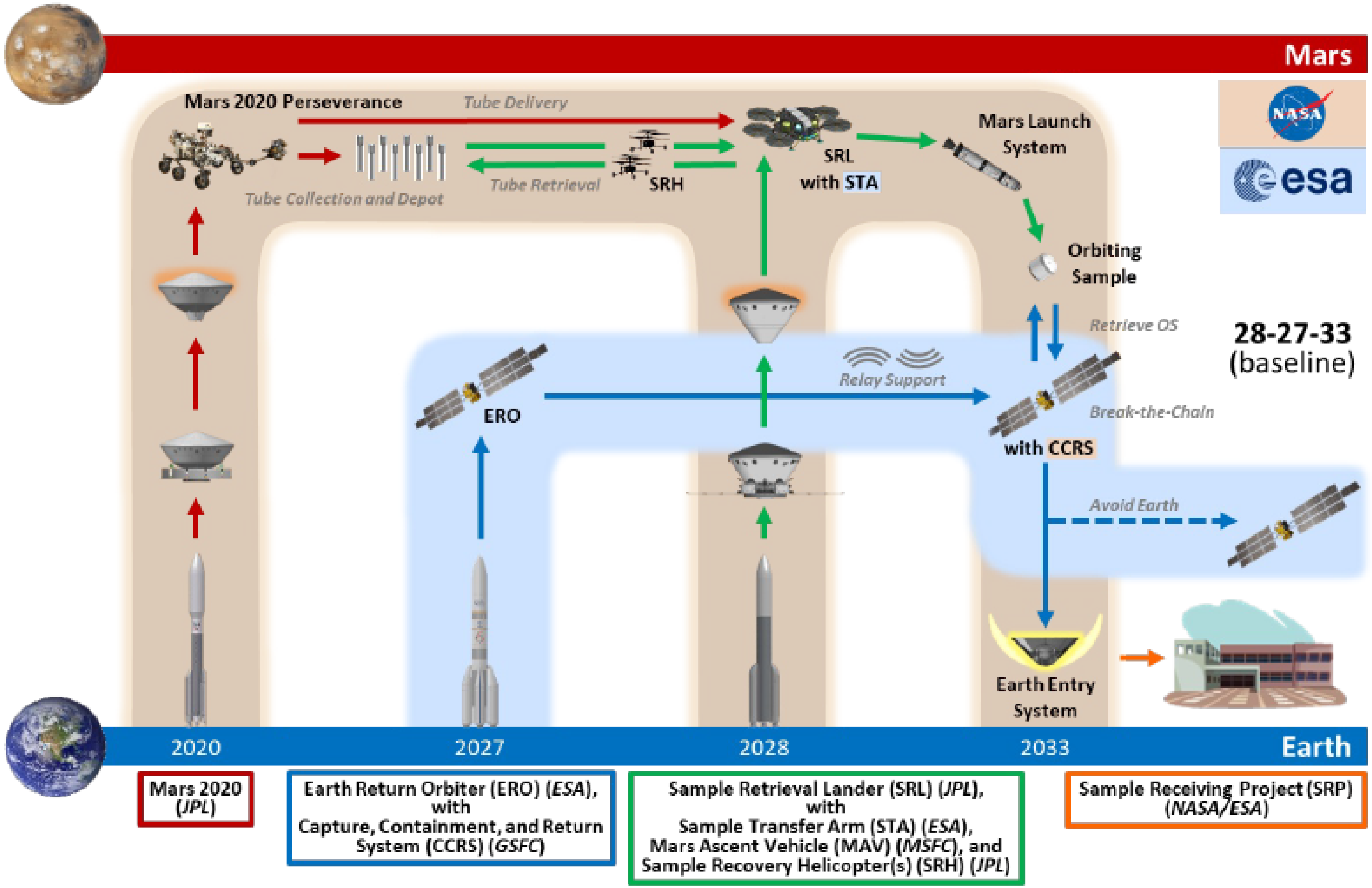
National Aeronautics and Space Administration

NASA

NASA/ESA
MARS SAMPLE RETURN

Mars Sample Return (MSR)

COSPAR PPP
April 26, 2023



Credit: Jeff Gramling and Michael Meyer

High Priority MSR Science Objectives Can be Addressed by Samples Collected So Far:

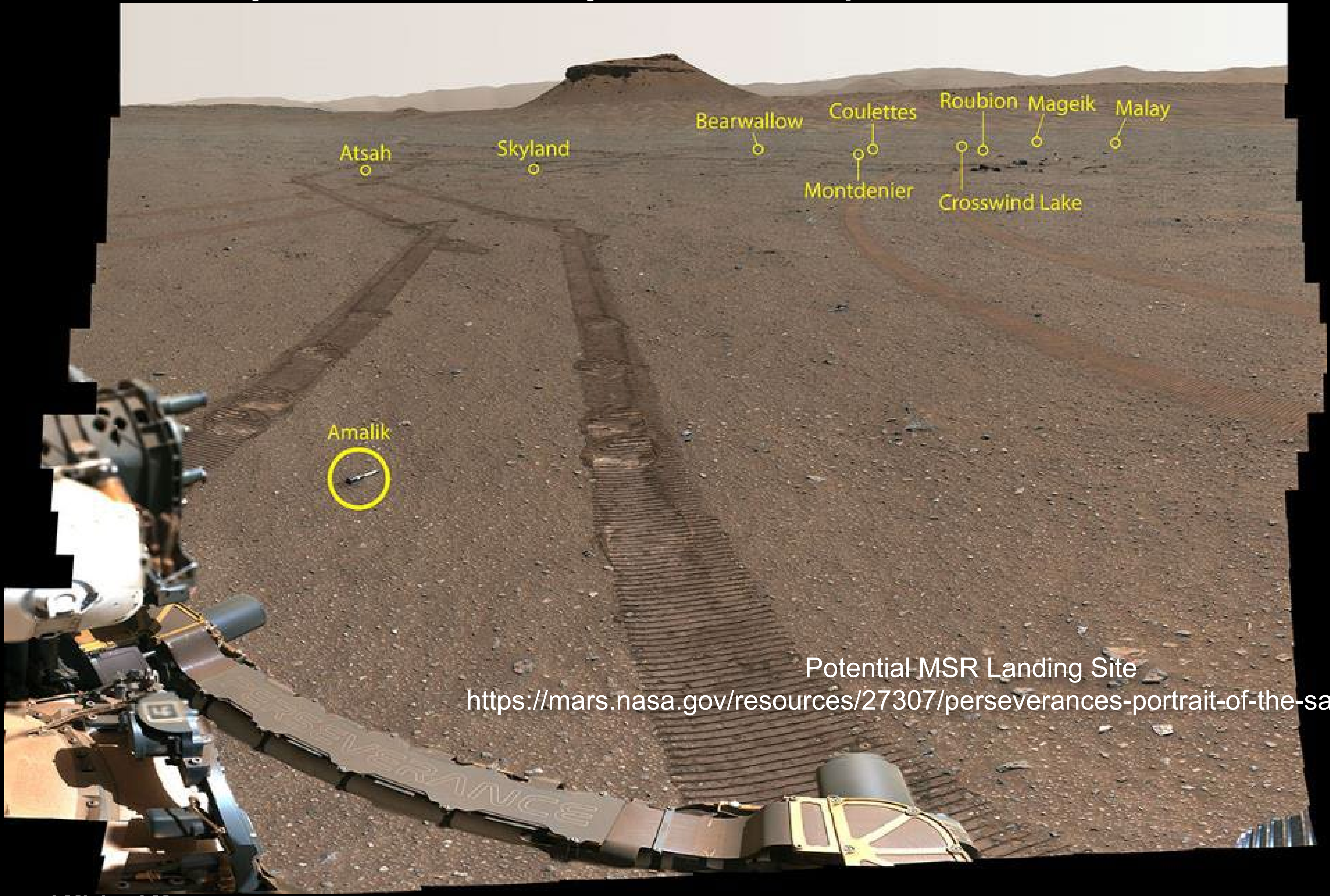
- ✓ Igneous rocks from the crater floor: absolute ages of units in Jezero crater to anchor the ages of Martian epochs; magmatic evolution on Mars
- ✓ Sedimentary rocks from the delta front: promising target for the search for evidence of ancient life
- ✓ Aqueous alteration products: insights into the history of near-surface water in this region of Mars
- ✓ Likely presence of organics: deduce origins (biogenic vs. abiogenic)
- ✓ Samples will also address gaps in our knowledge of concern to future human exploration

