STEP 7: Testing Plan Optimization of AI-Driven Communication Between Earth and Deep Space Probes

📄 Document: /docs/Testing_Plan.pdf

Objective of Step 7:
Develop a document that outlines the methodology for testing your AI communication optimization system, assuming it were operational.

What aspects will be evaluated?

The testing methodology (simulated)

Criteria for success

Anticipated challenges

1. Objective of Evaluation

The aim of this evaluation plan is to assess whether the proposed AI system is capable of:

Effectively prioritizing deep space data transmissions

Managing bandwidth efficiently under limited conditions

Adjusting to signal interruptions or scenarios with low availability

Given that this is a conceptual initiative, the evaluation will be conducted through simulations utilizing hypothetical scenarios and established success criteria.

2. Testing Environment (Simulated)

The evaluation will take place using

Simulated data from a deep space probe (for instance, emergency alerts, system logs, scientific images)

Simulated bandwidth conditions (such as high, medium, low, and blackout)

Simulated orbital positions along with signal delays

A mock scheduling engine designed to emulate AI decision-making.

3. Test Scenarios

Scenario	Description	Expected Outcome
1. Emergency Signal During Low Bandwidth	An emergency alert is generated while bandwidth is limited.	The AI should prioritize and transmit the emergency signal immediately
2. Science Data vs. Routine Logs	Large image and system logs created during medium bandwidth	The AI should prioritize the science data and delay/compress logs
3. Full Bandwidth Availability	All systems normal with maximum bandwidth.	AI should transmit all data efficiently without delay
4. Signal Interruption (e.g., solar flare)	Sudden loss of signal during transmission	AI should pause non-critical transmissions and resume after signal restores
5. Repetitive Data Patterns	Multiple similar logs or temperature readings	AI should recognize redundancy and deprioritize repeated data

4. Evaluation Metrics

Metric	Description
Accuracy	The frequency with which the AI accurately prioritizes data
Efficiency	The effectiveness of bandwidth utilization without unnecessary waste
Resilience	The speed and efficacy with which the AI reacts to disruptions
Transmission Success Rate:	Percentage of high-priority data successfully transmitted during critical periods

5. Success Criteria

The system will be deemed successful if:

100% of emergency messages are prioritized and dispatched punctually

At least 90% of bandwidth is utilized efficiently under normal conditions

The system is capable of recovering from signal loss autonomously

Non-essential data is either delayed or compressed without compromising mission integrity

6. Possible Testing Instruments if executed

Space communication simulators (for instance, GMAT or DSN visualizer)

Python simulation for bandwidth/data transmission

AI logic structured in Jupyter Notebook

7. Constraints

No actual space hardware utilized; all evaluations are theoretical

AI behavior presumes the precision of the trained model

Edge-case situations (for example, concurrent emergencies) necessitate future enhancement

8. Conclusion

This conceptual testing framework offers a systematic method for assessing the functionality, efficiency, and adaptability of the proposed AI-driven communication system. By replicating realistic scenarios encountered by deep space probes—such as bandwidth constraints, signal interruptions, and competing data priorities—the framework guarantees that the system can be evaluated within a mission-relevant context. The specified success criteria and evaluation metrics act as benchmarks for system performance. While this remains a conceptual design, the testing framework illustrates the potential for AI to improve NASA's deep space communication strategies through intelligent scheduling, prioritization, and adaptation.