Mars 2020 and Mars Sample Return Program Overviews, LVS, and Example of NEPP Contribution

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The decision to implement Mars Sample Return will not be finalized until NASA's completion of the National Environmental Policy Act (NEPA) process. This document is being made available for information purposes only.

Who am I?

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California Institute of Technology

James Skinner, PPE for M2020 and MSR
15+ years experience at JPL in CAEO (Specialist and PPE)

Today's focus will be on **unique features of M2020**, Overall **Campaign Concept of MSR**, and the discussion of the **shared sub-system LVS**

Summary of CAEO contributions to M2020

8442 reliability reviews
10712 radiation reviews
148 waiver risk assessments
748 completed ATL tasks
126 ATL FA/Physchar
597 POs placed
5 SEE, 1 DDD & 1 TID Rad tests
42 major EEE part issues reported at MMR, then resolved
35 GIDEP/JPL ALERT impacts
277 IOMs released
>72k workhours

Mars 2020 mission timeline

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Landing site shortlist February 2017	Design and build run thru late 2019	Launch Summer 2020	Cruise to Mars Late 2020/ early 2021	Landing on Mars early 2021	Surface Operations 2021

Perseverance is currently in healthy status and operating on MARS!

Covid Pandemic impacted late stages of Phase D and current Phase E.

The Mars 2020 Rover: Robotic Field Geologist + Astrobiologist

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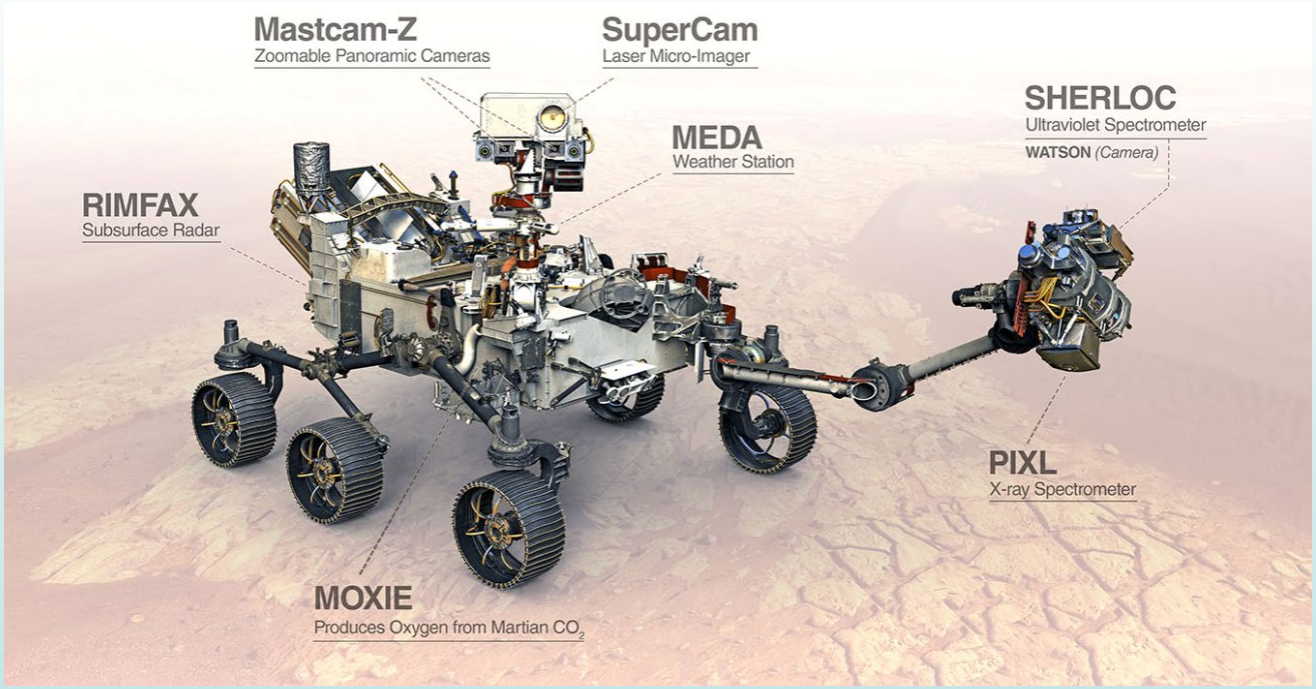

mars.nasa.gov

New types of instruments to measure fine-scale mineralogy, elemental composition of rocks for determining habitability, detecting biosignatures

PIXL & SHERLOC

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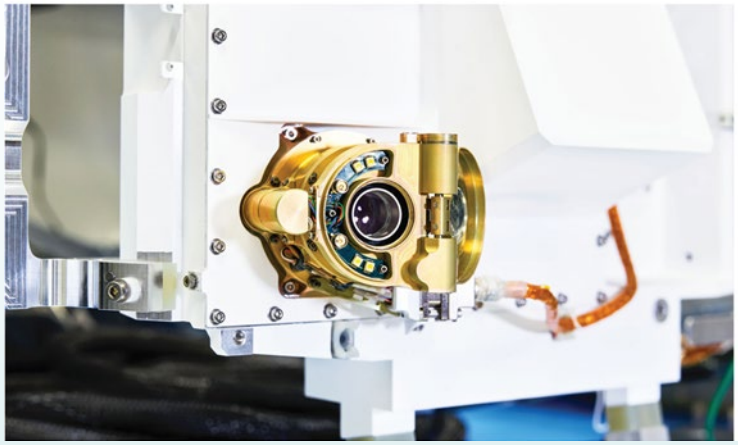
M2020 primary instruments mounted on turret arm