Green highlights tubes cached at Three Forks

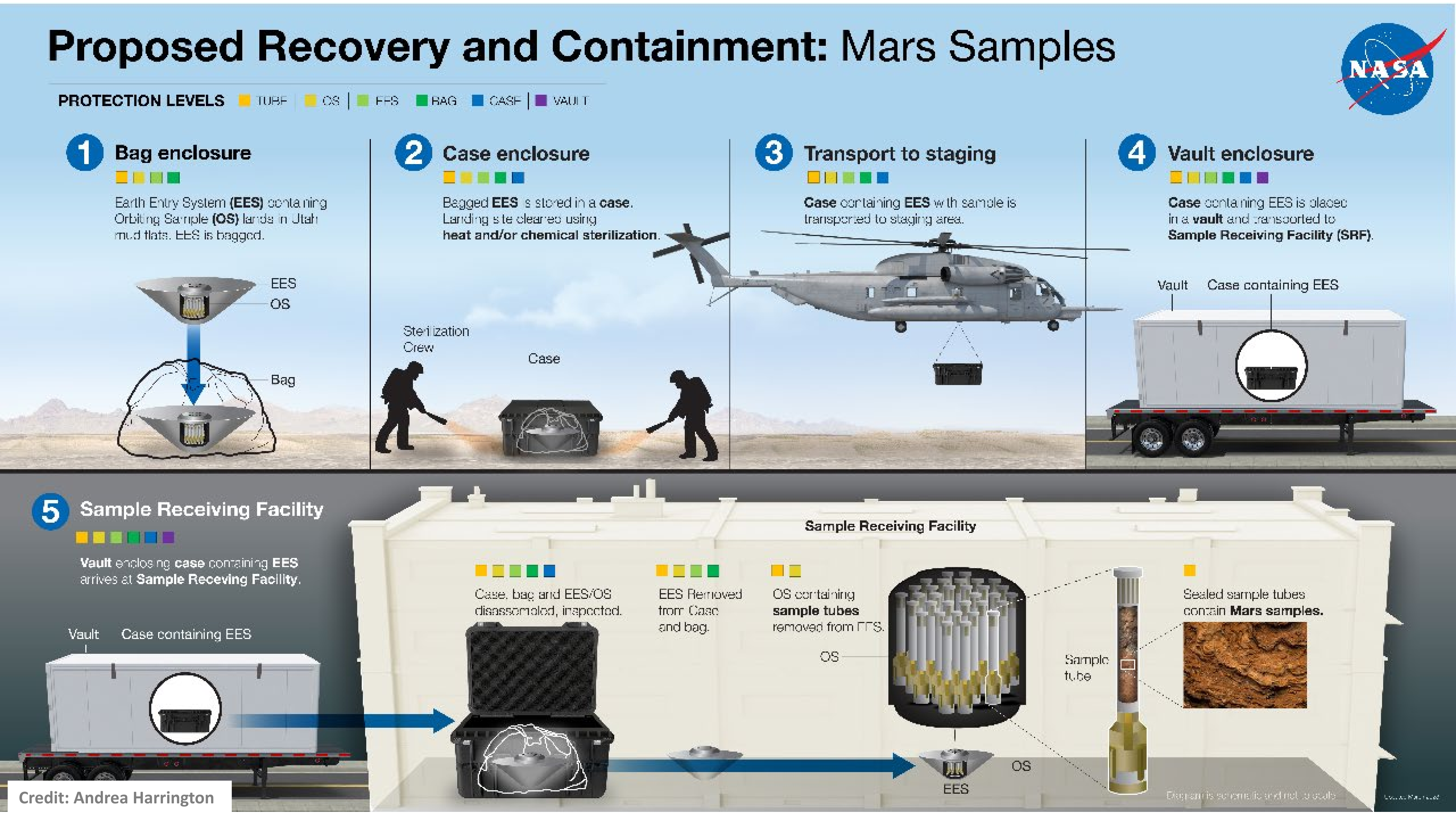
Credit: Jeff Gramling and Michael Meyer

*Beaty, et al. (2019)

Scientifically Return-Worthy Cache Deposited at Three Forks



Credit: Jeff Gramling and Michael Meyer



Proposed Recovery and Containment: Mars Samples
NASA
PROTECTION LEVELS TUBE OS EES BAG CASE VAULT
1 Bag enclosure
Earth Entry System (EES) containing Orbiting Sample (OS) lands in Utah mud flats. EES is bagged.
EES
OS
Bag
2 Case enclosure
Bagged EES is stored in a case. Landing site cleared using heat and/or chemical sterilization.
Sterilization Crew
Case
3 Transport to staging
Case containing EES with sample is transported to staging area.
4 Vault enclosure
Case containing EES is placed in a vault and transported to Sample Receiving Facility (SRF).
Vault
Case containing EES
5 Sample Receiving Facility
Vault enclosing case containing EES arrives at Sample Receiving Facility.
Vault
Case containing EES
Sample Receiving Facility
Case, bag and EES/OS disassembled, inspected.
EES Removed from Case and bag.
OS containing sample tubes removed from EES.
OS
EES
OS
Sample tube
Sealed sample tubes contain Mars samples.
Diagram is schematic and not to scale
Credit: Andrea Harrington

