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# Operational Use of Machine Learning for Anomaly Detection

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How is Anomaly Detection (AD) Used in Space Operations?

- Machine Learning (ML) algorithm analyzes streams of engineering telemetry

- Alerts operators to unexpected spacecraft behavior
  - Human must analyze alerts

- "Anomaly" in data science is any unusual behavior
  - Not just major problems
  - Example: Lunar eclipse produces "anomaly" in data

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Multiple Projects Applying ML/AD to Space Operations
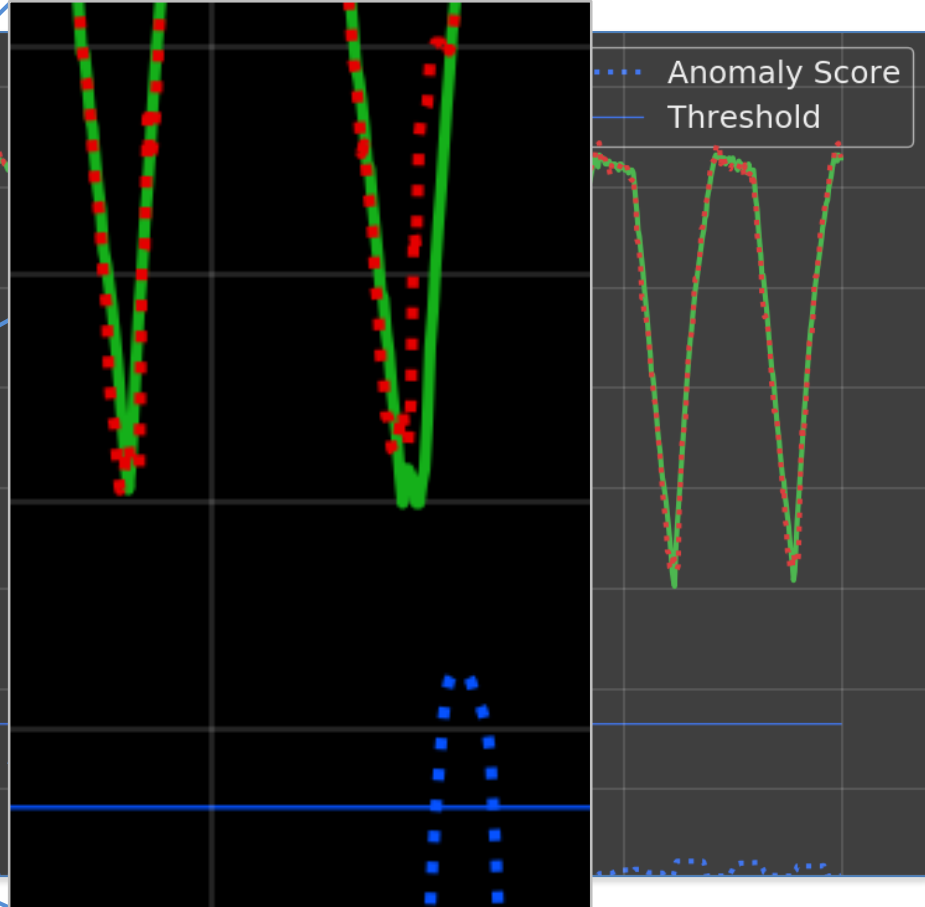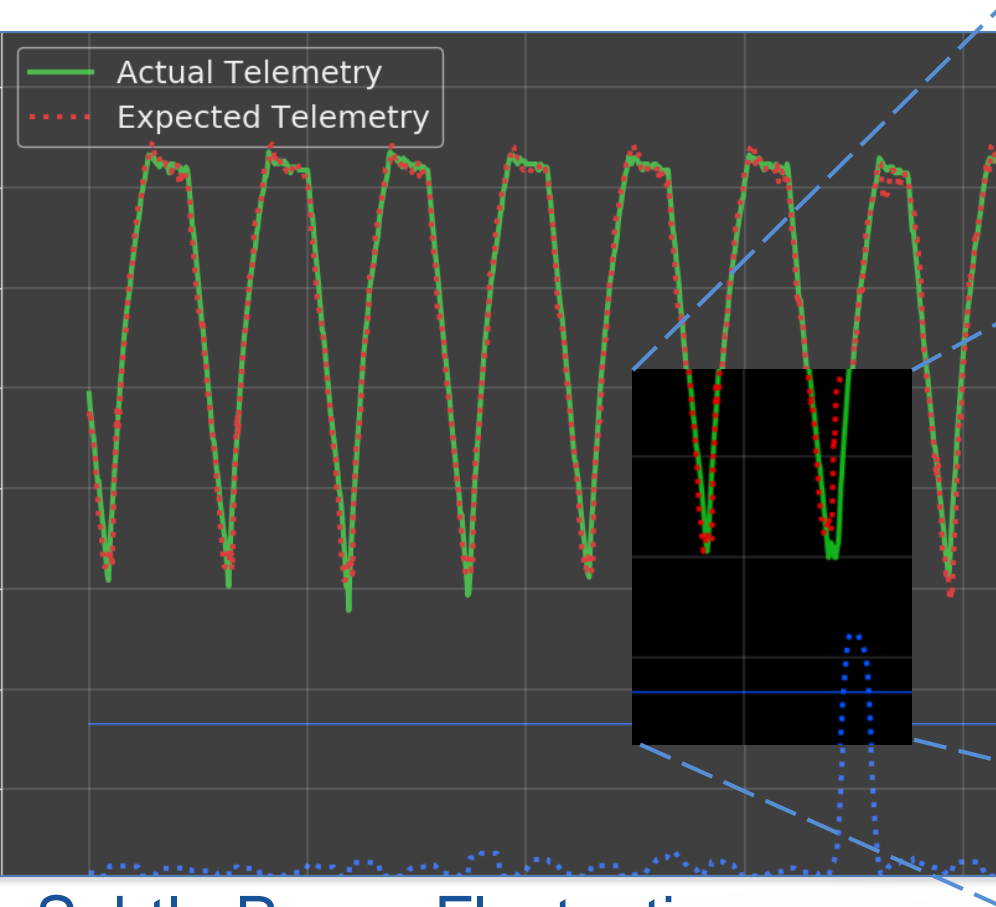
- Rapidly emerging technology