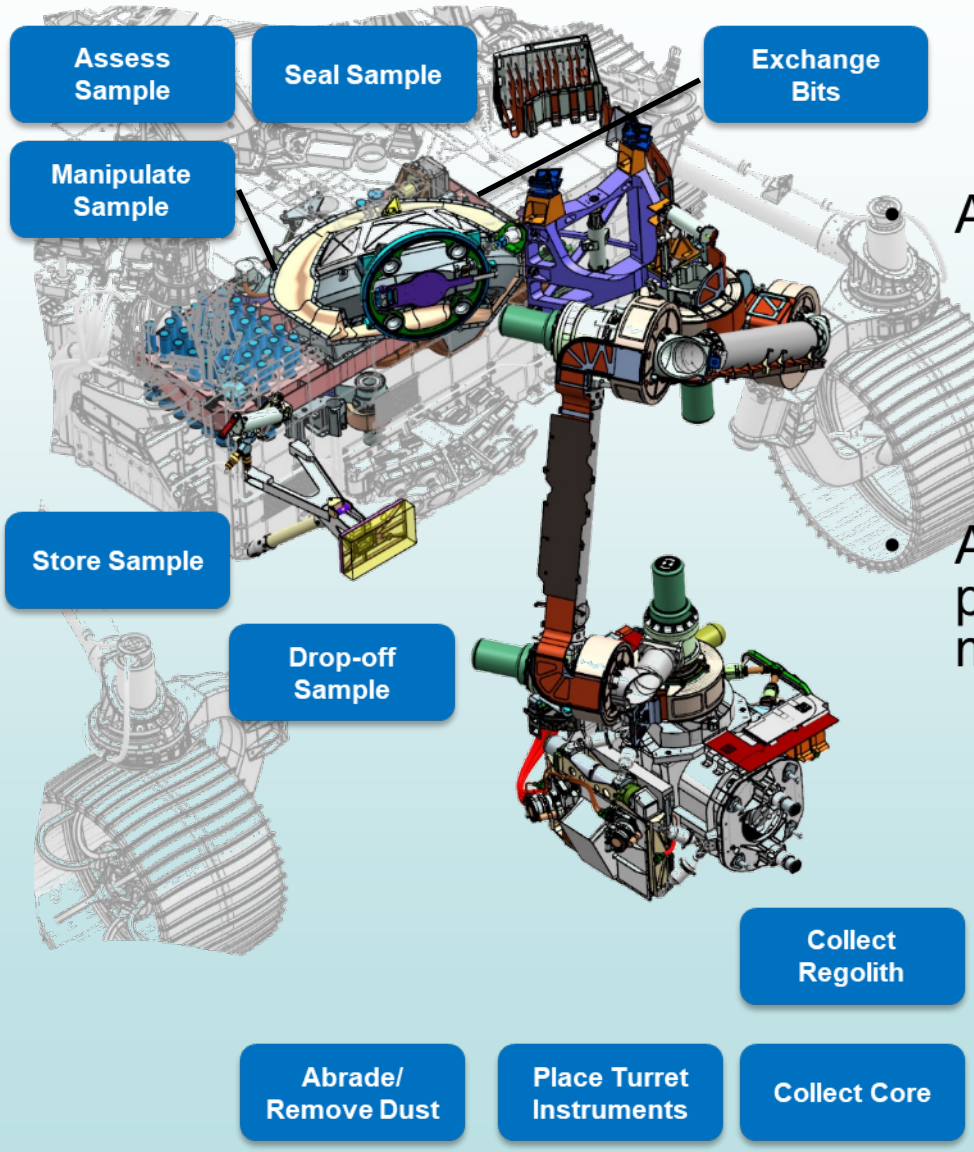


"The Scanning Habitable Environments with Raman & Luminescence for Organics & Chemicals (SHERLOC) is an arm-mounted, Deep UV (DUV) resonance Raman and fluorescence spectrometer utilizing a 248.6-nm DUV laser and <100 micron spot size. SHERLOC enables non-contact, spatially resolved, highly sensitivity detection and characterization of organics and minerals in the Martian surface and near subsurface."

"The Planetary Instrument for X-ray Lithochemistry (PIXL) for the Mars-2020 rover is an X-ray fluorescence instrument that rapidly measures elemental chemistry at sub-millimeter scales by focusing an X-ray beam to a tiny spot on the target rock or soil and analyzing the induced X-ray fluorescence."

mars.nasa.gov

Sampling & Caching Subsystem (SCS)



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Accommodate PIXL & SHERLOC
- Prepare surfaces
  - Abrade and remove dust
- Position on targets in workspace
- Position on instrument calibration targets on Rover

Acquire, document, prepare, and place on the surface Martian materials and blanks
- Acquire rock cores and regolith
- Accommodate and manipulate witness plate assemblies
- Assess samples (vision and volume)
- Seal samples
- Store samples
- Drop prepared samples on Mars