MSR SRF Capabilities and Priorities

Receive Spacecraft

↓

Hardware Disassembly

↓

Sample Tube
Pre-Basic Characterization

↓

Samples Opened and
Basic Characterization

↓

Samples Picked
and/or subdivided → Sample Safety Assessment, Preliminary Examination, and/or Select Early Science

↓

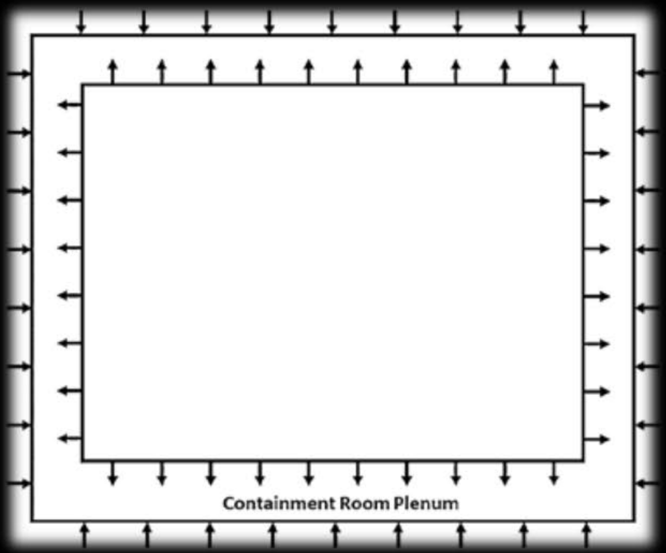
Allocated Sample
Sterilization Process
(Irradiation or Heat) → Global Safe Sample Distribution for Earth-based Science Investigations

Provide High-Containment & Contamination Control
Accommodate highest priority instrumentation
Fully operational by sample arrival
Enable rapid of release of samples

Credit: Andrea Harrington

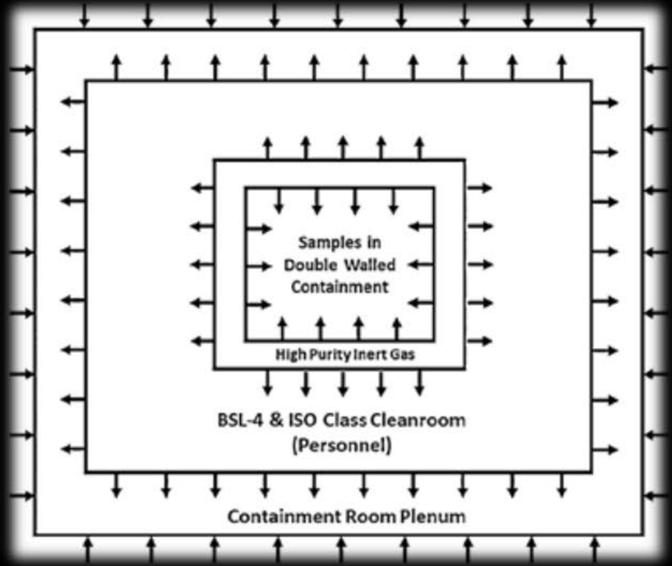
This combined effort requires the integration of both negative and positive pressure environments to meet the needs of PP and contamination control (CC).

Pristine Cleanroom Facilities within High-Containment



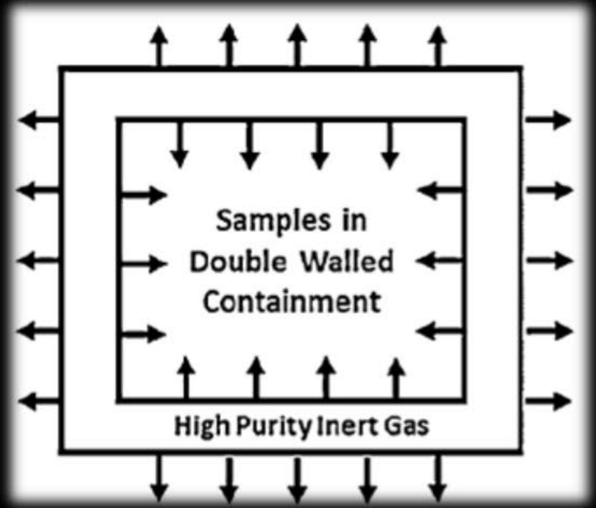
Outermost layer is negative pressure/containment to offer the greatest protection.