- Different AD approaches have different capabilities

- How General Dynamics is applying ML/AD

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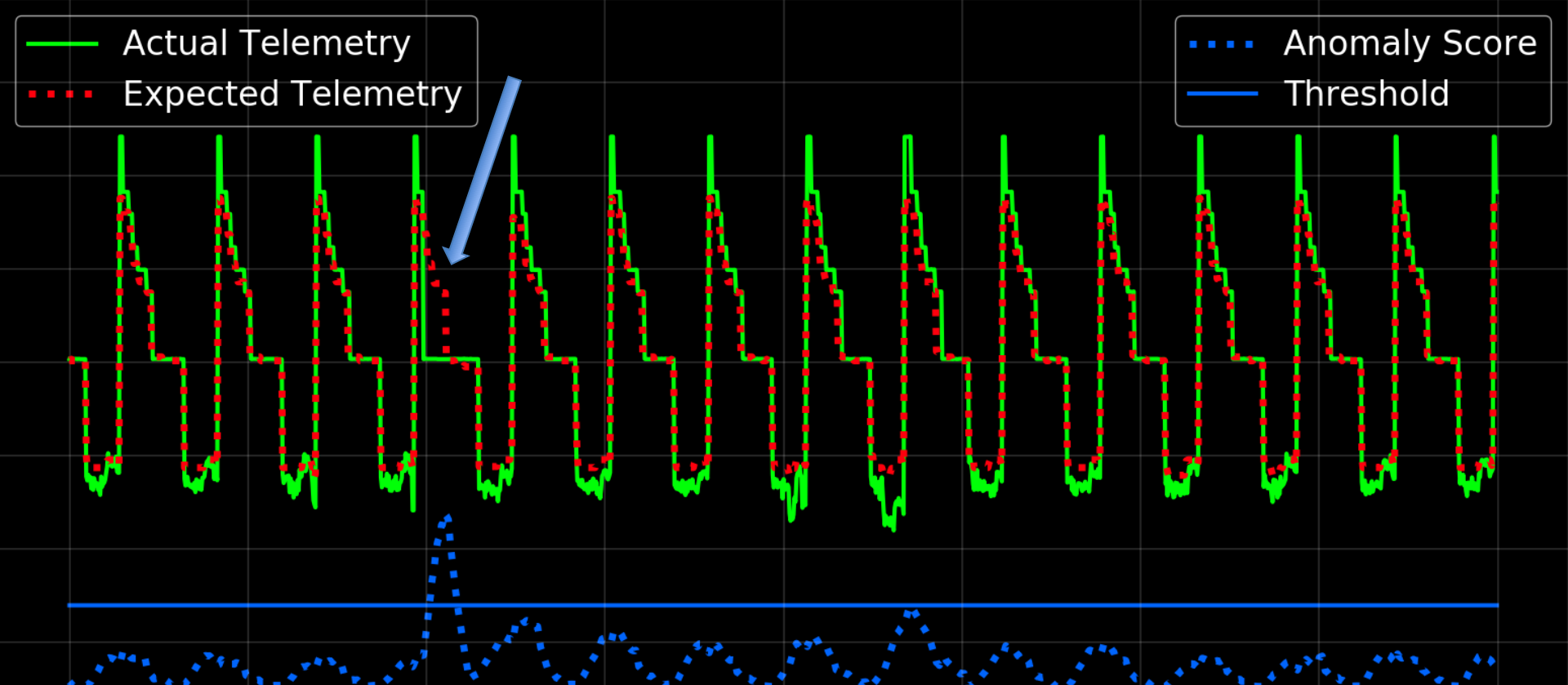
Example Alert
24 hours, 14 orbits