Jezero Crater- Fan Delta Selected as Perseverance Landing site

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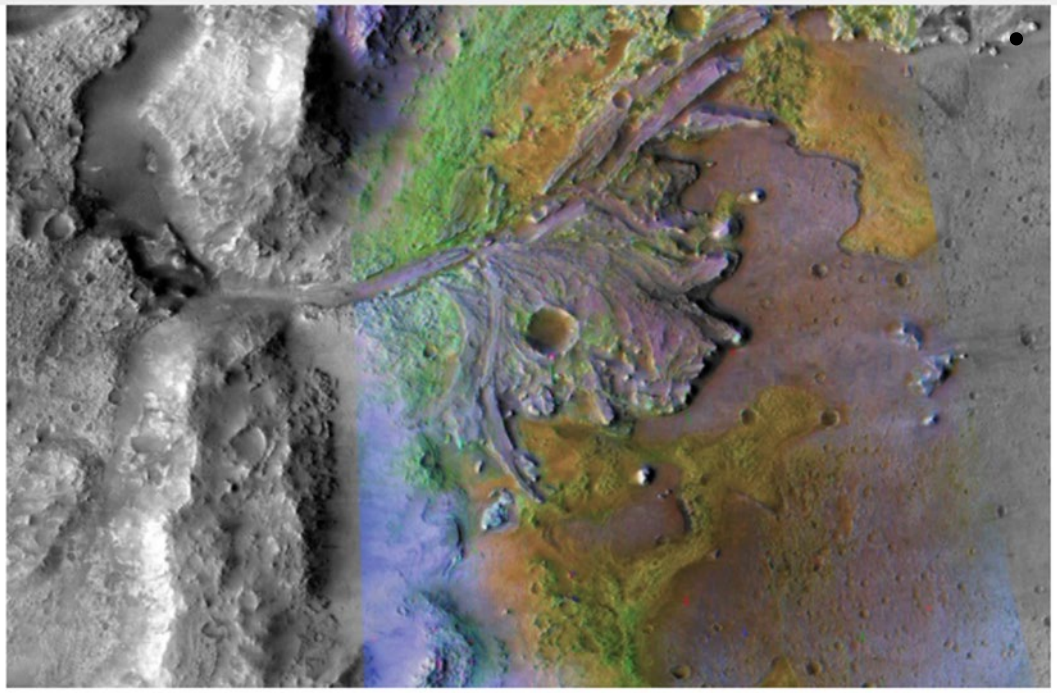

https://science.nasa.gov/

"Jezero Crater tells a story of the on-again, off-again nature of the wet past of Mars. More than 3.5 billion years ago, river channels spilled over the crater wall and created a lake. Scientists see evidence that water carried clay minerals from the surrounding area into the crater lake. Conceivably, microbial life could have lived in Jezero during one or more of these wet times."

NEPAG

Assemble a Returnable Cache of Samples

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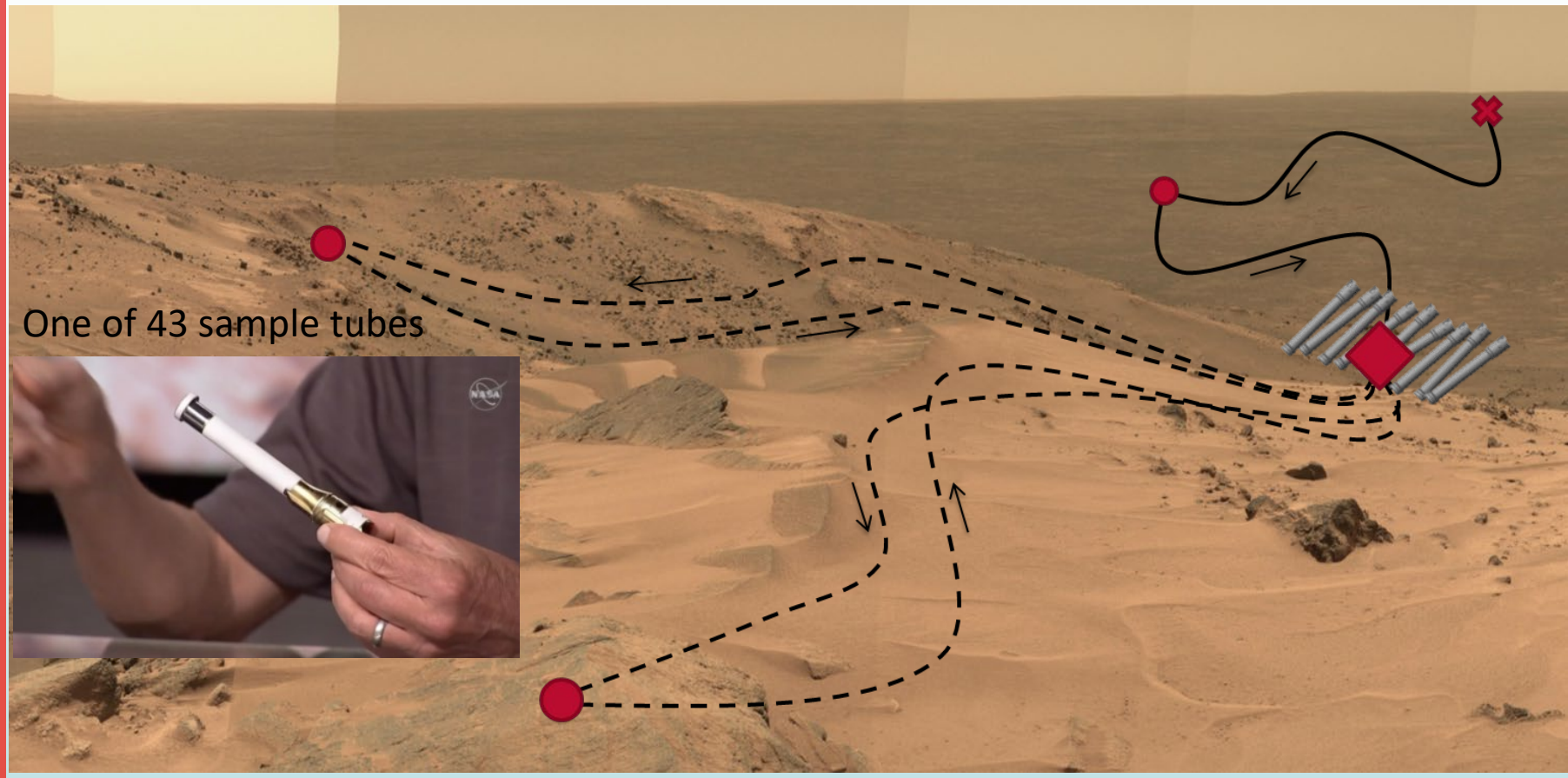

Mars 2020 would enable an enormous leap in Mars science from eventually returning to Earth a cache filled with compelling rocks and soils for analysis using the full power of the world's laboratory capability.

