Artificial Intelligence and Analytics in JPL's Innovation Experience Center

Ground System Architectures Workshop (GSAW) Session 12A

Chris A. Mattmann – Deputy CTO, Chief Technology and Innovation Office
Office of the Chief Information Officer

March 5, 2020

Many thanks to Valentino Constantinou, and Tom Soderstrom for contributions to these slides!!

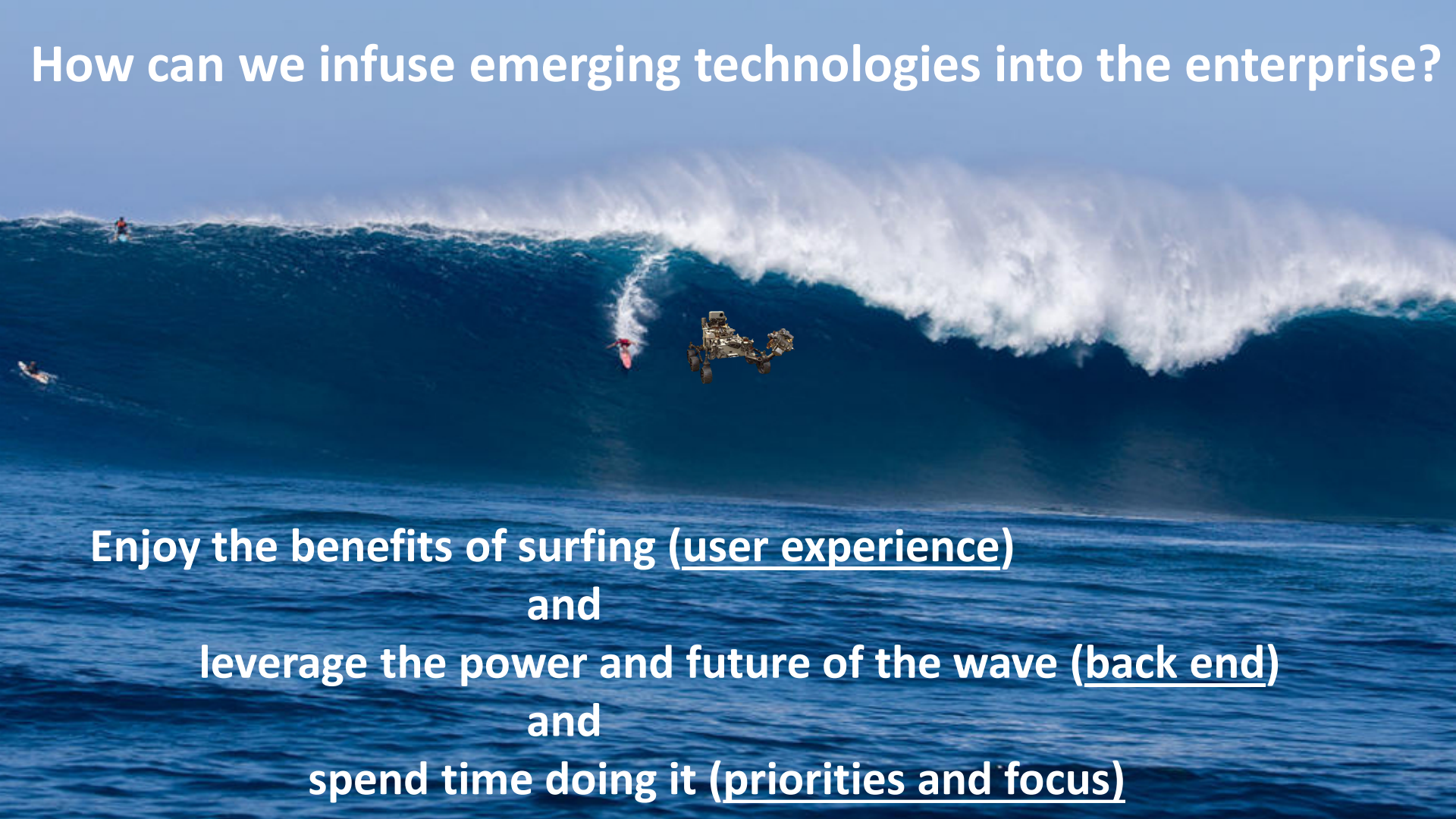
Jet Propulsion Laboratory
California Institute of Technology

The Chief Technology and Innovation Office Today

Purpose

- **Envision** and evaluate the future IT technologies needed by OCIO, JPL and NASA
- **Detect** and infuse innovation and technology into projects/missions, business, science and engineering
- **Engage** promising industry partners for OCIO and JPL's benefit
- **Infuse** future talent into OCIO and JPL
- **Train** JPLers in new IT technologies and ways of working

How can we infuse emerging technologies into the enterprise?



Enjoy the benefits of surfing (user experience)

and

leverage the power and future of the wave (back end)

and

spend time doing it (priorities and focus)

T

WHAT ARE THE EMERGING TECHNOLOGY WAVES?

New Habits

Cyber Security Challenges

Applied AI

Accelerated Computing

Ubiquitous Computing

Software Defined Everything

HOW DO WE MAKE IT LIMITLESS?

Participate at: techwaves@jpl.nasa.gov

T

WHAT ARE THE EMERGING TECHNOLOGY WAVES?

New Habits
Work from anywhere, always connected, gaming, sharing, open source, reduced footprint, cord-cutting

Cyber Security Challenges
At scale, authentication, encryption by default, role-based training, BlockChain

Applied AI
Deep Learning, Machine Learning, IA, Intelligent Digital Assistants, NLP, automation, data-driven, APIs, analytics, combinations

Accelerated Computing
Serverless, edge computing, HPC, GPUs, Neuromorphic, Quantum

Ubiquitous Computing
Mobile, smart devices, AR, IoT, NUI

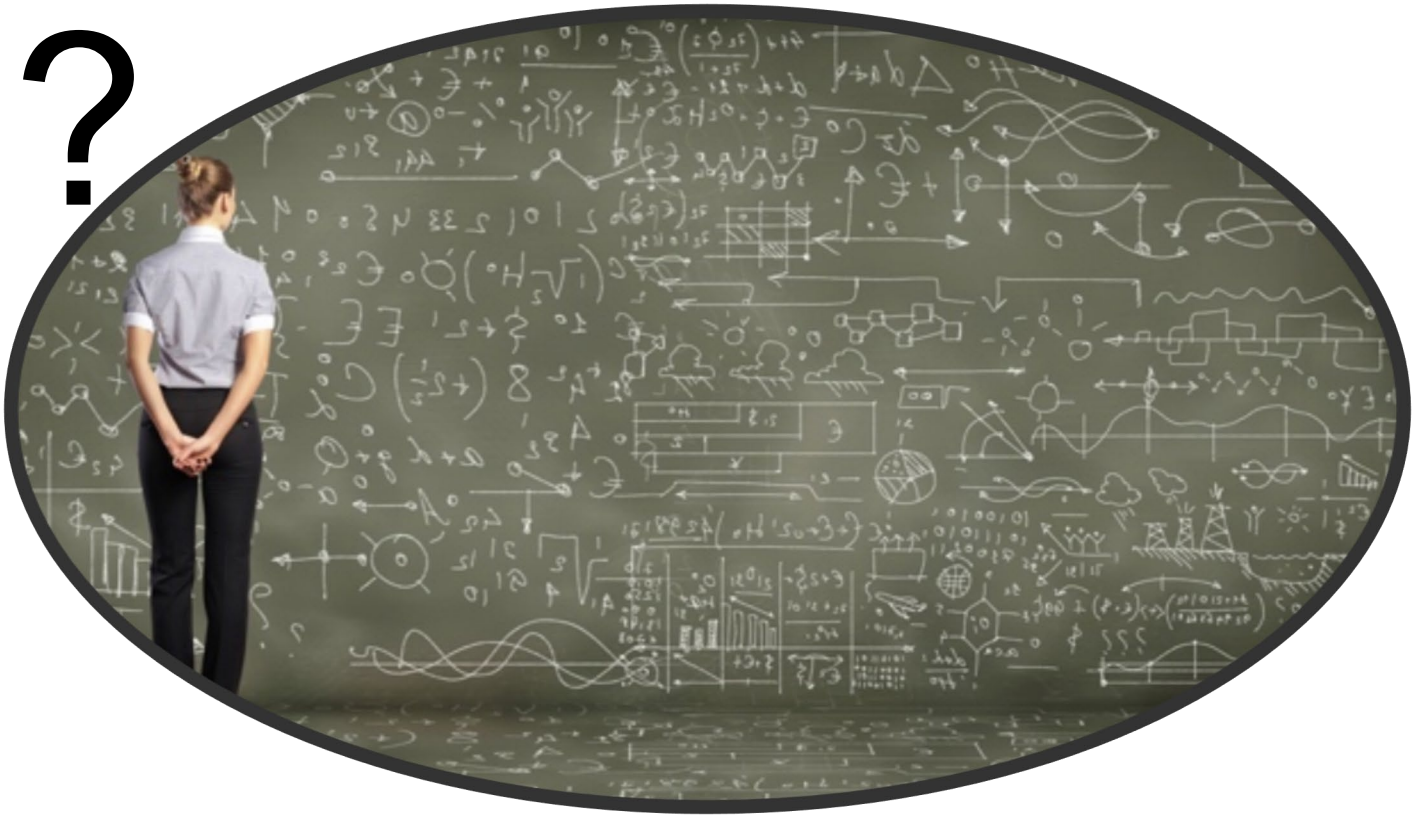
Software Defined Everything
Programming everything, APIs, Software Defined Networks, containers, DevOps, Open Source, self-healing, everything distributed

HOW DO WE MAKE IT LIMITLESS?