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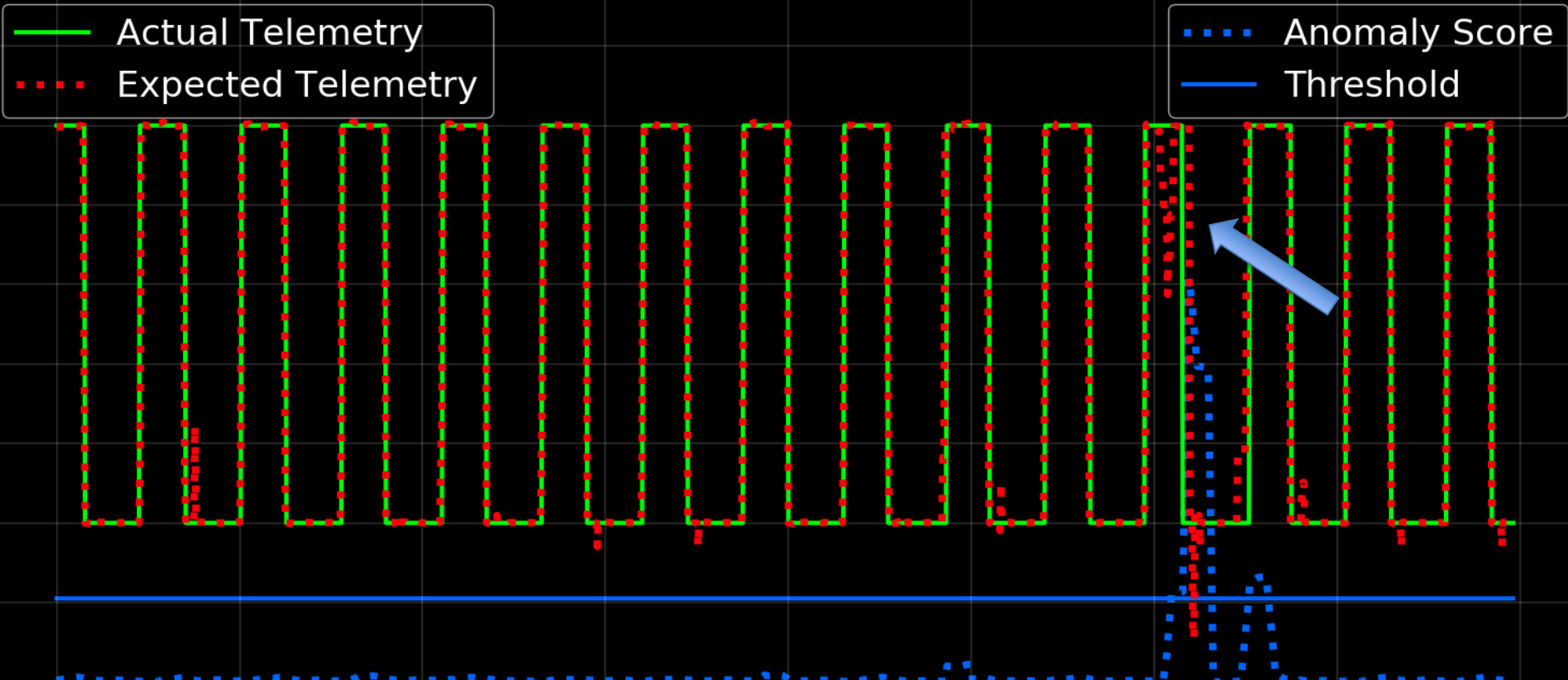Mission Systems

