National Aeronautics and Space Administration

Content-based On-board Summarization to Monitor Infrequent Change

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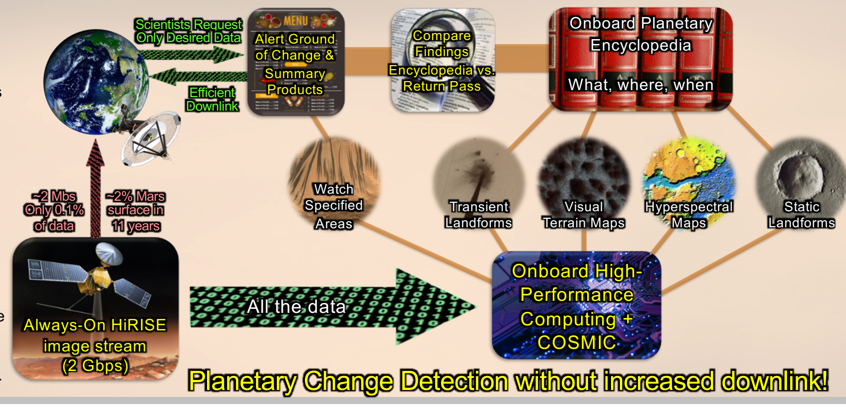
Program: 6x Strategic Initiative

Project Objective:

COSMIC will extend several proven, flight-heritage technologies from the Machine Learning & Instrument Autonomy group (MLIA, 398J) to create a robust, flexible orbital system for conducting planetary surveys and change monitoring in the Martian environment. Using orders of magnitude more data than can be downlinked, subsequent onboard processing may extract scientific features of interest onboard, especially change. The system will be designed to facilitate and support scientist-driven exploration of Mars, delivering planet-wide summarization databases, monitoring scientist-specified areas for high-detail change, recognizing coarser changes in non-monitored areas, and providing relevant, informative descriptions of onboard images to advise downlink prioritization. This system will demonstrate a key new exploration paradigm: **Observe most, return best**.

Extending the modern HiRISE instrument to a futuristic version that is capable of near-continuous observation, our system will render the 22 Tb/day image stream into a coherent, compressed encyclopedia of Martian landmarks. Repeat overpasses then difference updated results, performing change detection without direct pixel comparison or downlink.



Harnessing the power of the upcoming High Performance Space Computing platform (HPSC AIST) and Machine Learning, COSMIC permits scientists to specify the specific kinds of targets (rather than specific lat/lon/time) to monitor, summarize, and track for change on a planetary scale. When change is found, or anytime scientists wish to peek into the growing onboard encyclopedia, they may request only the data desired. COSMIC never gets in the way of scientists requesting the images they want; instead, it provides low-bandwidth options of discoveries in images that may never have been requested at all.

To do this, COSMIC supports a request and alert system to make specifying desired behavior as simple as possible, forming the first off-world database for science queries.

Scales to Mission Needs

Increasing Autonomy Role with Heritage

Increasing Autonomy

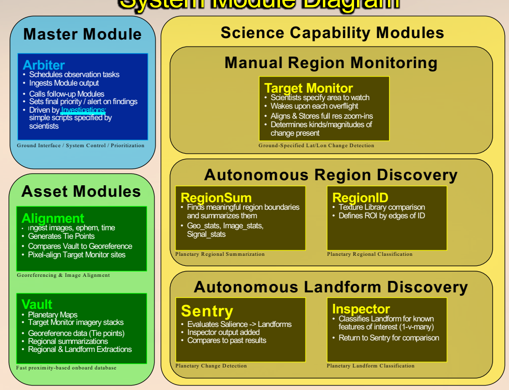
1) **Inform Ops / Science Team**
Enables "Aware" Data DL Selection
Observe-most-return-best Approach
Just doing this is a big win!

2) **Prioritize Downlinks**
Minimize risk by sending "most interesting" data first

3) **Filter Downlinks**
Conserve bandwidth, don't send redundant/bad data

4) **On-board Response (Agile Science)**
Queue up follow-on observation (reschedule)
Task Second Instrument for Co-located Observation
Captures otherwise-invisible transients
Significantly reduced Ops load

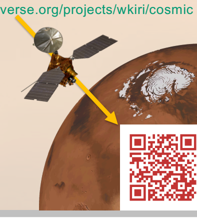
System Module Diagram



Crowd-Sourced Labels

ZOONIVERSE

Zooniverse.org is a free public platform that allows scientists to post image-labeling challenges for citizen scientists to complete. A perfect match for Machine Learning, Zooniverse permits the collection of the thousands of labels necessary to train next-generation autonomous systems. Give ours a try to support this project!
https://www.zooniverse.org/projects/wkiri/cosmic

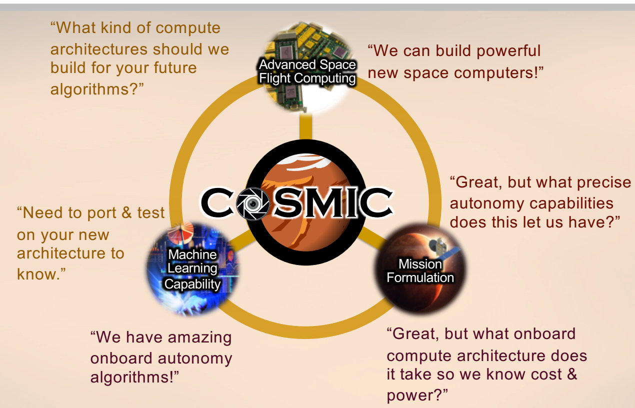


Transient Landforms Currently Selected for COSMIC Detection Demonstration

Benefits to NASA and JPL:

Currently there is a chicken-and-egg problem in bringing advanced autonomy to future missions. Autonomy algorithm groups like MLIA (398) have transformative capabilities, but to get them onboard, missions need to know what kind of onboard computer would be required, while flight computer designers want to know precise architectural questions to optimize for the new algorithms. Likewise, missions need to know the precise cost in heat generated, volume, and dollars to include the compute necessary to run the autonomy. Each party needs to know information the others aren't easily able to provide.

COSMIC will attempt to bridge this triple divide by building a functional system and porting it to three potential flight architectures. Trade-off studies will then be performed against the various ML algorithms used, compute architectures employed, and the resulting performance in terms of accuracy, memory requirements, and wall clock compute time. These trade-off studies will enable missions to easily select and adopt the autonomy best suited to their needs with full awareness of the cost, power, compute, and memory implications for orbital exploration of Mars or targets yet more distant.



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"Look and you will find it. What is unsought will go undetected." - Sophocles

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