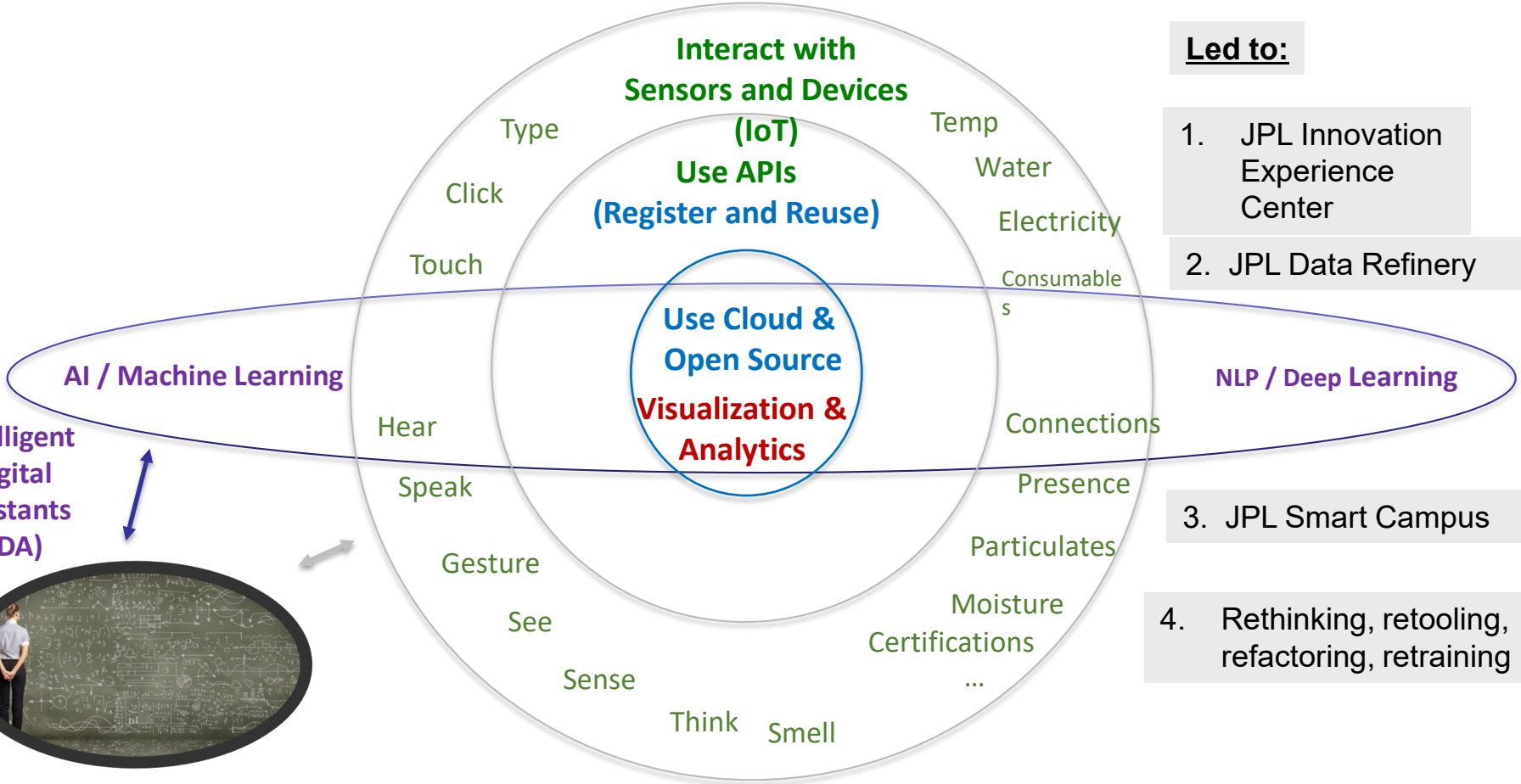
Participate at: techwaves@jpl.nasa.gov

Jet Propulsion Laboratory
California Institute of Technology

How do we find answers?
How do we detect new questions?

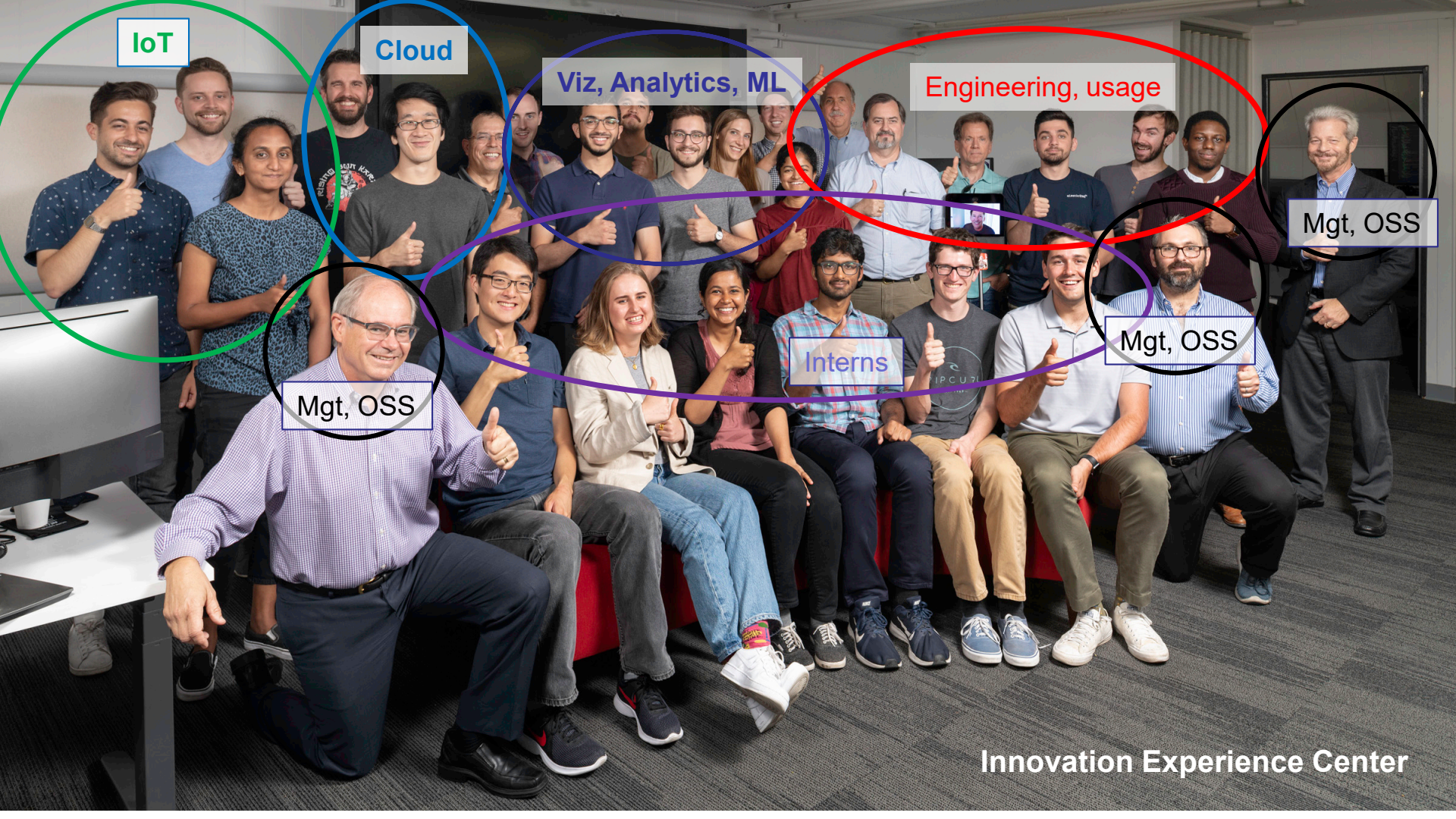


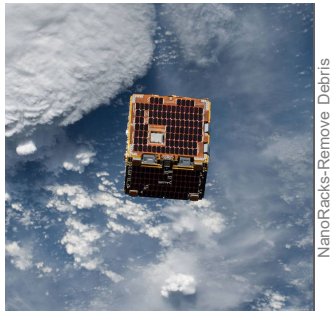
We apply the key emerging technologies to help



Led to:

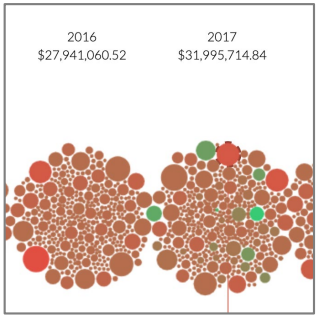
1. JPL Innovation Experience Center
2. JPL Data Refinery
3. JPL Smart Campus
4. Rethinking, retooling, refactoring, retraining


IoT
Cloud
Viz, Analytics, ML
Engineering, usage
Mgt, OSS
Mgt, OSS
Interns
Mgt, OSS
Innovation Experience Center

