Power load on subsystems

This can come from real past missions, simulation data, or test satellites.

◆ **Preprocessing**

Before the AI can learn, we clean and prepare the data. This includes:

- Smoothing noisy signals
- Filling small gaps in transmission
- Normalizing values so different units (e.g. volts vs amps) can be compared more easily

◆ **Anomaly Detection AI**

We use two main types of models:

- **Unsupervised models** (like autoencoders or clustering): These learn what "normal" looks like, then flag anything that doesn't fit the pattern.

- **Time-series models** (like LSTMs): These understand the rhythm of the system over time and spot slow-developing problems.

These models can work together — one for quick alerts, another for catching subtle trends.

🔹 **Alert & Decision System**

Once an anomaly is detected, the system:

- Assigns a confidence score
- Sends an alert to mission control
- (Optional) Automatically triggers a backup system or safe mode if confidence is high and delay is risky

3. Why This AI Is a Good Fit

Unlike traditional rule-based systems that require someone to define every possible failure mode, this AI learns the satellite's normal behavior directly from the data. It doesn't need to have seen past failures — just enough normal behavior to know when something's off.

4. Where the Data Comes From

To train and test the system, we'll use:

- **Historical telemetry** from satellites that experienced power problems
- **Synthetic data** created by injecting fake anomalies into clean data (like sudden power drops or long slow declines)
- **Normal operation logs** to teach the AI what regular patterns look like

5. Deployment Ideas

The AI could run:

- **On the ground**, analyzing live downlinked telemetry
- **On the satellite itself**, for deep-space missions where round-trip time is too long for humans to intervene quickly

We aim to make the system lightweight enough to fit into modern satellite software stacks.

6. Scalability & Adaptability

The solution is flexible enough to work on:

- Low-Earth Orbit (LEO) constellations where many satellites operate together
- Deep-space missions with long communication delays
- Older missions where adding automation retroactively could extend satellite lifespan

It can also adapt to other anomaly types like thermal issues or attitude control problems with only minor changes.

7. Risks & Ethics

- **False alarms:** We minimize these using thresholds and ensemble methods, and always keep a human-in-the-loop at the start.
- **Overtrust in AI:** We phase in autonomy slowly. The AI only acts alone when confidence is high.
- **Data privacy:** All data is anonymized and stored securely.

8. Conclusion

Our AI system is like a quiet onboard engineer always watching, learning what's normal, and ready to call for help the moment something's not right. It's simple, smart, and can make a big difference in keeping space missions alive and well.