Subtle Power Fluctuation

Value of ML/AD

- <u>Filters data</u> to prevent data overload
  - Finds "needle in the haystack"
  - Increases <u>situational awareness</u> by detecting unnoticed behaviors

- ML is not smarter than engineers
  - Cheaper, faster, and can look more closely at more data

- Fills gap between limit checking and human analysis

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Data Challenges

Several challenges appear in engineering data that AD algorithms must be specifically designed to address:

- Varying predictability

- Discrete Values

- Trends and Drift

- Independent-Dependent variable relationships

- Non-Periodic behavior

- Special activities

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Discrete Data: Charge Mode
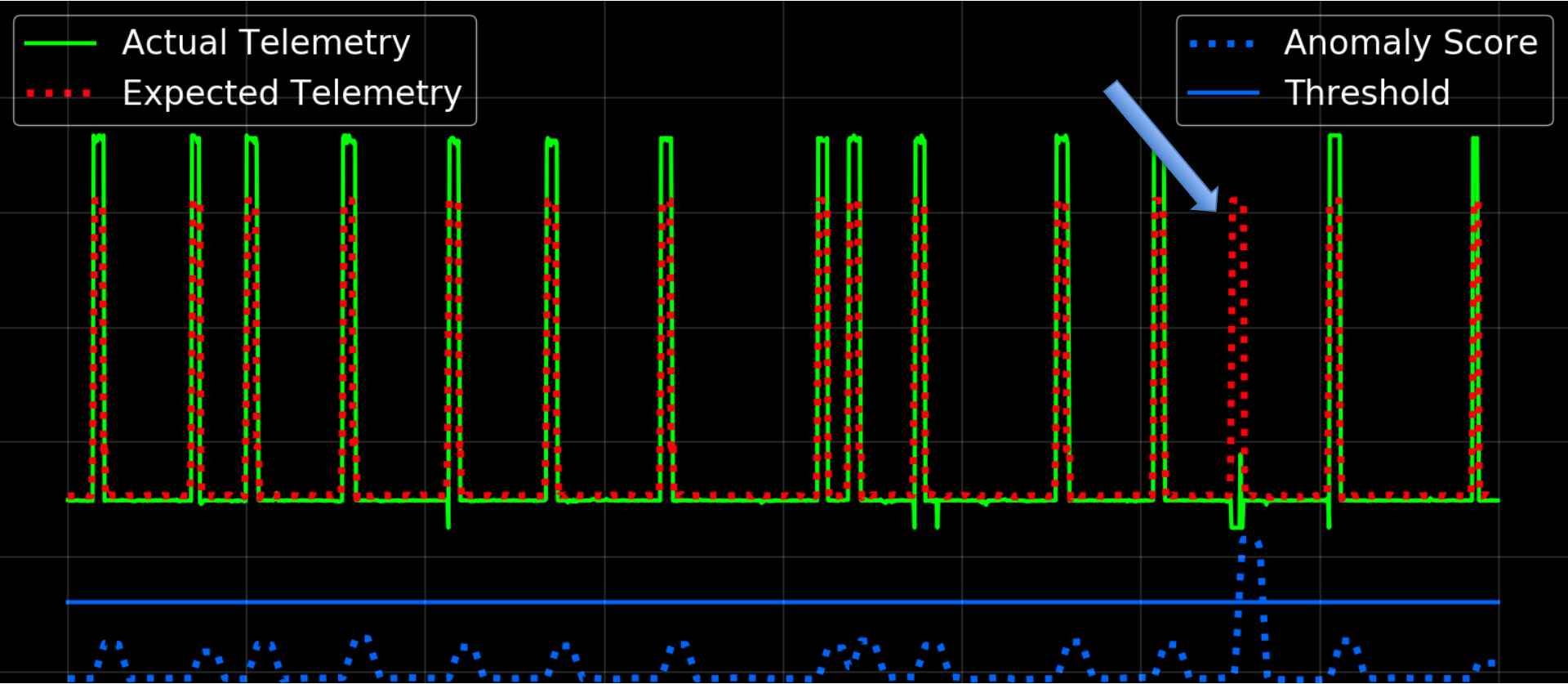Anomalies are dependent on timing

