A DATA-DRIVEN APPROACH TO CUBESAT HEALTH MONITORING

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INTRODUCTION

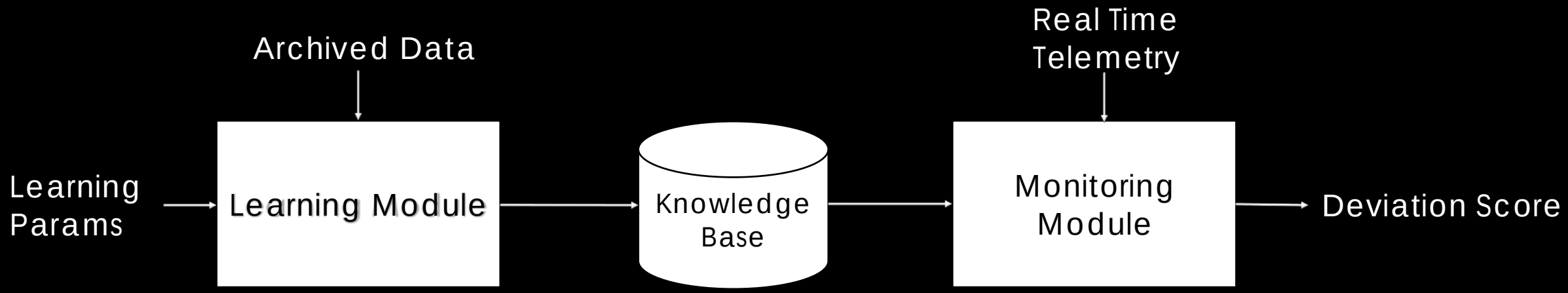
- Spacecraft health monitoring is very important
  - Verify proper functionality
  - Involves looking at sensor readings and telemetry
- Can be a challenging task
  - Becomes more difficult as complexity of spacecraft increases
  - Traditional techniques become impractical
  - Even more challenging for CubeSat's

DATA-DRIVEN TECHNIQUES

- More simple and manageable
- Uses data mining and machine learning
  - Archived data used to create models
  - Models compared against real time data
- Many benefits over traditional approaches
  - Deep system knowledge not necessary
  - Relationship between multiple sensors captured
  - Faster and more autonomous

INDUCTIVE HEALTH MONITORING (IMS)

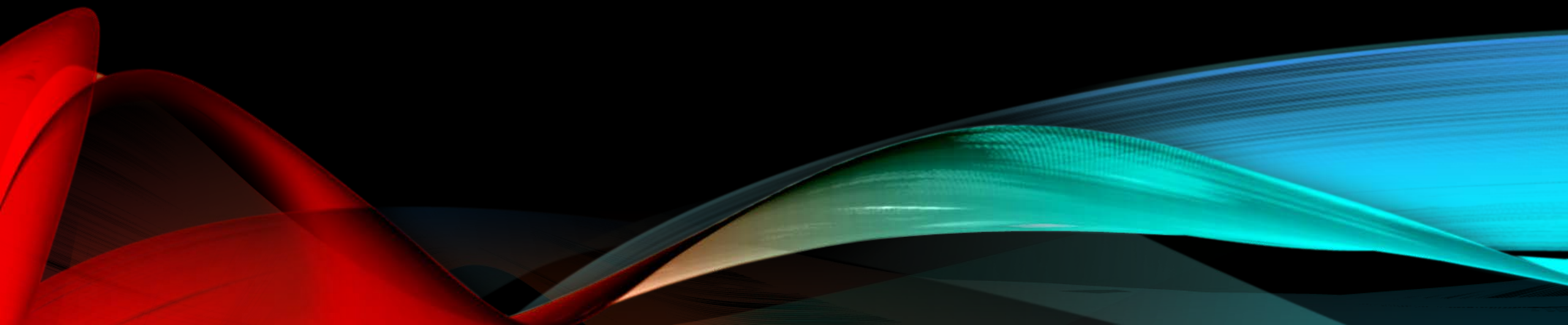
- Created for use in various programs and missions in NASA
- Models relationship between a set of sensors in time-series data as clusters
  - Vector used to hold values of several related system parameters
  - Each cluster defines a unique nominal state
  - Group of clusters create a knowledge base
- Knowledge base produces deviation value



IMS DATA

- Nominal archived data required
  - Free of errors
  - Comprehensive
- Easily updatable