Planned MSR Campaign

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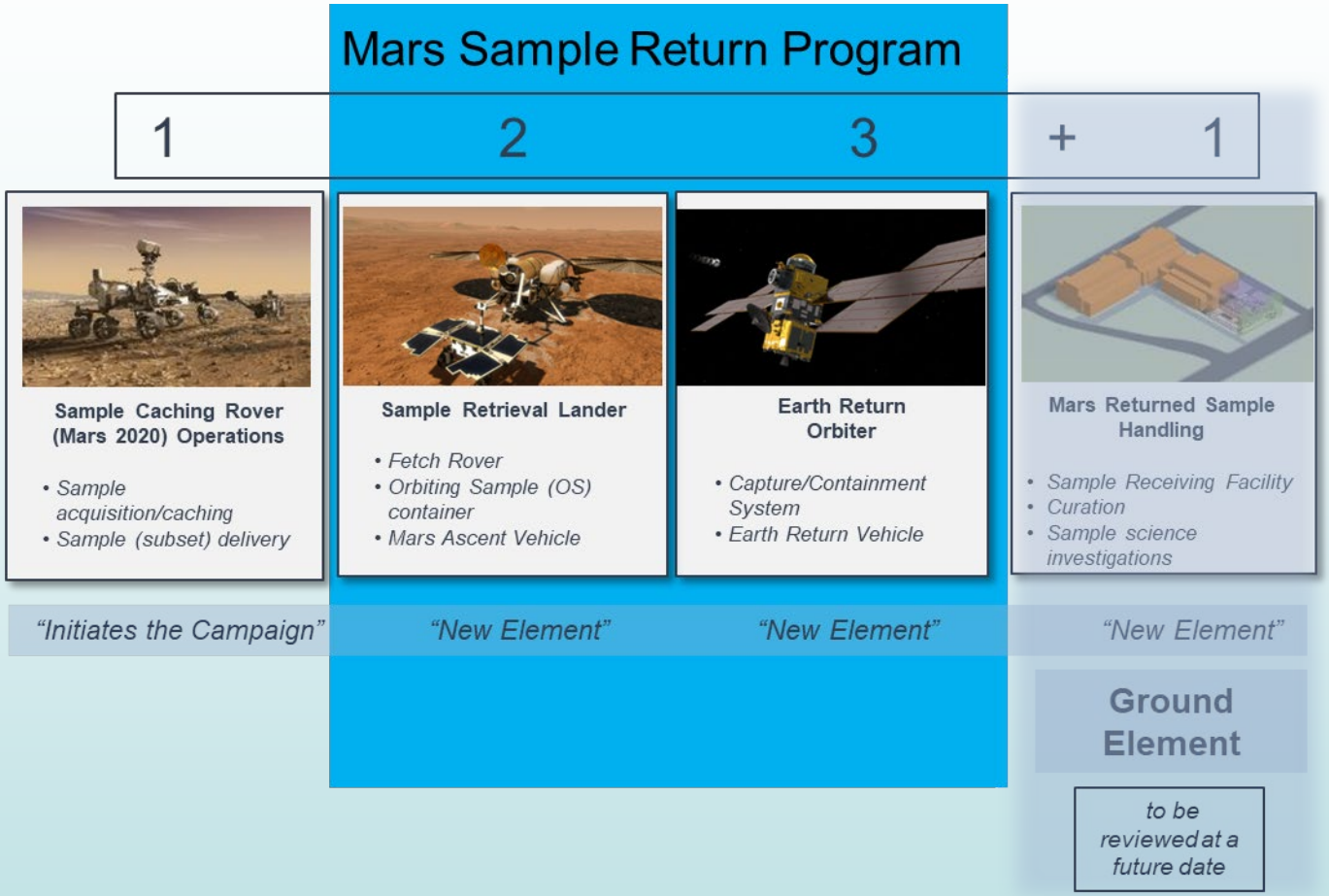
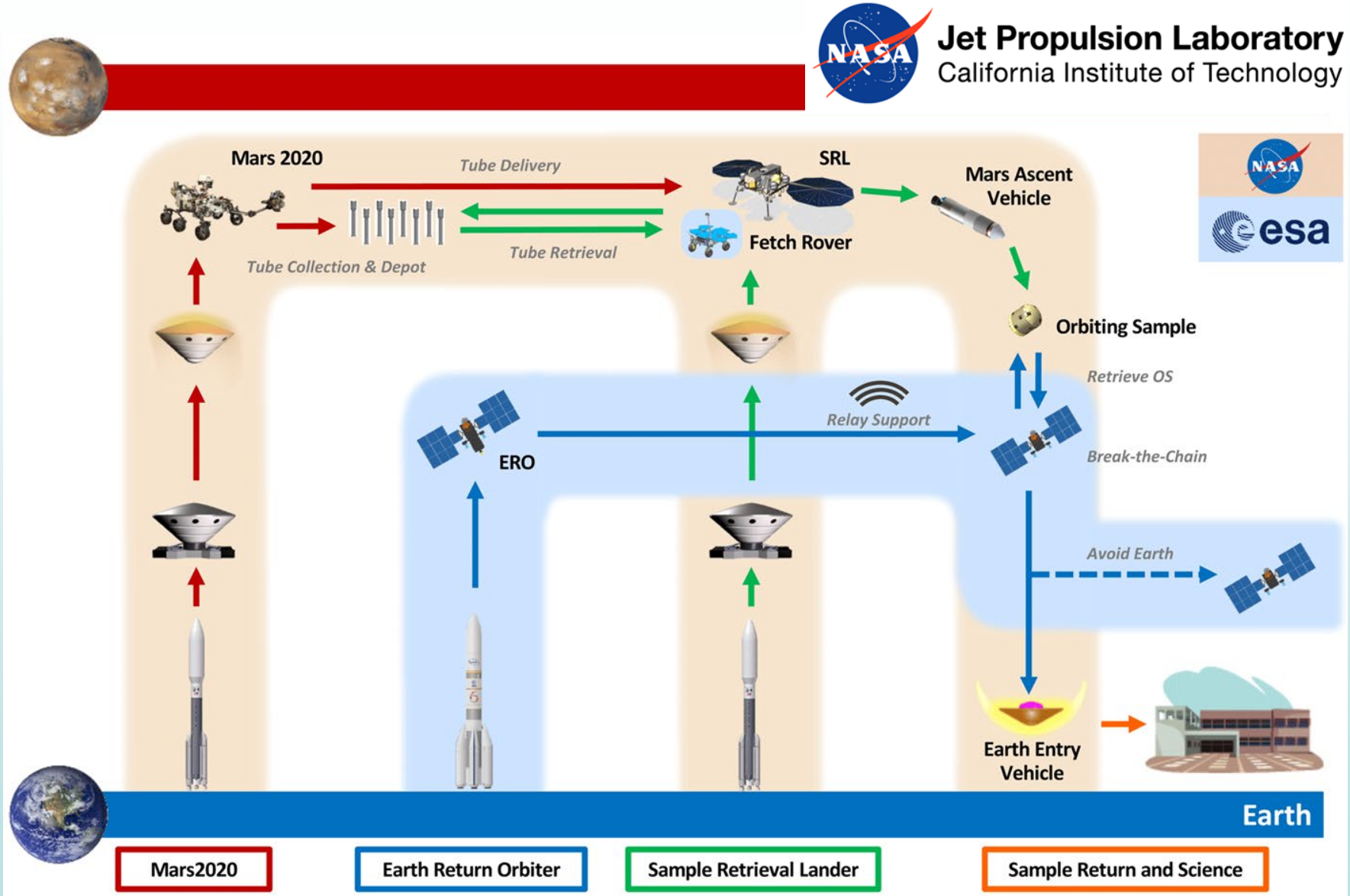