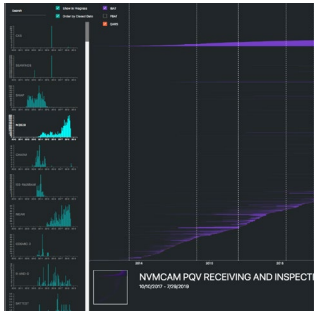


NanoRacks-Remove Debris

Small Satellite
Data Science



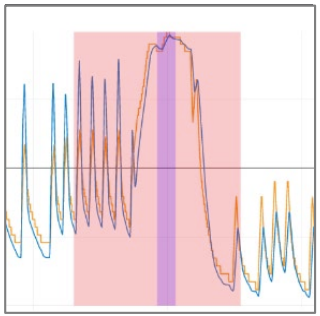
Visual Financial
Analytics



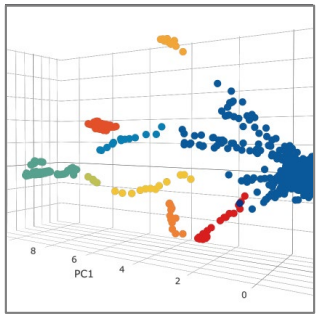
BETR

*work of the Studio

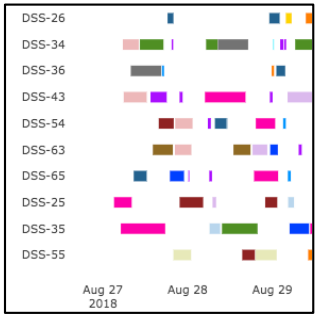
EXCALIBUR
Exoplanet Classifier



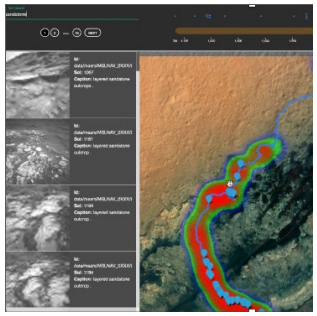
Telemanom
Anomaly Detection



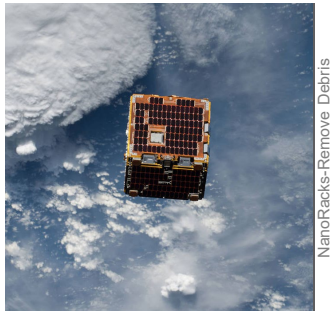
Alarm Management



DSN Scheduling

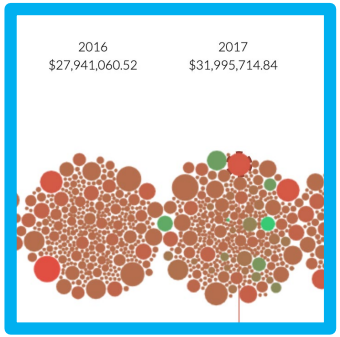


MAARS Image
Captioning

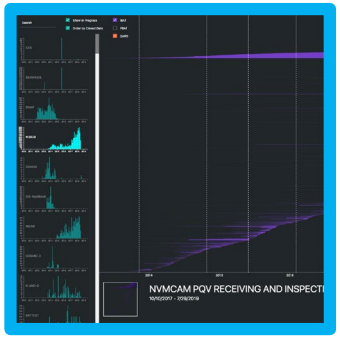


NanoRacks-Remove Debris

Small Satellite
Data Science



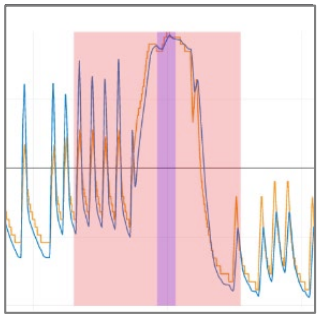
Visual Financial
Analytics



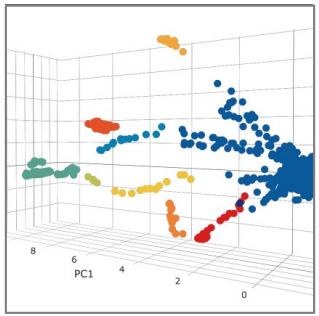
BETR

*work of the Studio

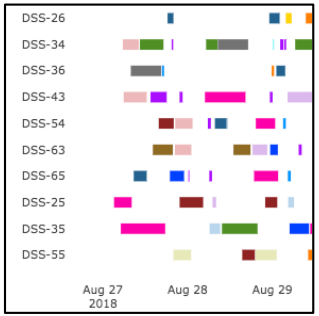
EXCALIBUR
Exoplanet Classifier



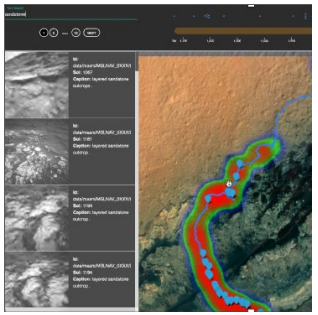
Telemanom
Anomaly Detection



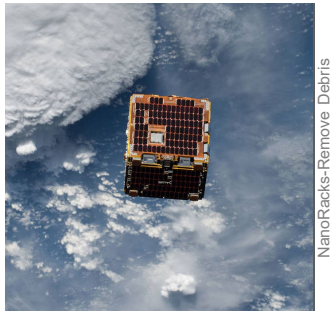
Alarm Management



DSN Scheduling

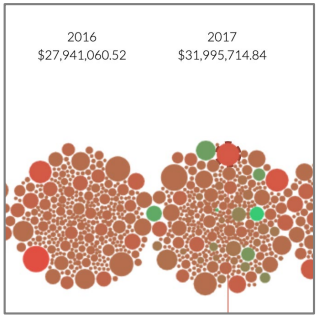


MAARS Image
Captioning

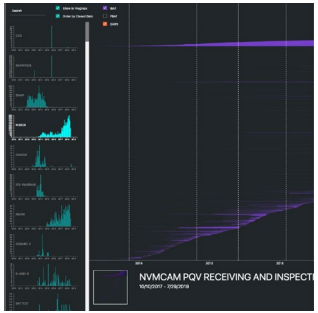


NanoRacks-Remove Debris

Small Satellite
Data Science



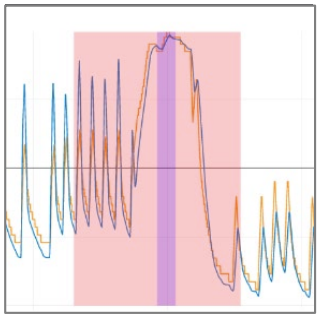
Visual Financial
Analytics



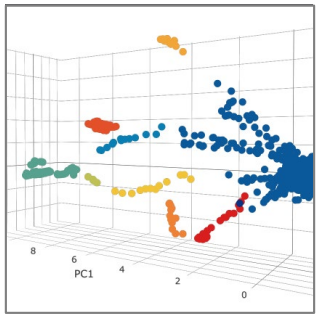
BETR

*work of the Studio

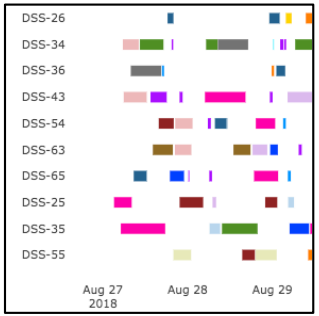
EXCALIBUR
Exoplanet Classifier



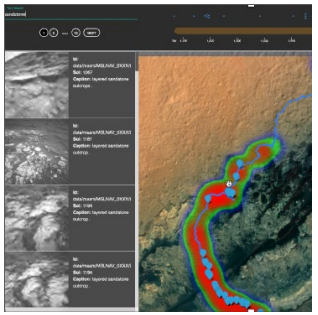
Telemanom
Anomaly Detection



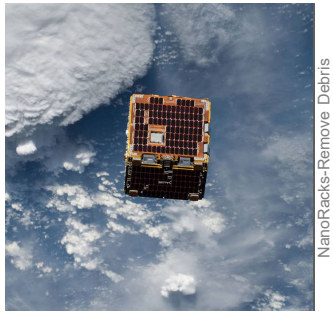
Alarm Management



DSN Scheduling

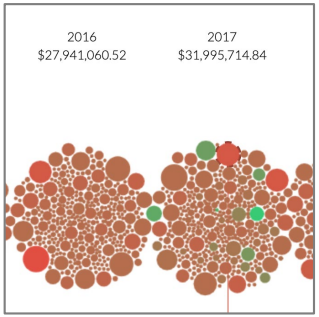


MAARS Image
Captioning

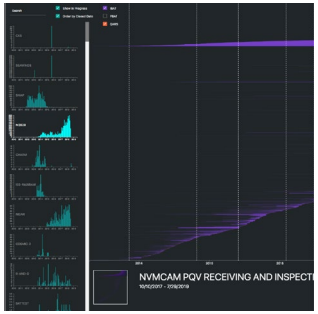


NanoRacks-Remove Debris

Small Satellite
Data Science



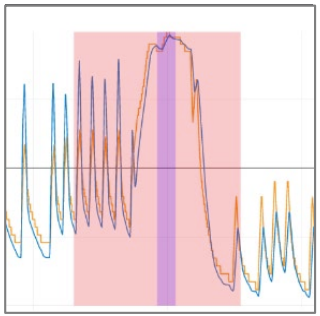
Visual Financial
Analytics



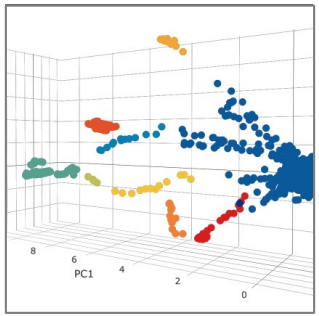
BETR

*work of the Studio

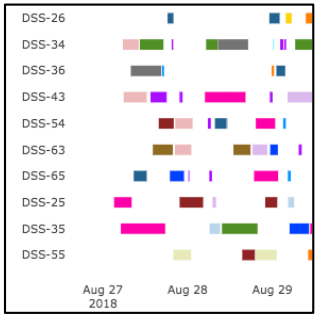
EXCALIBUR