POLYSAT HEALTH MONITORING SYSTEM

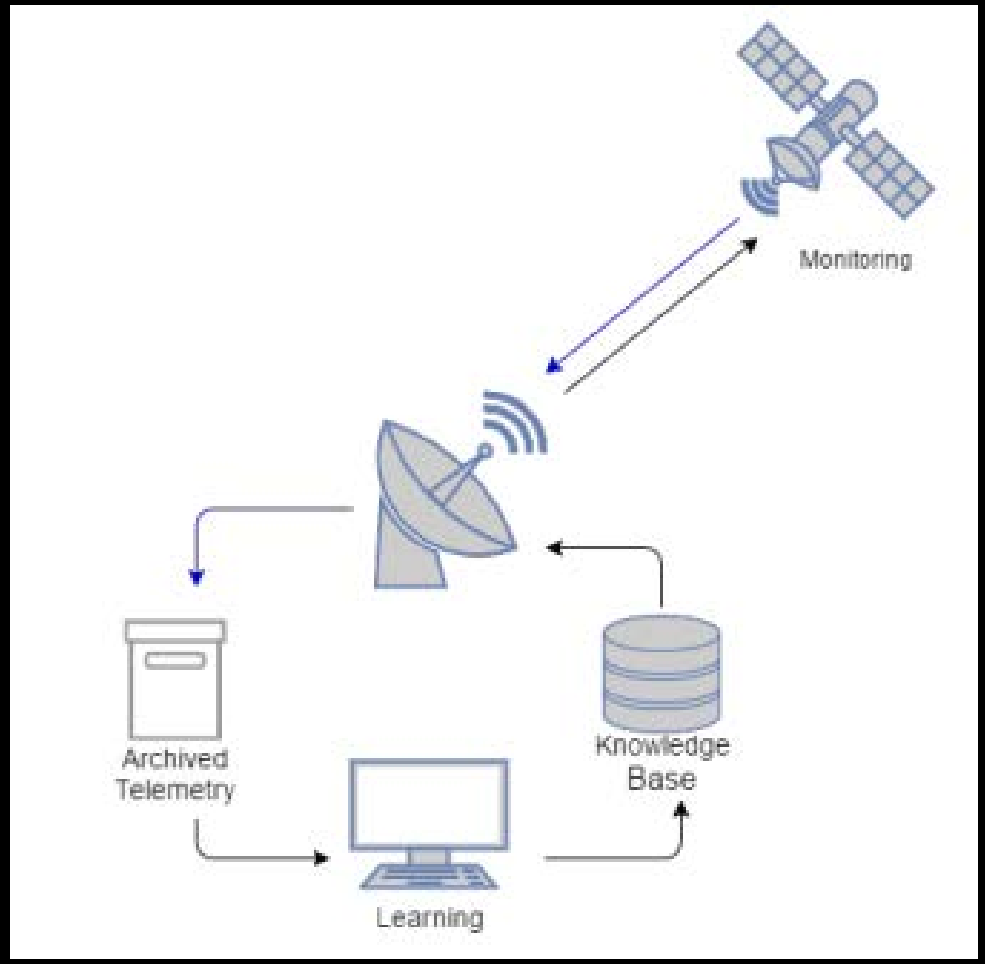


OVERVIEW

- Designed around IMS learning/monitoring phases
- Learning done on ground
- Monitoring on spacecraft

Learning Models:

- Archived data from IPEX mission
  - 50,000 data points
  - Over 150 features
- Two main models created
  - Temperature, Power
- Monitoring implemented in flight software