Combined facility and specialized isolator approach



This measure may be necessary to ensure sample pristinity is not lost to sterilization in an off-nominal event.

BSC-III Cabinet within a Pristine Glovebox



Innermost layer is negative pressure/containment to offer the greatest protection.

Credit: Andrea Harrington

Mars Sample Receiving Facility (SRF) Modality Options

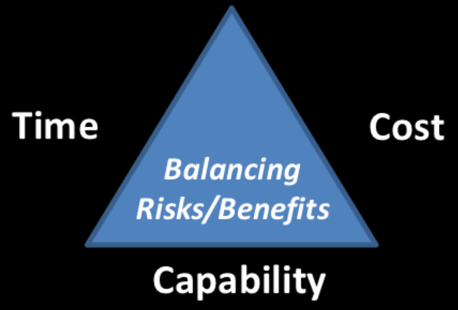
- Decommissioned Existing BSL-4 facilities ONLY
- New Traditional, Fixed High-Containment Facility
- New Modular High-Containment Facility
- Hybrid (New + Existing facilities)

Credit: Andrea Harrington

HIGHLIGHT OF OVERARCHING CONSIDERATIONS

Mars Sample Receiving Facility (SRF) Assessment Study (MSAS) –
Assess the utilization of 4 modality options and accommodation potentialities

Structural Constraints
Personnel Safety
PP Requirements
CC Requirements
Preliminary Examination Requirements
Science Requirements
Construction Timeline
Operational Timeline
Adaptability to Changing Needs
Facility Fair Use/Access to Samples
Partnership/Reutilization Opportunities
Cost Effectiveness (short and long-term)
Pristine Sample Conservation



Upon completion of the assessment studies, the preferred modality and refined requirements would be utilized for site-specific design but will not be finalized until NASA's completion of the National Environmental Policy Act (NEPA) process.