Exoplanet Classifier



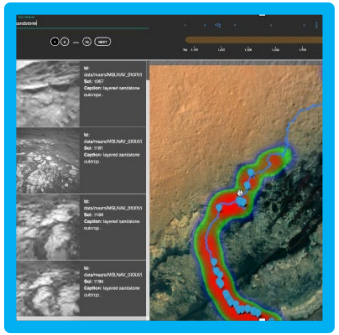
Telemanom
Anomaly Detection



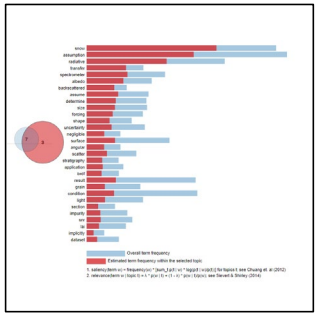
Alarm Management



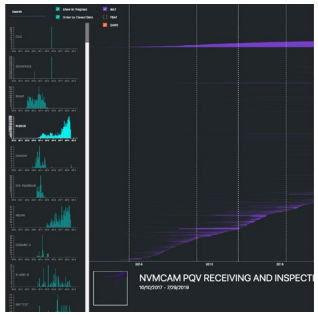
DSN Scheduling



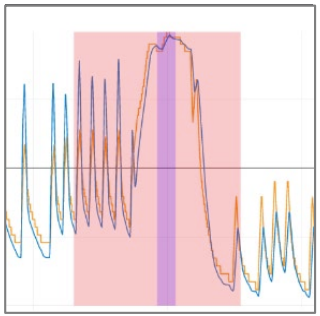
MAARS Image
Captioning



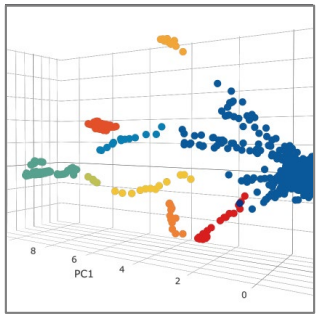
Foundry
Data Science



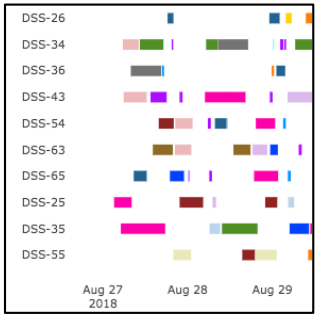
BETR



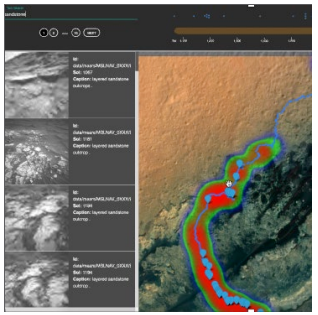
Telemanom
Anomaly Detection



Alarm Management



DSN Scheduling



MAARS Image
Captioning

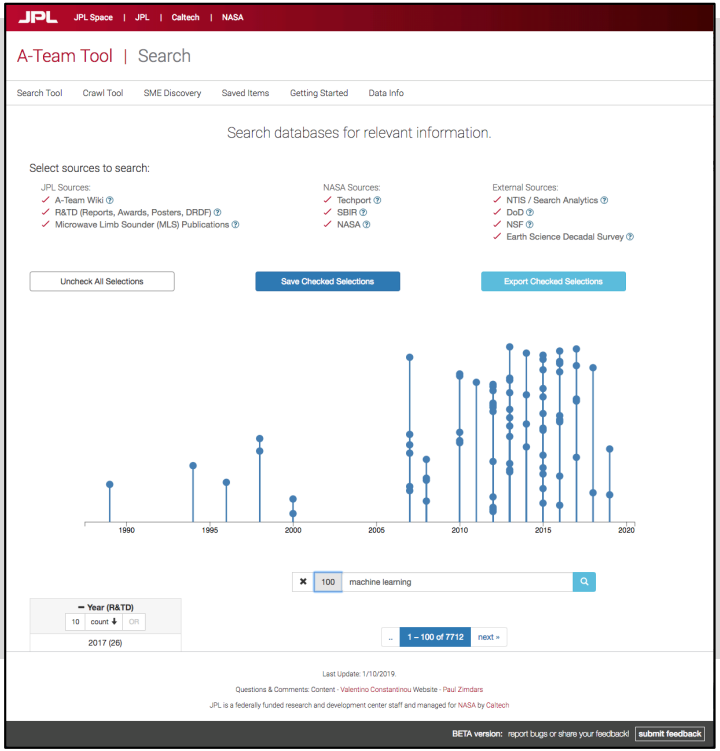
Mission Formulation and Planning

Mission Operations

Mission Formulation and Planning

Foundry A-Team and Proposals Tools

Natural Language Processing (NLP) for Information Retrieval



Analytics and machine learning **aids early mission technology concept research and formulation.**

Foundry A-Team and Proposals Tools

Natural Language Processing (NLP) for Information Retrieval

Analytics and machine learning **aids early mission technology concept research and formulation.**

"one major advantage … is to quickly track down RTD for other efforts … otherwise accessing these documents can be very time-consuming."

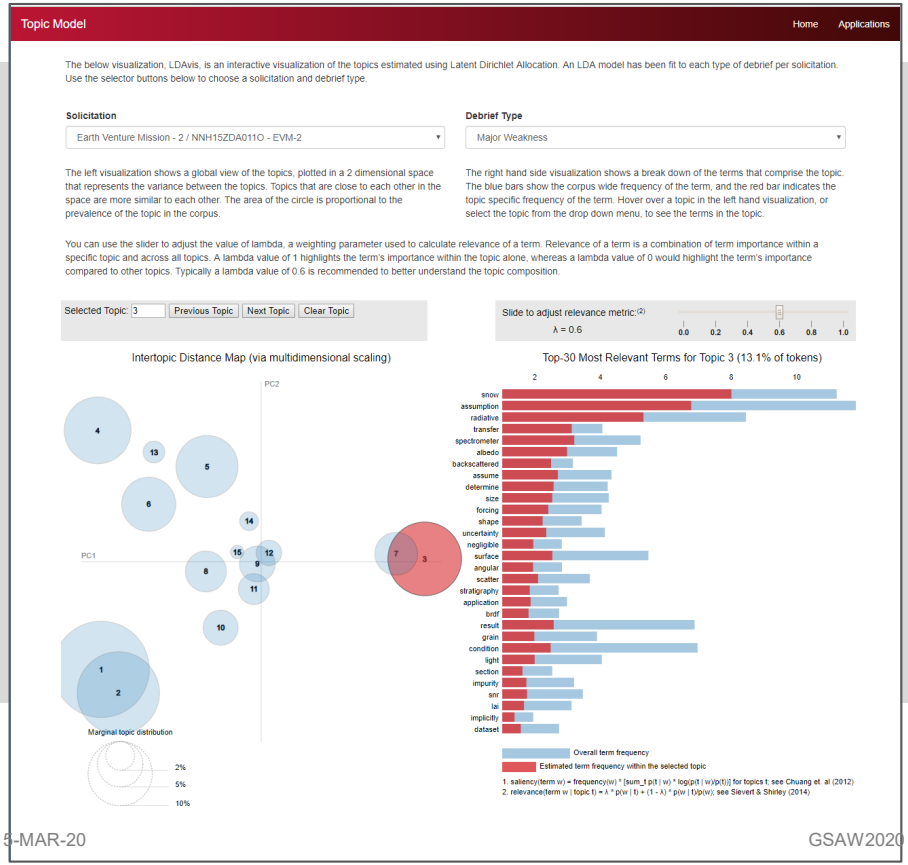
- Morgan Cable (3225 – Astrobiology and Ocean Worlds)

"one-stop-shop for accessing this Information [about high-resolution mass spectrometers]"

- Morgan Cable (3225 – Astrobiology and Ocean Worlds)

Foundry A-Team and Proposals Tools

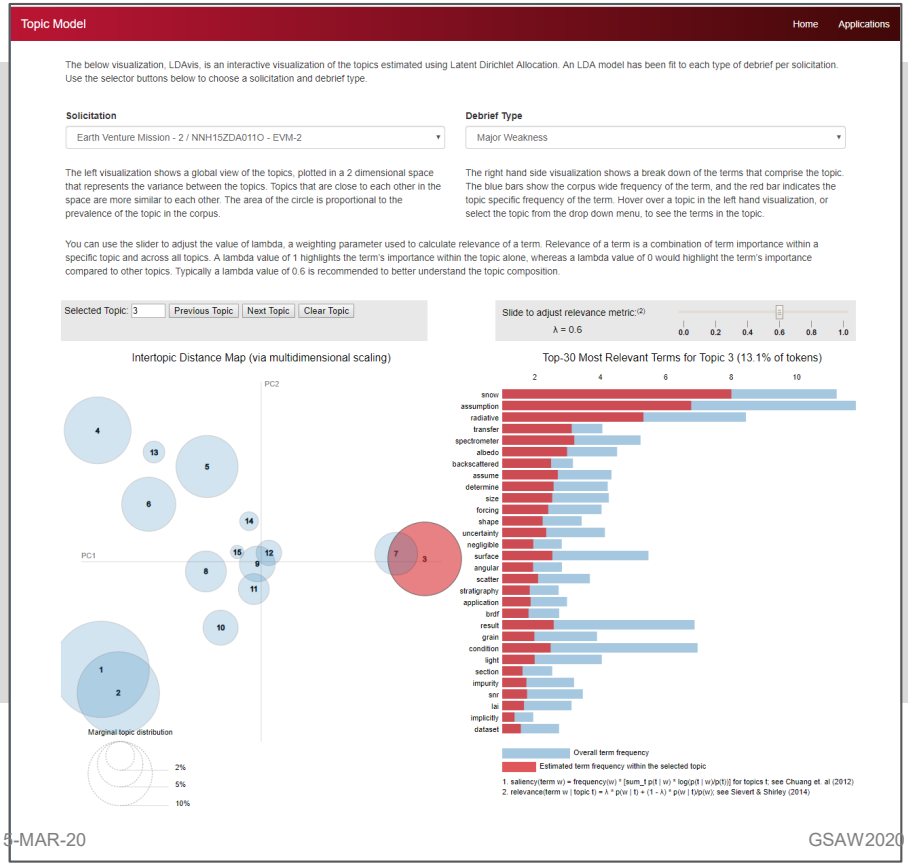
Natural Language Processing (NLP) for Information Retrieval



Analytics and machine learning **uncovers patterns in debriefs** which can be used to improve future proposals.

Foundry A-Team and Proposals Tools

Natural Language Processing (NLP) for Information Retrieval



Analytics and machine learning **uncovers patterns in debriefs** which can be used to improve future proposals.