- The MSR Campaign spans three launches and one ground element
- The MSR Program manages development and operations of elements 2 and 3 above and interfaces to elements 1 and 4; program concludes with recovery/containment of OS for transfer to SRF
- The MEP Program manages M2020 Phase E operations & will be the home of the future SRF Project

Planned MSR Overall Campaign Flow



Pre-Decisional Information – For Planning and Discussion Purposes Only

Major MSR Flight Elements

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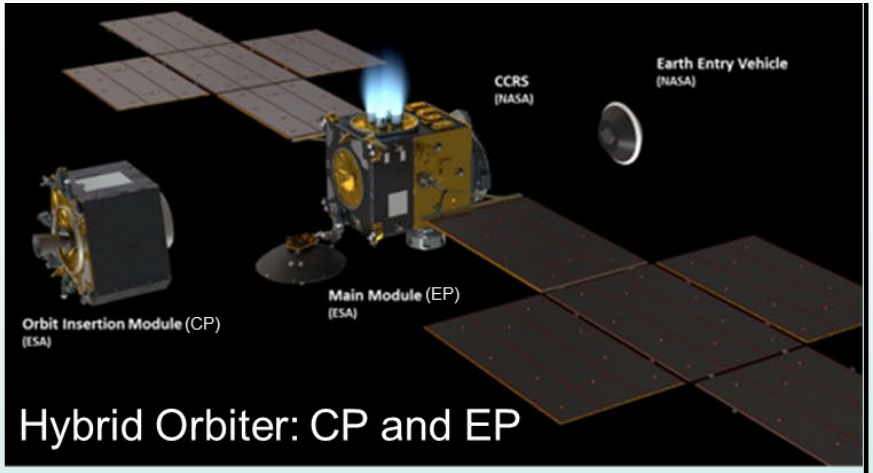
ERO Mission Concept



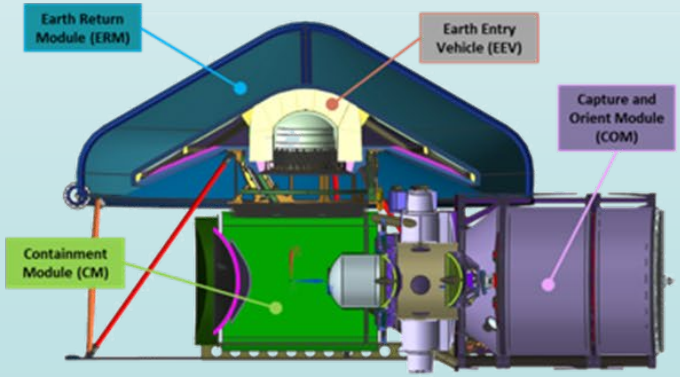
SRL Mission Concept

Platform

Cruise & EDL
(ballistic cruise option)

Mars Ascent Vehicle

Capture, Containment and Return System (CCRS)