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Drifting Data: Command Error Counter
Challenging because it leaves training range
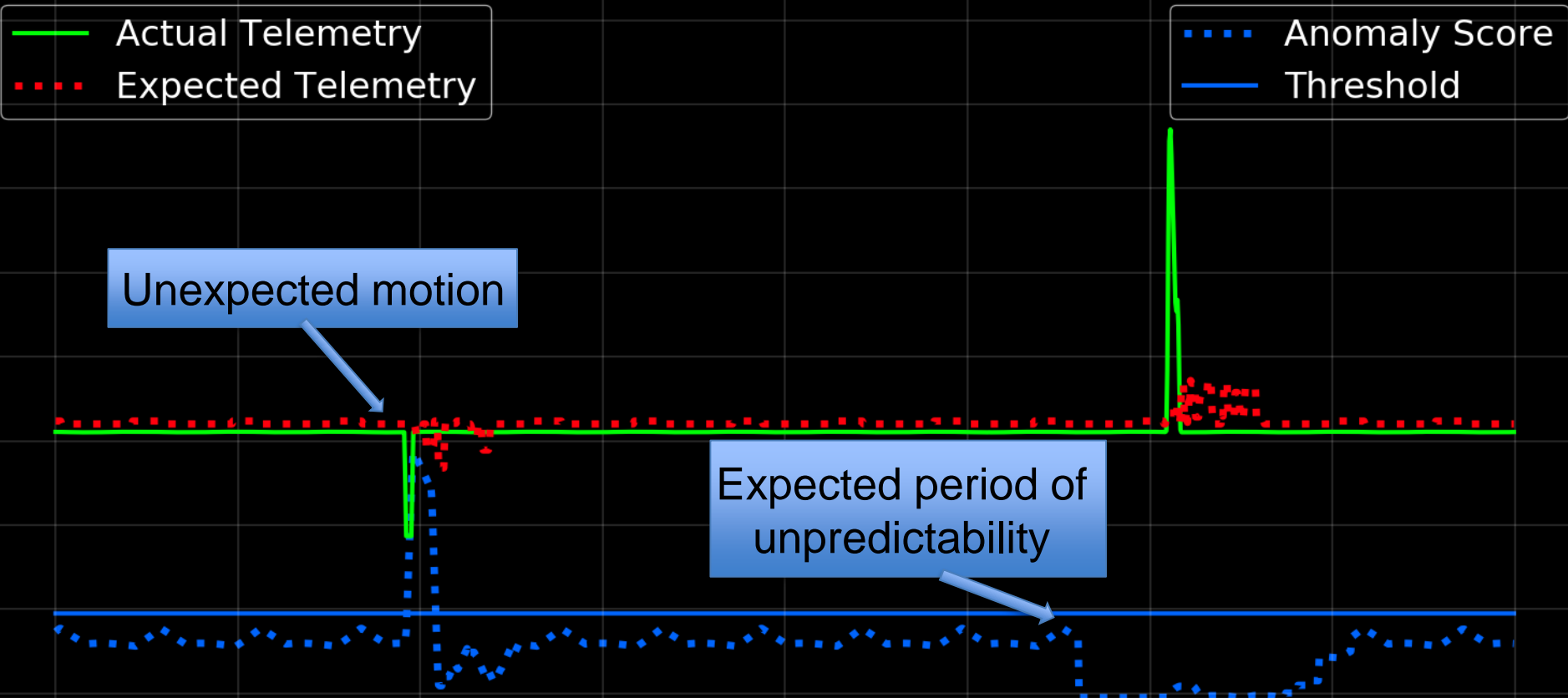
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Non-Periodic Data: Missed Contact

AD relies on relationship between sent and received signal strength

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Actual Telemetry
Expected Telemetry
Anomaly Score
Threshold

Unexpected motion

Expected period of unpredictability

Special Activity: Reaction Wheel Motion
Compensates for expected period of unpredictability

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Use Cases for ML/AD
in Space Operations

Value of Data Sharing

- Lack of data sharing slows machine learning research in space operations

- Machine learning research is data-driven
  - Other industries can post datasets online for researchers to study

- Consider collaborating with existing machine learning projects
  - Low-cost, low-risk way to get ahead with emerging technology

References

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