The A-Team and Proposal Debrief Tool **reduce concept and proposal research effort** while **introducing new research capabilities.**

Business Event Transaction Registry (BETR)

An Institutional Framework for Monitoring Lifecycles

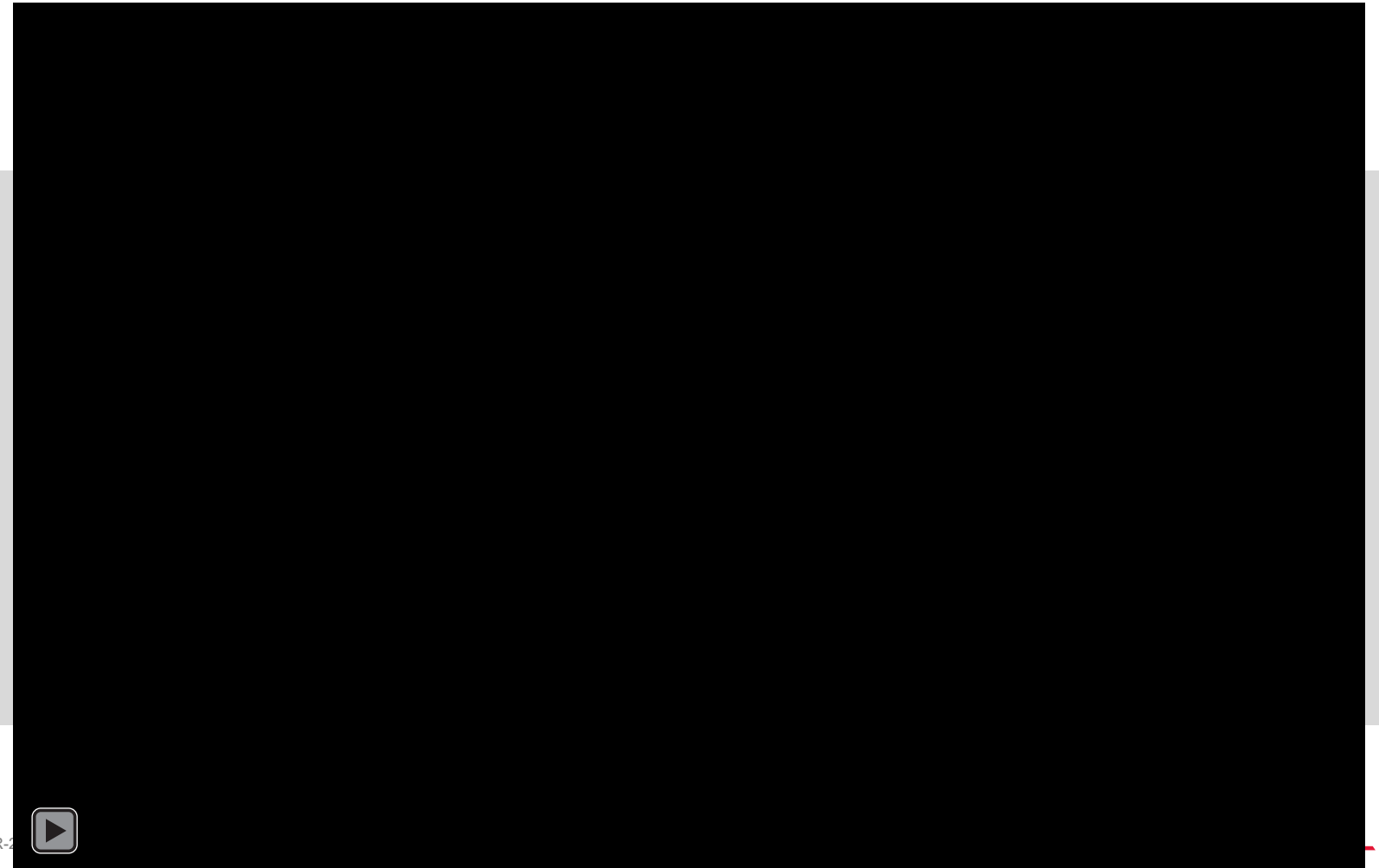
BETR is a tool that provides the ability to **examine engineering footprint** in a common way.

Business Event Transaction Registry (BETR)

An Institutional Framework for Monitoring Lifecycles

BETR is a tool that provides the ability to **examine engineering footprint** in a common way.

We can now start to examine processes across several areas of JPL seamlessly, and use analytics and visualization for monitoring and improvement.



Mission Formulation and Planning

Mission Operations

Optimization of DSN Scheduling

Decrease Human-in-the-Loop Time for Mission Scheduling

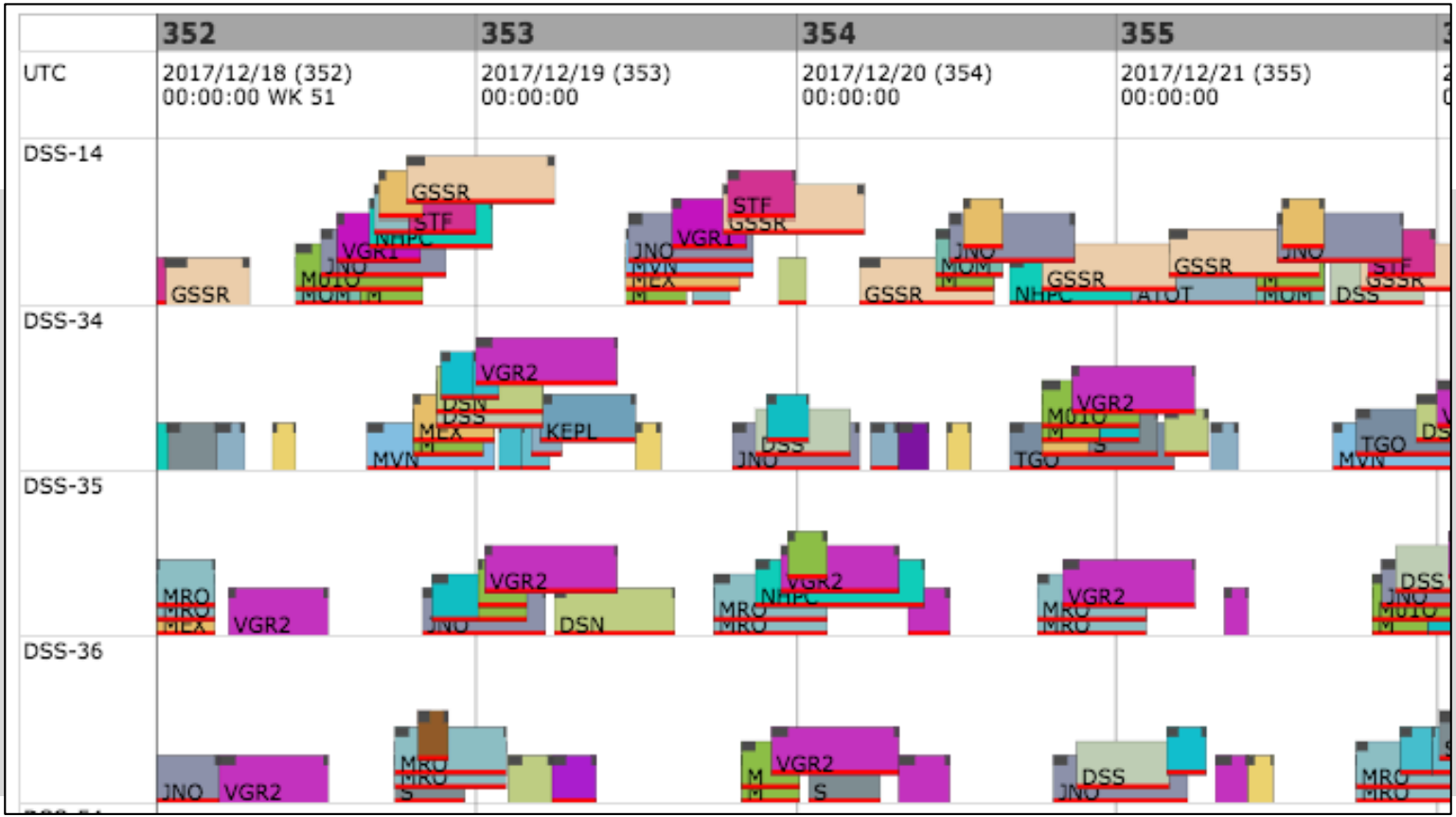
Missions make requests to the DSN months (sometimes years) in advance to ensure coverage for science and operations.

Optimization of DSN Scheduling

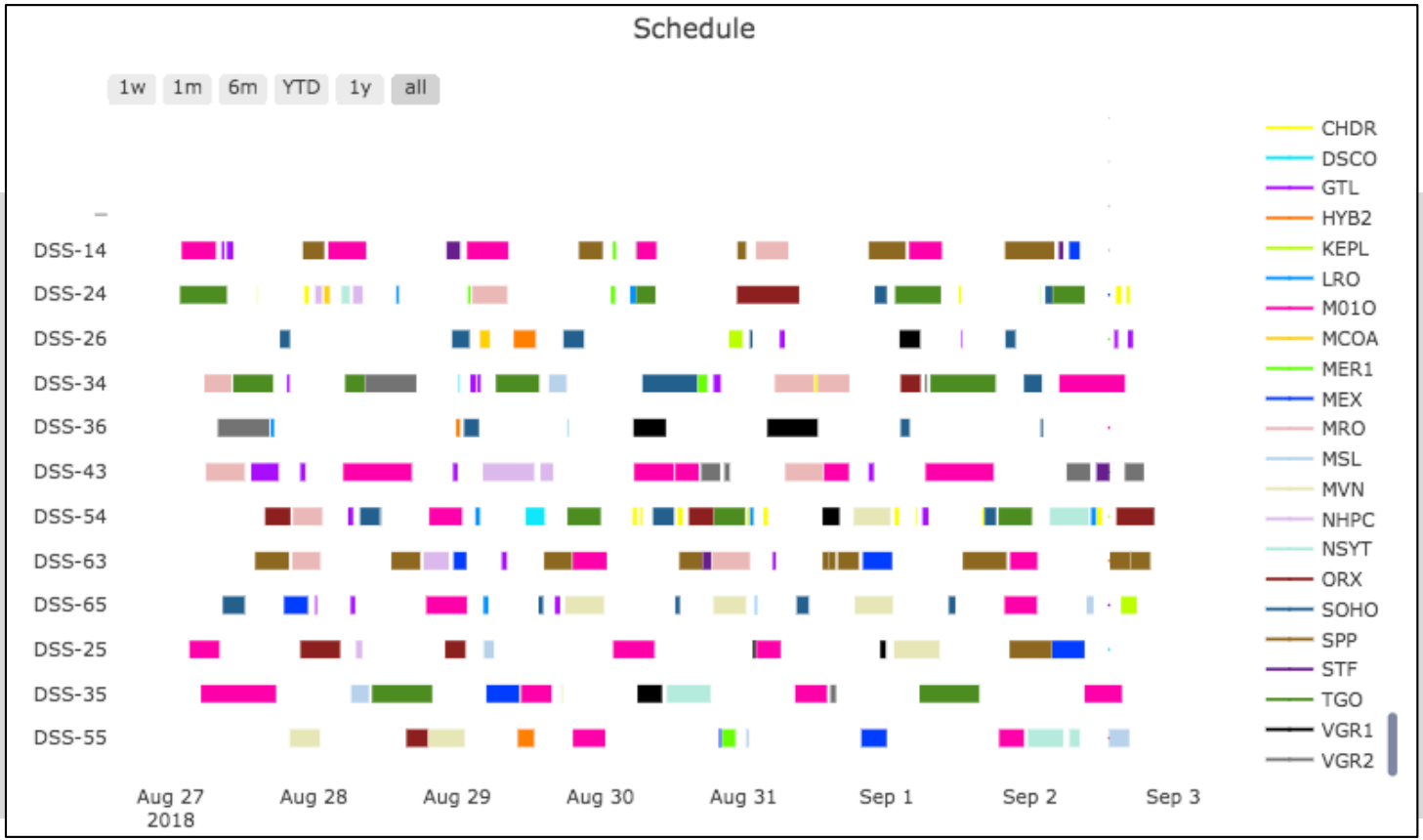
Decrease Human-in-the-Loop Time for Mission Scheduling

Missions make requests to the DSN months (sometimes years) in advance to ensure coverage for science and operations.