Sample Fetch Rover

Orbiting Sample

SRL Mission Concept overview

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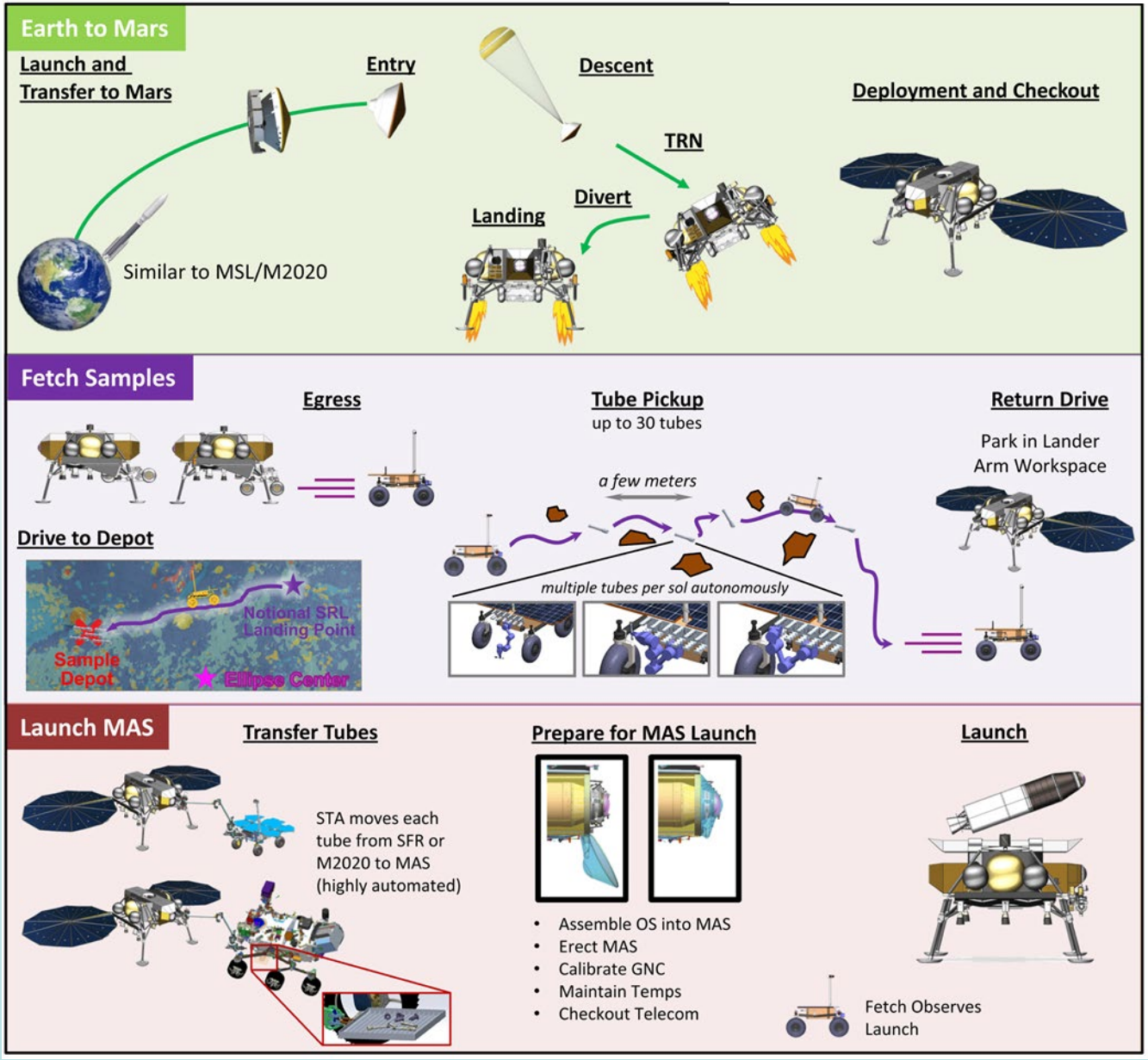

Landing Vision System - LVS

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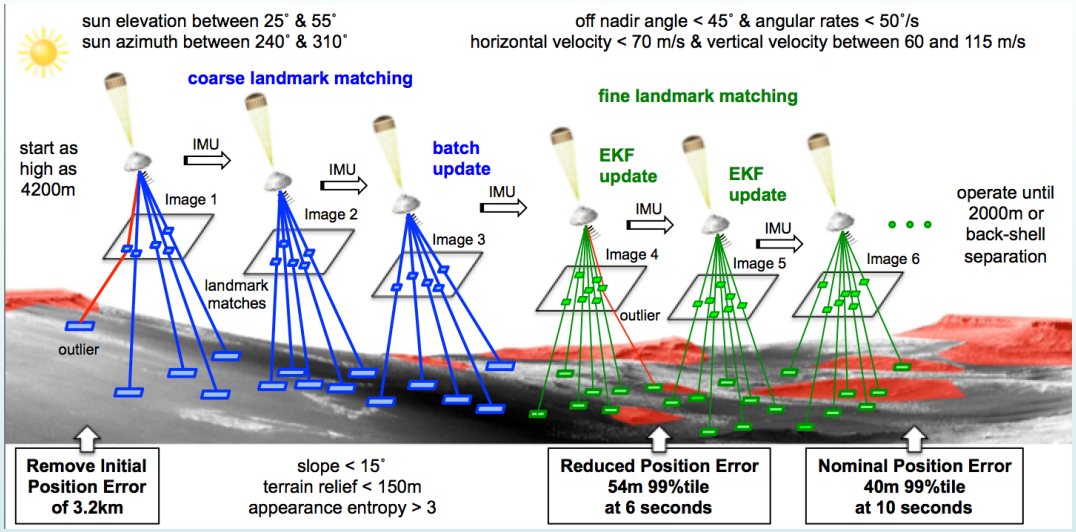
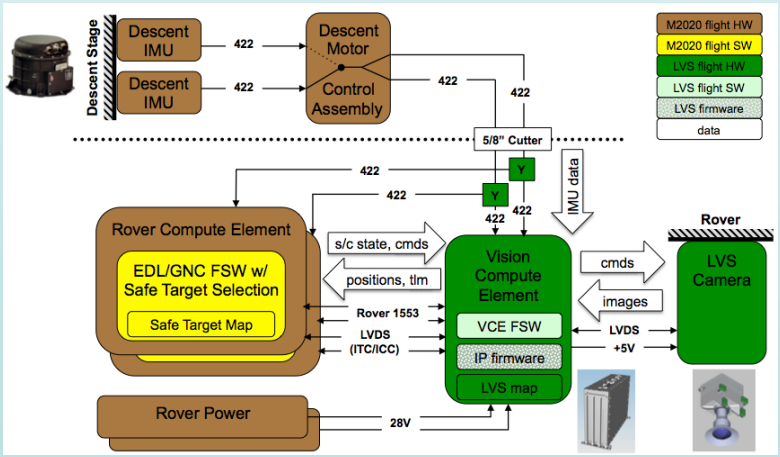
- LVS is JPL's solution for Terrain Relative Navigation (TRN).
- LVS hardware includes the Landing Camera (LCAM) and Vision Compute Element (VCE)