Credit: Andrea Harrington

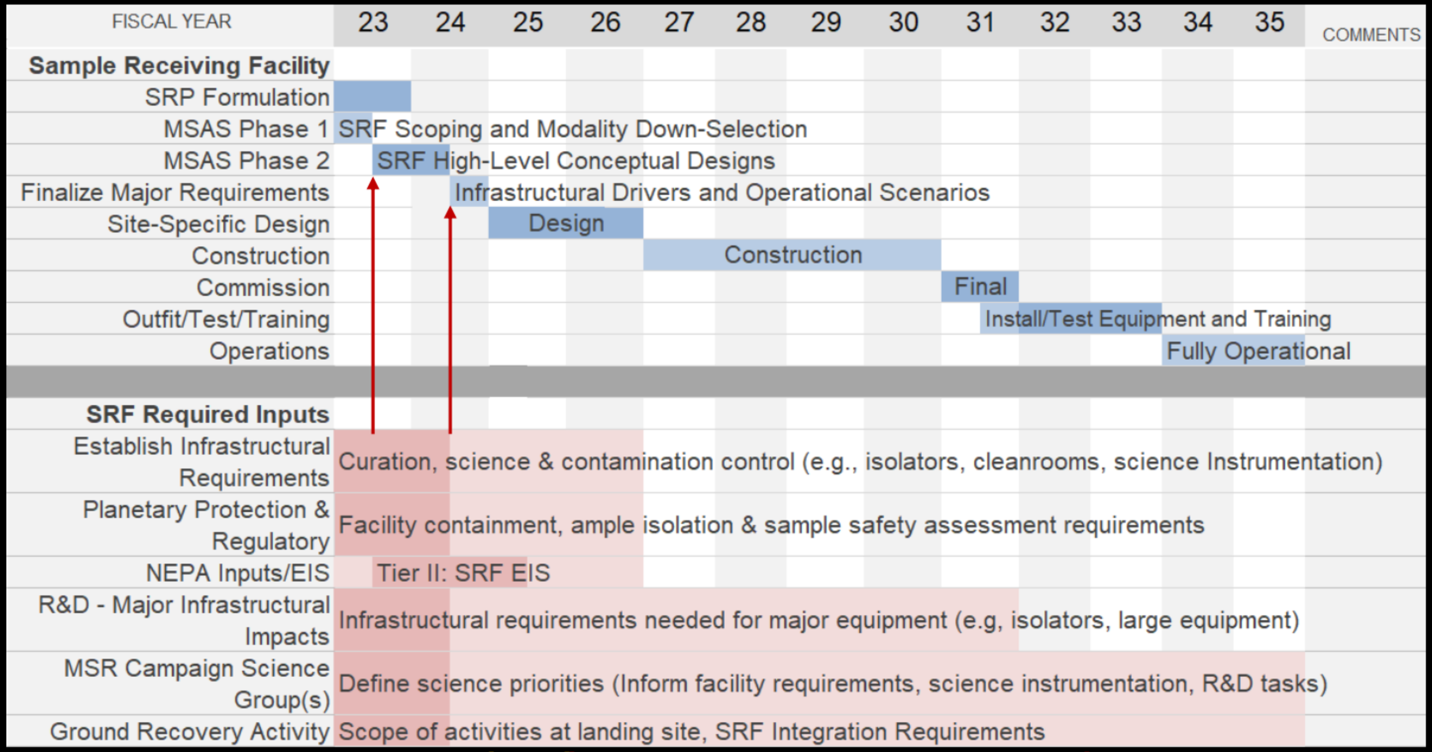
SRF Notional Instrument List

MSR SRF Instruments	SSAF	Curation & PE	Time Sen. Science	Ster. Sen. Science
Magnetometer		X		
Magnetic Susceptometer		X		
Micro-X-ray diffractometer with total scattering and pair-distribution function (PDF) analysis capability		X	X	X
Petrographic Microscope		X		X
Multispectral/Hyperspectral Imager [10-20 micron resolution]	X	X		
Variable Pressure-Field Emission Scanning Electron Microscope with electron and Focused Ion Beam (FIB) columns and multiple detectors	X	X	X	X
High Resolution X-ray Computed Tomography (HR-XCT)	X	X		
Variable Pressure-Field Emission Scanning Electron Microscope with electron columns and multiple detectors	X	X	X	X
Deep Ultraviolet Fluorescence	X	X	X	X
Confocal Raman Spectrometer	X	X	X	X
Fourier Transform-Infrared Spectrometer (FTIR)	X	X	X	X
Ultra-High Performance Liquid Chromatography Liquid Chromatography (UHPLC-MS/MS) with tandem Mass Spectrometry	X		X	X
Capillary Electrophoresis–Mass Spectrometry (CE-MS)	X		X	X
Electrospray ionization (ESI)-Mass Spectrometry AND/OR MALDI-ESI-MS	X		X	X
Matrix-assisted laser desorption/ionization time of flight (MALDI-TOF-MS)	X		X	X
Gas Chromatography (GC) Isotope Ratio Mass Spectrometer with quadrupole mass spec and higher temperature conversion elementalanalyzer (TC/EA)	X		X	X
Epifluorescence Microscope	X		X	X
DNA Sequencer and associated '-omics' equipment (see note)	X		X	X
Real-time PCR machine, i.e. a thermal cycler with fluorescence reading capability	X			
Selected Ion Flow Tube Mass Spectrometry (SIFT-MS) or Photon Transfer Reaction-Mass Spectrometry (PTR-MS)	X			X
Electron Paramagnetic Resonance (EPR) Spectroscopy–			X	X
Brunauer-Emmett-Teller (BET) surface area analysis			X	X
Optical laser spectrometer (Sample Analysis at Mars (SAM) instrument)			X	X
Inductively coupled plasma - optical emission spectrometry (ICP-OES)			X	X
Mössbauer Spectroscopy				X

Instrument list from SSAF and MSPG2 Reports (*Astrobiology 2022*)

Credit: Andrea Harrington

SRF High-Level Notional Schedule & Status



Inform Site-Specific Design
Major infrastructural impacts

Refine Workflows
Minor infrastructural impacts

Finalize Instrumentation
No infrastructural changes possible without schedule slip (programmatic risk)

On Schedule

- A&E Firms have provided final inputs for MSAS
- Preliminary Findings are under Stakeholder Review
- Released an RFI to gauge interest in the potential co-development of a new facility https://sam.gov/opp/45ac7570b2cb4c25b926bc7b858111fb/view
- Preparing for MSAS Phase 2
- Working closely with:
  - ESA on all SRF planning activities
  - International MSR Science Working Groups to develop SRF notional requirements

Pre-Decisional. For planning and discussion purposes only.

Credit: Andrea Harrington