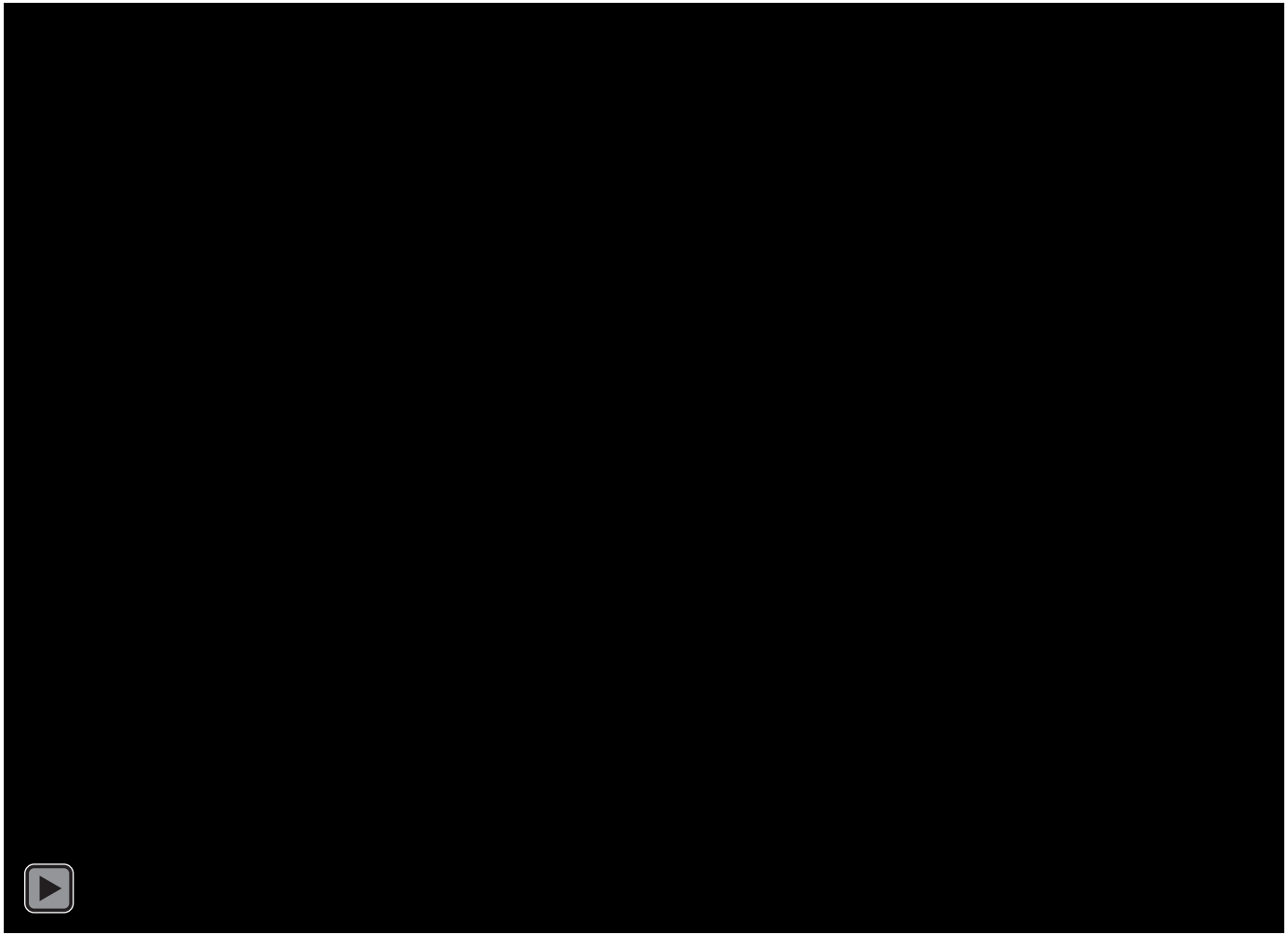
Scheduling is always difficult due to overlapping requirements.
Our current tools work – but require manual labor.



S[3] tool showing “conflicting” tracking requests before any scheduling resolution.



Visualized output from use of reinforcement learning (RL)
and multi-integer linear programming (MILP) approach.



MAARS Rover Image Captioning

Increasing Science Throughput with On-Board Deep Learning

High Performance Spaceflight Computer (HPSC) will power the next generation of surface vehicles.

MAARS Rover Image Captioning

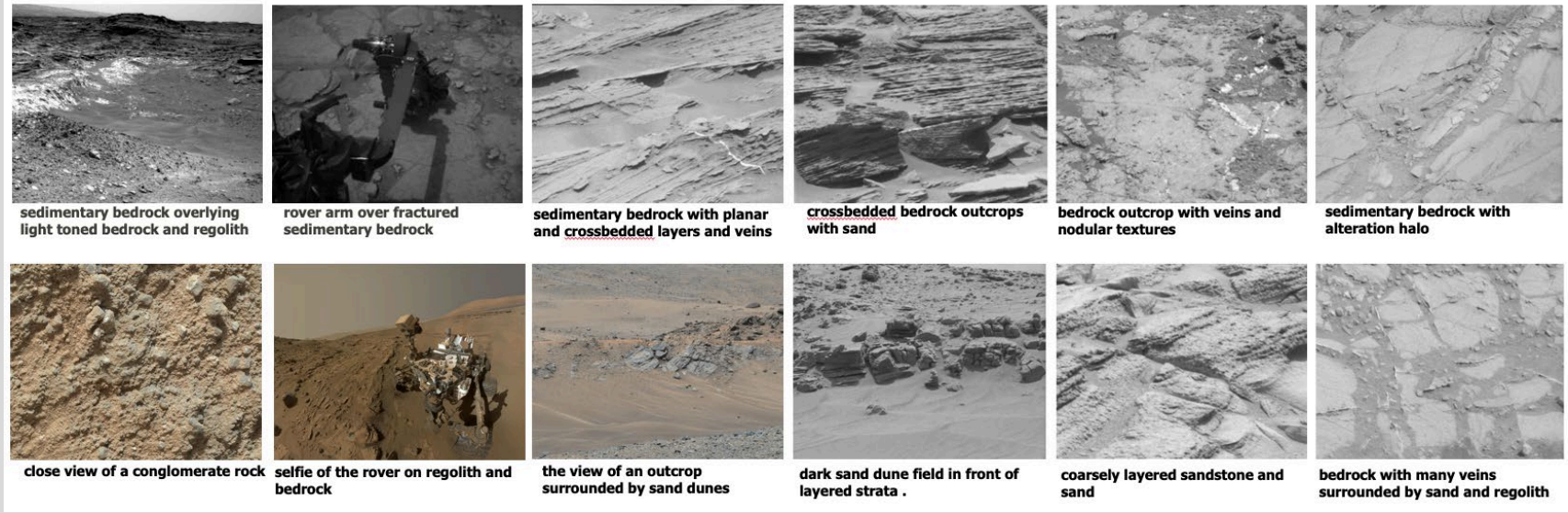
Increasing Science Throughput with On-Board Deep Learning