- Landing Error with just IMUs alone could be as high as 3.2km from desired landing location.
- LVS will decrease error to 40m.
- Estimates location by comparing LCAM camera images to map data (from MRO) with IMU data.
- Processes hundreds of landmarks in <10sec
- Storage and access of map data and LVS output is critical

THE LANDER VISION SYSTEM FOR MARS 2020 ENTRY DESCENT AND LANDING-Johnson, Aaron, Chang

Vision Compute Element

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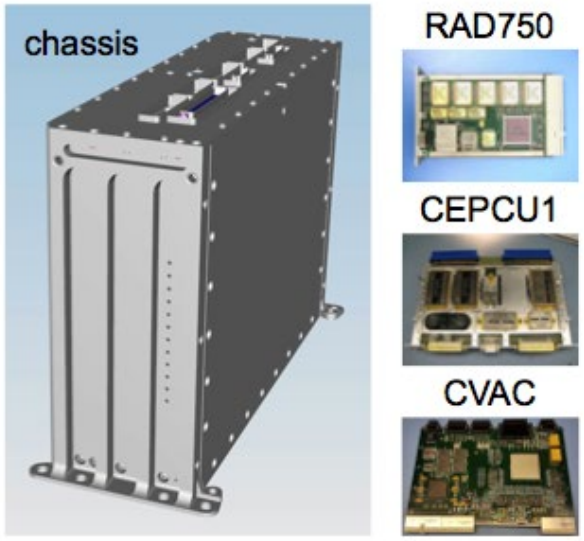

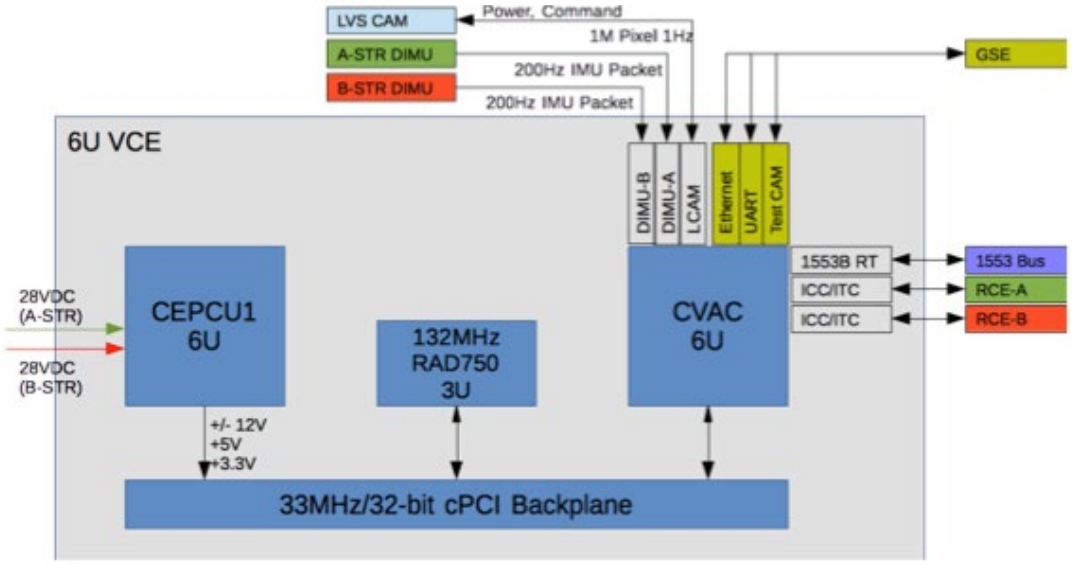

"The VCE has three cards that fit in a custom 6U chassis and interface over a standard cPCI backplane. The 28VDC provided to the VCE is converted to the necessary internal voltages by the Compute Element Power Conditioning Unit 1 (CEPCU1). The CEPCU1 provides power to the other cards in the box as well as the LCAM. A BAE RAD750 flight processor board provides a general purpose processing capability that runs the VCE flight software described below. Both the CEPCU1 and the RAD750 are build-to-print designs from MSL."