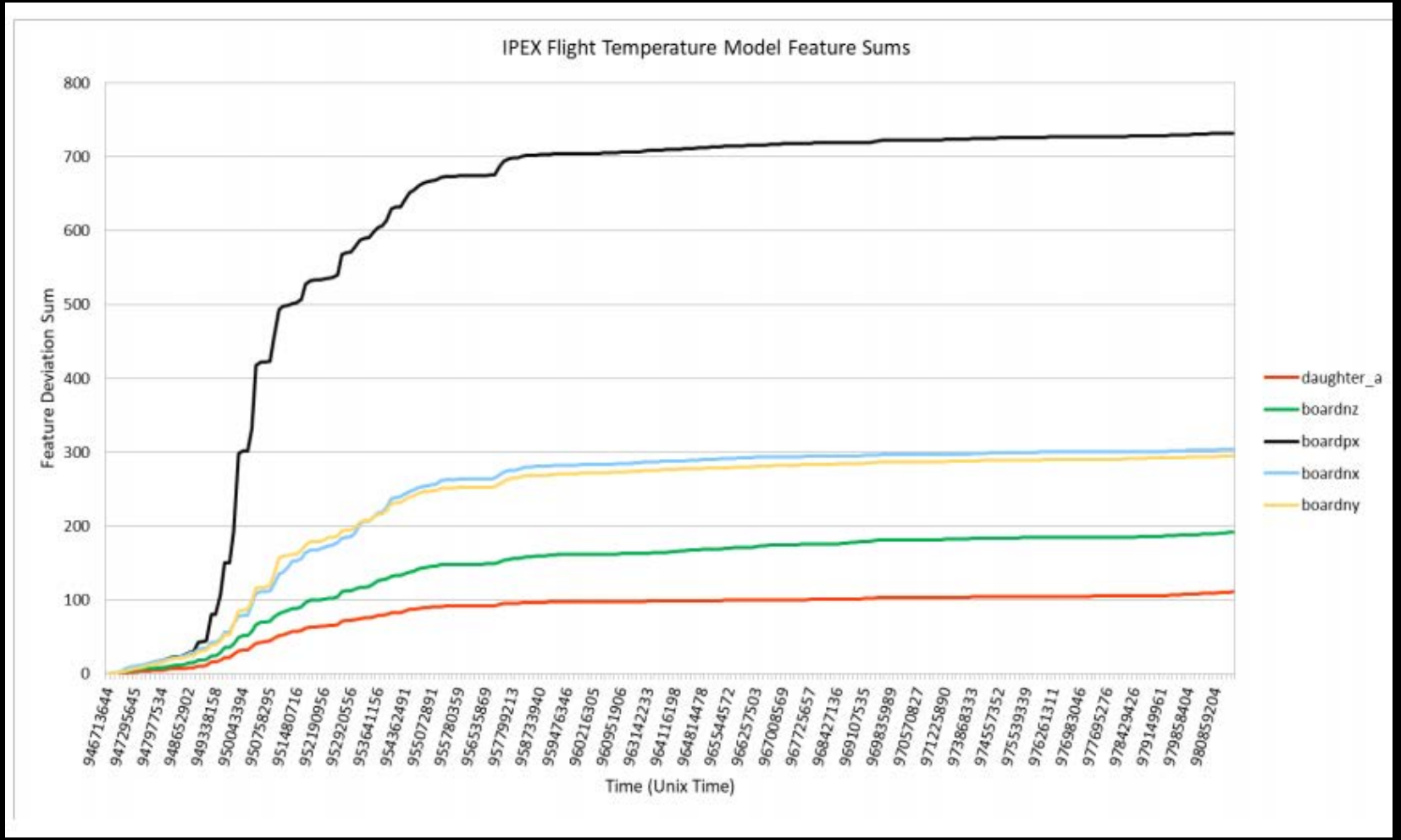
RESULTS

TESTS ON ARCHIVED DATA

- IPEX data with known anomalies used
- Goal to identify anomalous sensors
- Temperature and Power models tested
- Run separately and deviation scores analyzed

TEMPERATURE MODEL

- Temperature issues with side panels
- Positive X panel got very hot
- Thermal conductivity improved



REAL-TIME CUBESAT TESTING

- Tested monitoring system on the flight software
- Ran on test unit for ISX mission
  - Side panels not assembled
- Used same temperature and power models

Important Results:

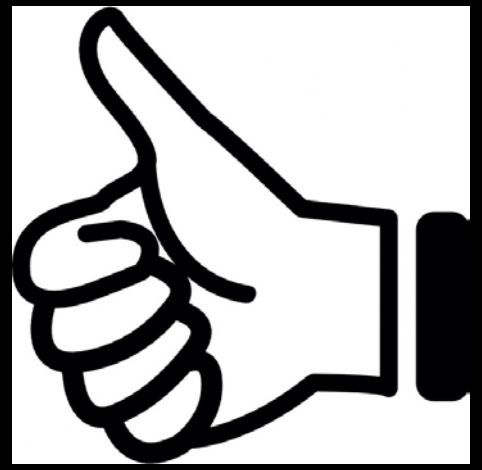
- Not all parameters have similar behavior mission to mission
- Importance of updating model

OTHER TESTS

- Fault Injection
  - Simulated error injected into ISX test unit
  - System successfully detected error
- Resource Usage
  - System tested with relatively large models
  - Deviation value calculated in less than 60 ms
  - Very low CPU usage, and acceptable memory usage

CONCLUSIONS

- Application of IMS has great potential
- Archived data can have a purpose
- As more data is collected, the better the models become
- Our health monitoring system provided great results
  - Identified anomalies in archived data and real-time tests
  - Performed efficiently
- Flight tests to be performed on future missions



QUESTIONS?