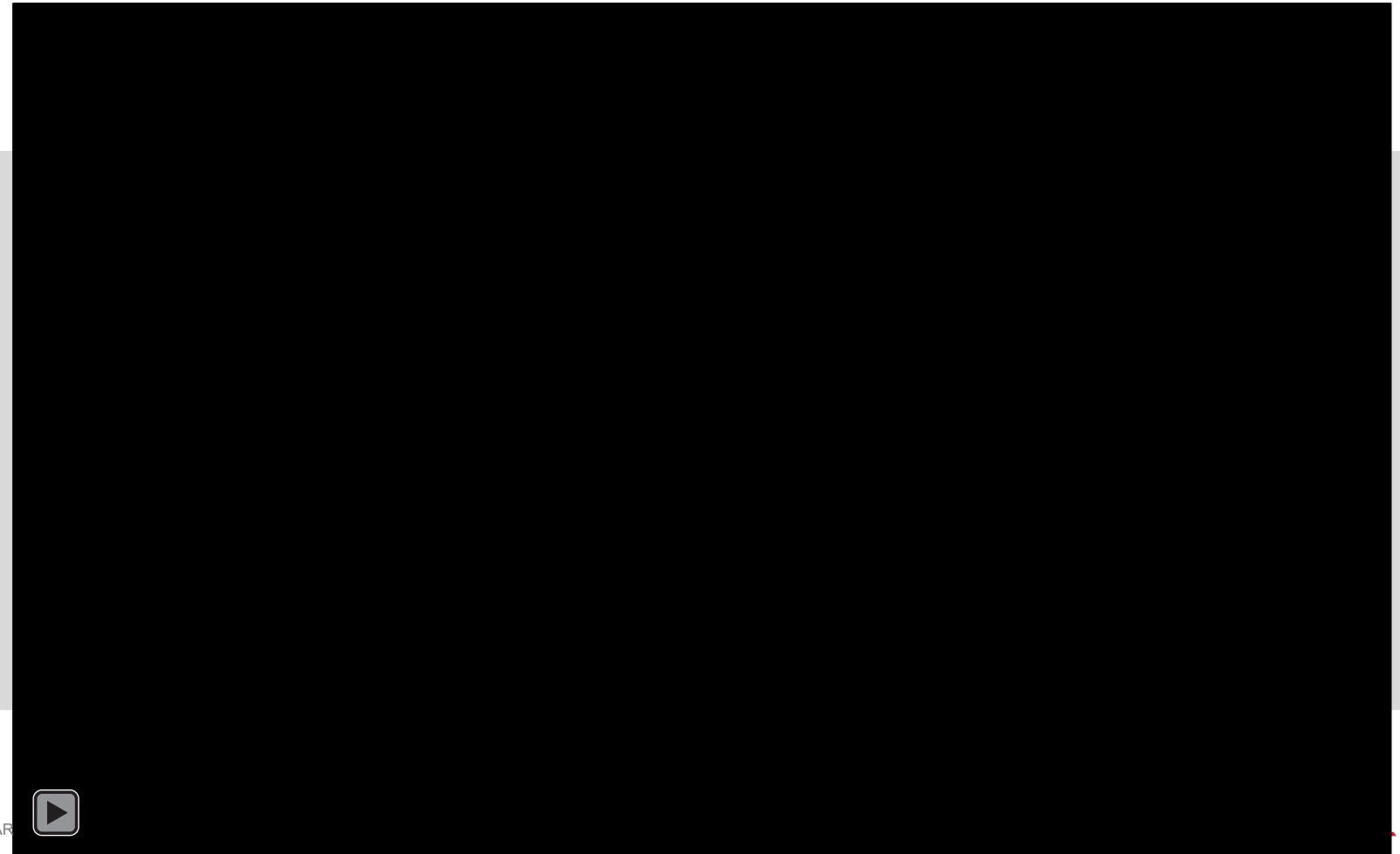
High Performance Spaceflight Computer (HPSC) will power the next generation of surface vehicles.

Instead of 200 images per day for scientific analysis and target selection – what about 1 million captions?

MAARS Rover Image Captioning

Increasing Science Throughput with On-Board Deep Learning





Telemanom Time Series Anomaly Detection

Application to Spacecraft and Mission Operations

Monitoring thousands of telemetry channels for changes in behavior is prohibitively difficult and time-consuming.

Telemanom Time Series Anomaly Detection

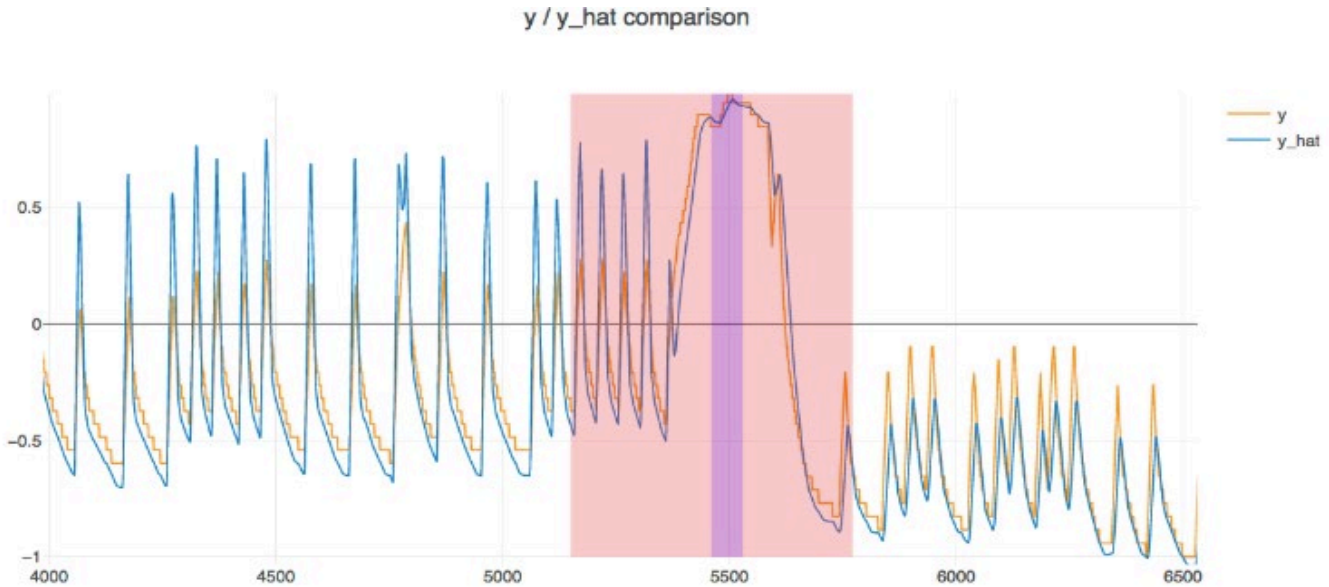
Application to Spacecraft and Mission Operations

Monitoring thousands of telemetry channels for changes in behavior is prohibitively difficult and time-consuming.

A modeling and software architecture for any time-series data – today's focus on enhancing mission operations.

Telemanom Time Series Anomaly Detection

Application to Spacecraft and Mission Operations



A detection of contextual anomaly using Telemanom on
Mars Science Laboratory thermal channels.

Alarm (Anomaly) Management

Characterization and Prioritization of Detected Anomalies

In a critical scenario, hundreds of alarms could be active at any moment across multiple telemetry channels.

Alarm (Anomaly) Management

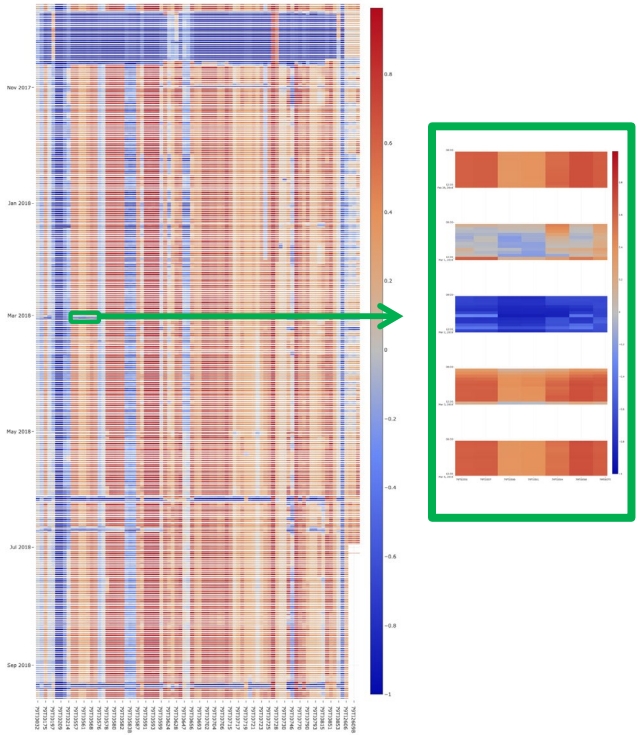
Characterization and Prioritization of Detected Anomalies

In a critical scenario, hundreds of alarms could be active at any moment across multiple telemetry channels.

Alarm management is developing methodologies in alarm prioritization, fault detection, and state estimation – extensions being researched that complement previous and current work.