The Computer Vision Accelerator Card (CVAC) is a new card developed for LVS on Mars 2020

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Computer Vision Acceleration Card- CVAC

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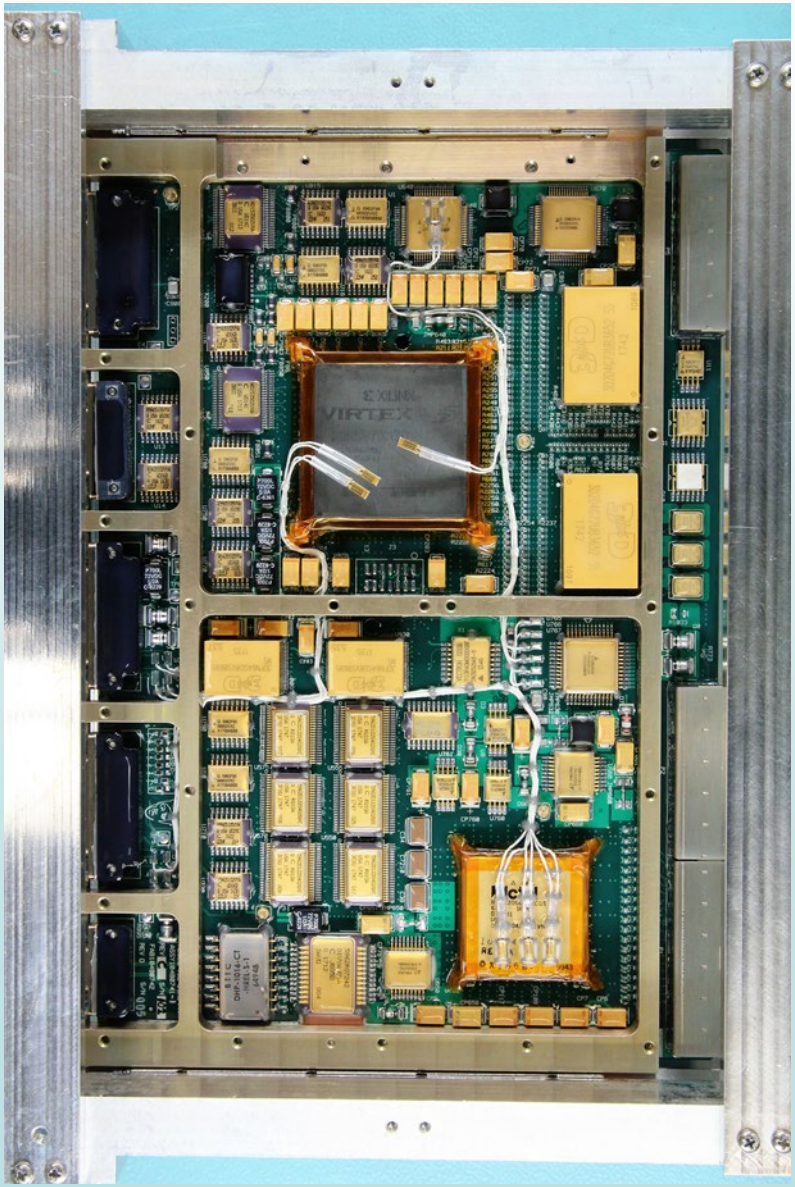

- CVAC provides all of the data interfaces for the VCE including: DIMU, LCAM, 1553 and ITC/ICC. It also provides serial UART and Ethernet ports.
- Two FPGAs and significant memory for rad-hard non-volatile storage (32 MB NOR), intermediate processing (1 GB DDR2 SDRAM) and **data products.**
- The Vision Processor FPGA (VP) on the CVAC is a **Virtex5QV** FPGA containing image processing modules required to match landmarks at high rate to achieve the LVS processing time requirements.
- The VP controls access to the DDR2 and NAND memory and it contains the logic
- Interface to the LVS sensors: the LCAM through an asynchronous serial command interface and channel-link for image data, and the DIMU data through RS-422.
- The VP is fully reprogrammable and it is loaded by the second “Housekeeping” FPGA (HK) on the CVAC.
- The HK is a burn once RTAX 2000 which handles the time synchronization with the spacecraft, power management, VP configuration, NOR memory management, ADC and the 1553 and ICC/ITC spacecraft interfaces.

NAND Block Memory using Commercial NAND Flash TSOP

3DFN64G08VS8695

GENERAL DESCRIPTION

The 3DFN64G08VS8695 is a high-density non-volatile NAND Flash memory is organized as 8G x 8. Each 8 Gbit NAND device is organized as 1G x 8 bits, and can be accessed by activating the associated control signals: #CE*n*, #WE*n*, #RE*n*, #RB*n* (*n* from 0 to 7).

Using high performance and high reliability CMOS technology combined with 3D PLUS patented stacking technology, this FLASH memory module provides an area efficient solution for high capacity data storage needs.

NAND flash stores data products which include the map data, algorithm outputs, including LVS results and all LCAM images

In 2010 Irom and Nguyen reported on SEU, SEFI, and TID results for TSOP testing.
"At one end of the spectrum, flash memories are used to store small amounts of mission-critical data such as boot code or configuration files and, at the other end, **they are used to construct multi-gigabyte data recorders that record mission data."** Radiation Tests of Highly Scaled, High-Density, Commercial, Nonvolatile NAND Flash Memories—Update 2010, Irom, Nguyen

One key finding "The differences between SEU susceptibility between SLC and MLC devices are clearly noticeable by comparison of data presented…The SLC 5-nm part (8 Gb) is less susceptible than is the MLC 32-nm part (32 Gb)."

In 2015, 3DFN64G08VS8695 introduced into market after manufacturer's qualification

http://nepp.nasa.gov

ACKNOWLEDGMENTS

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Jason Heidecker, JPL CEAO Digital Specialist

JPL LVS/VCE team-Johnson, Umsted, Bergh, Schroeder, Zheng, …