Alarm (Anomaly) Management

Characterization and Prioritization of Detected Anomalies

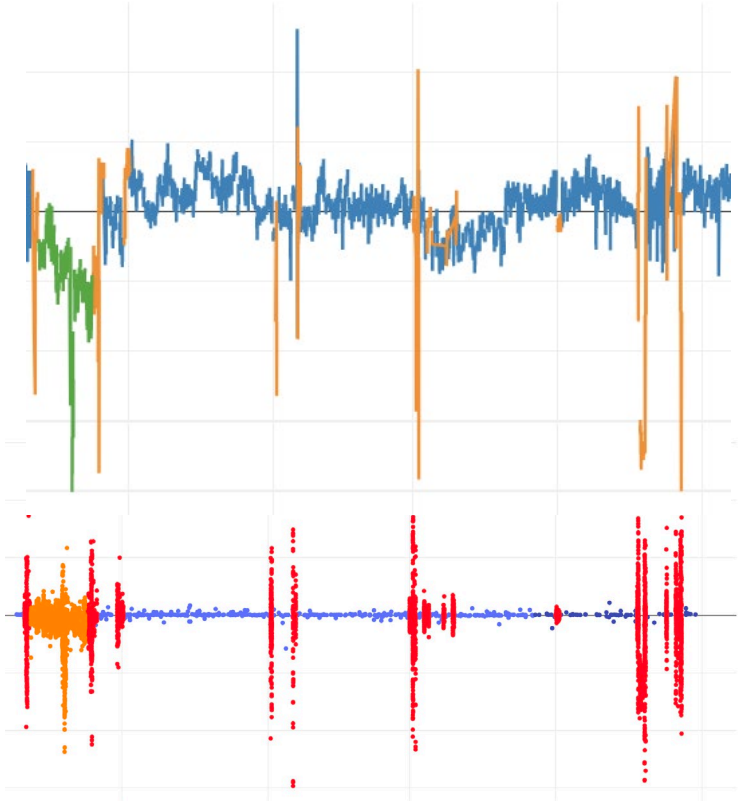


Alarm (Anomaly) Management

Characterization and Prioritization of Detected Anomalies

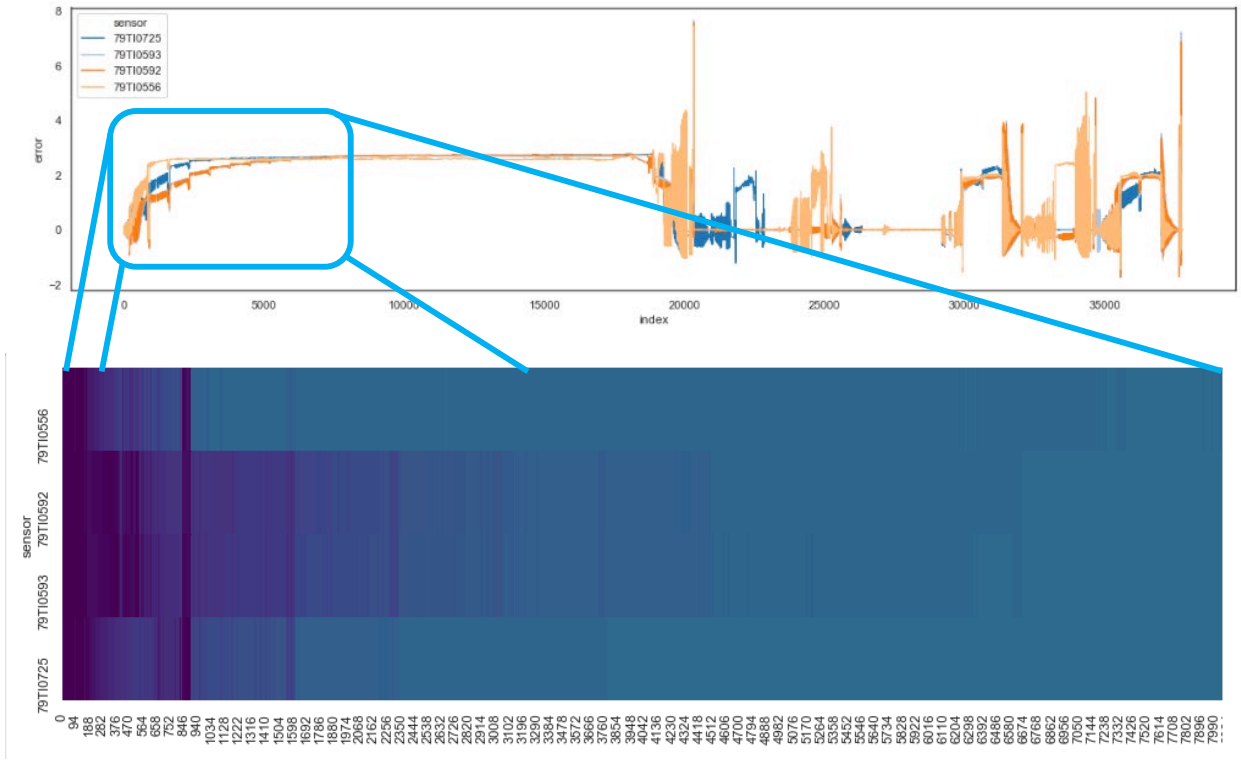
Estimated states

Model Errors
(anomalies)



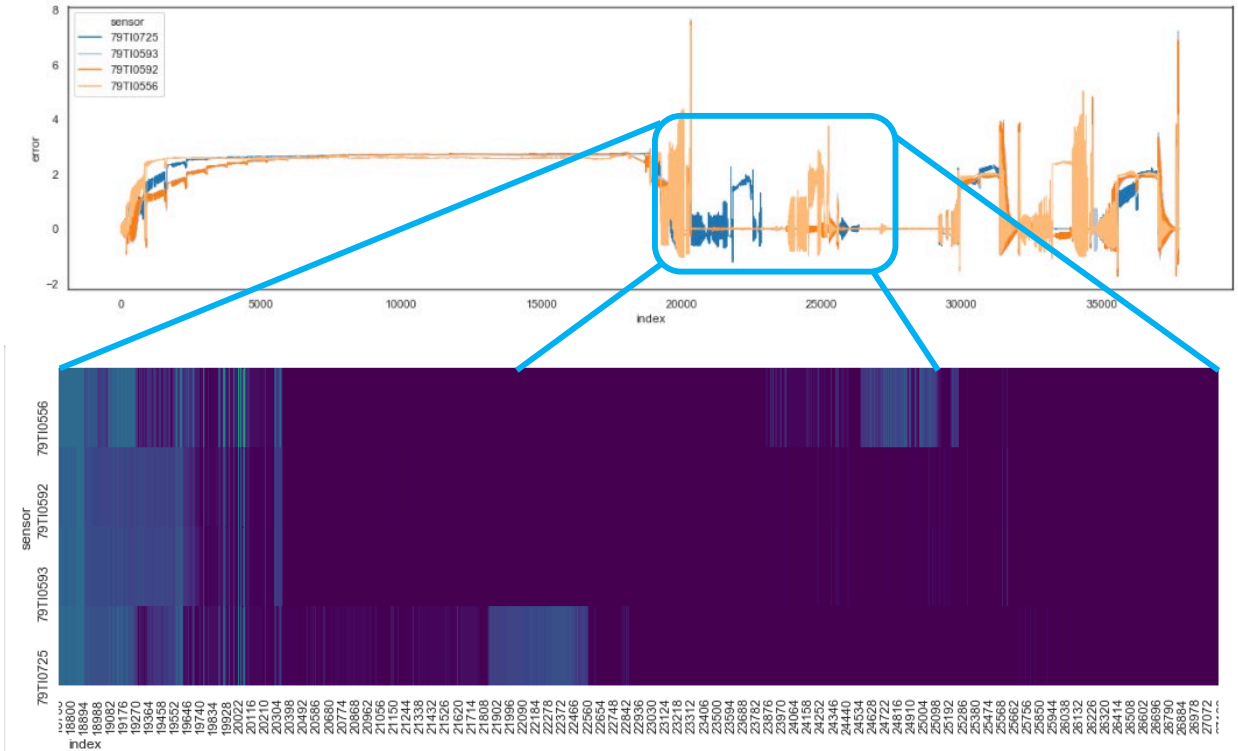
Alarm (Anomaly) Management

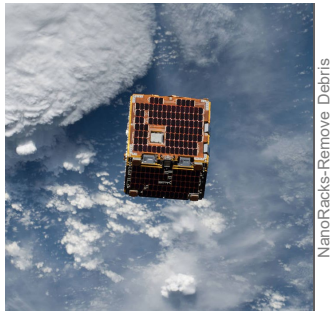
Characterization and Prioritization of Detected Anomalies



Alarm (Anomaly) Management

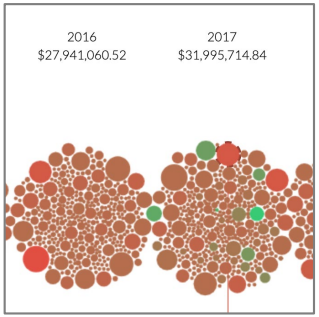
Characterization and Prioritization of Detected Anomalies



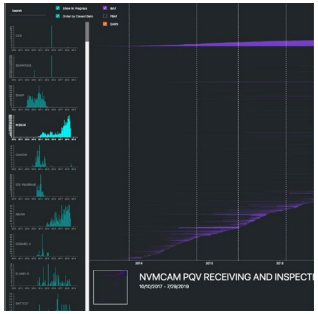


NanoRacks-Remove Debris

Small Satellite
Data Science



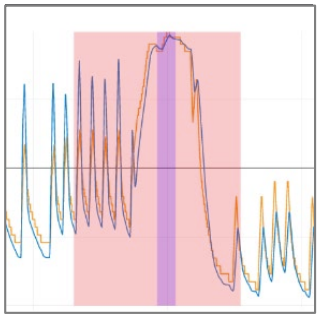
Visual Financial
Analytics



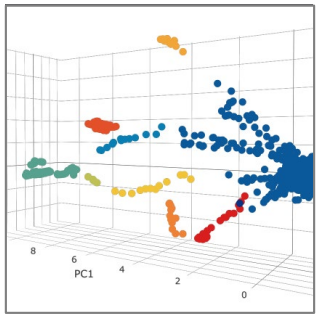
BETR

*work of the Studio

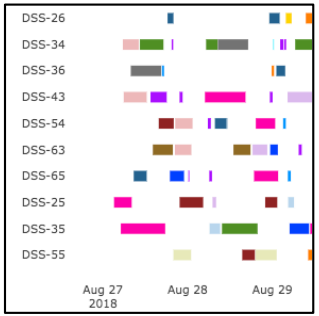
EXCALIBUR
Exoplanet Classifier



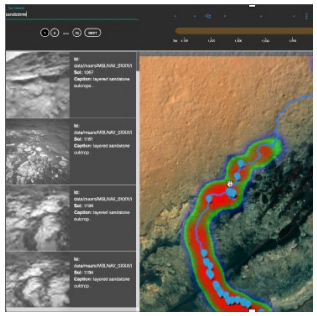
Telemanom
Anomaly Detection



Alarm Management



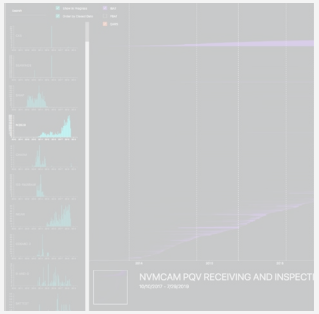
DSN Scheduling



MAARS Image
Captioning

Small Satellite
Data Science

Visual Financial
Analytics



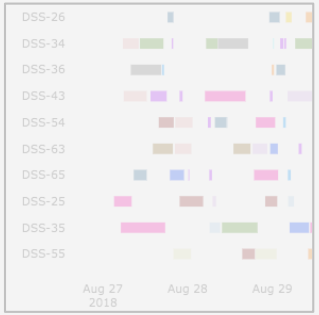
BETTY

EXCALIBUR
Exoplanet Classifier

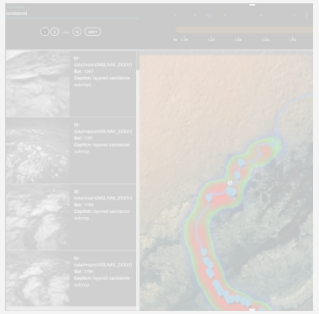
Thank You!

Telemanom
Anomaly Detection

Alarm Management



DSN Scheduling



MAARS Image
Captioning


JPL
Jet Propulsion Laboratory
California Institute of Technology