iMARS Engineering Team

Implementation and Challenges

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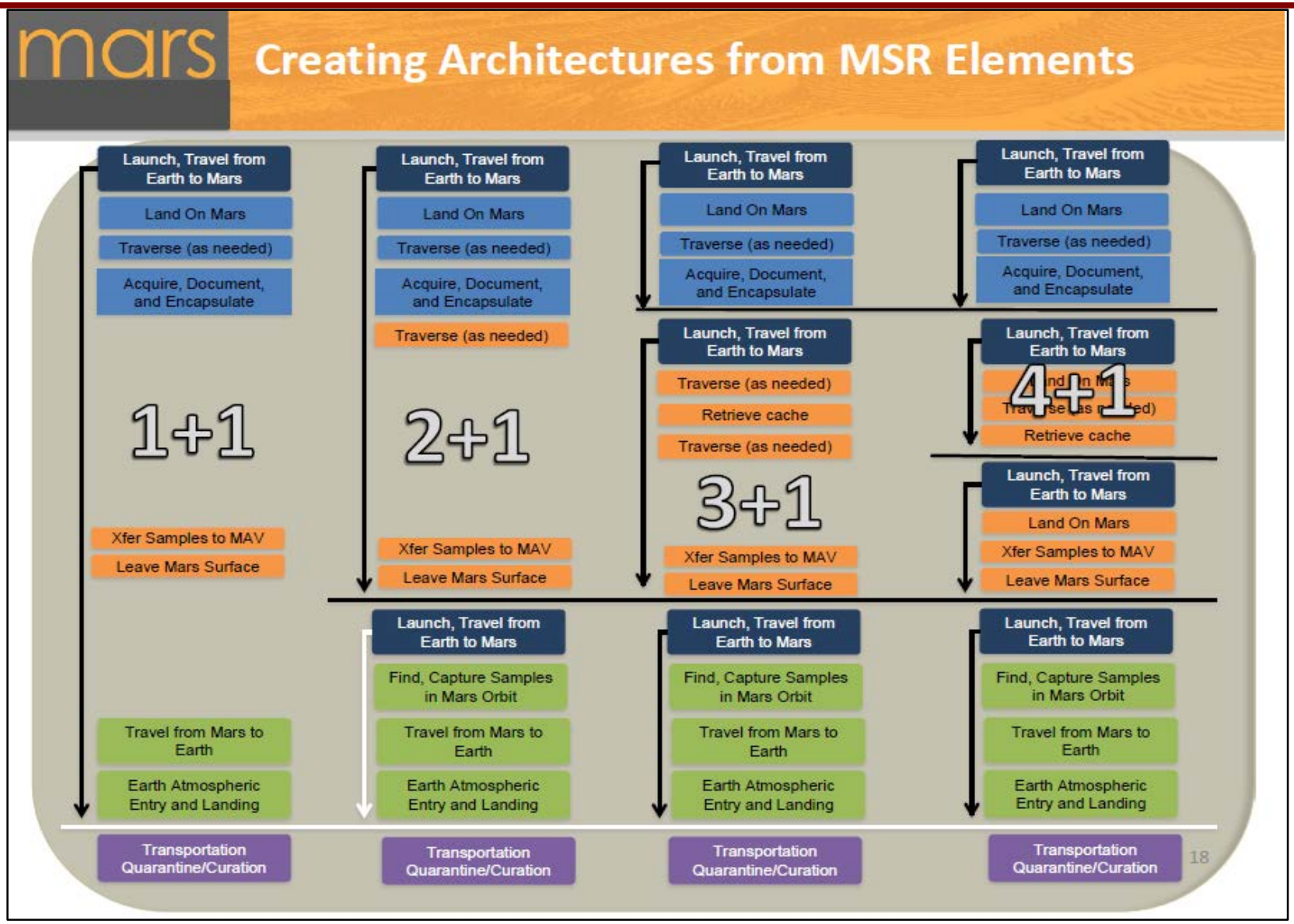
A presentation to the IEEE Aerospace Conference
March 11, 2015

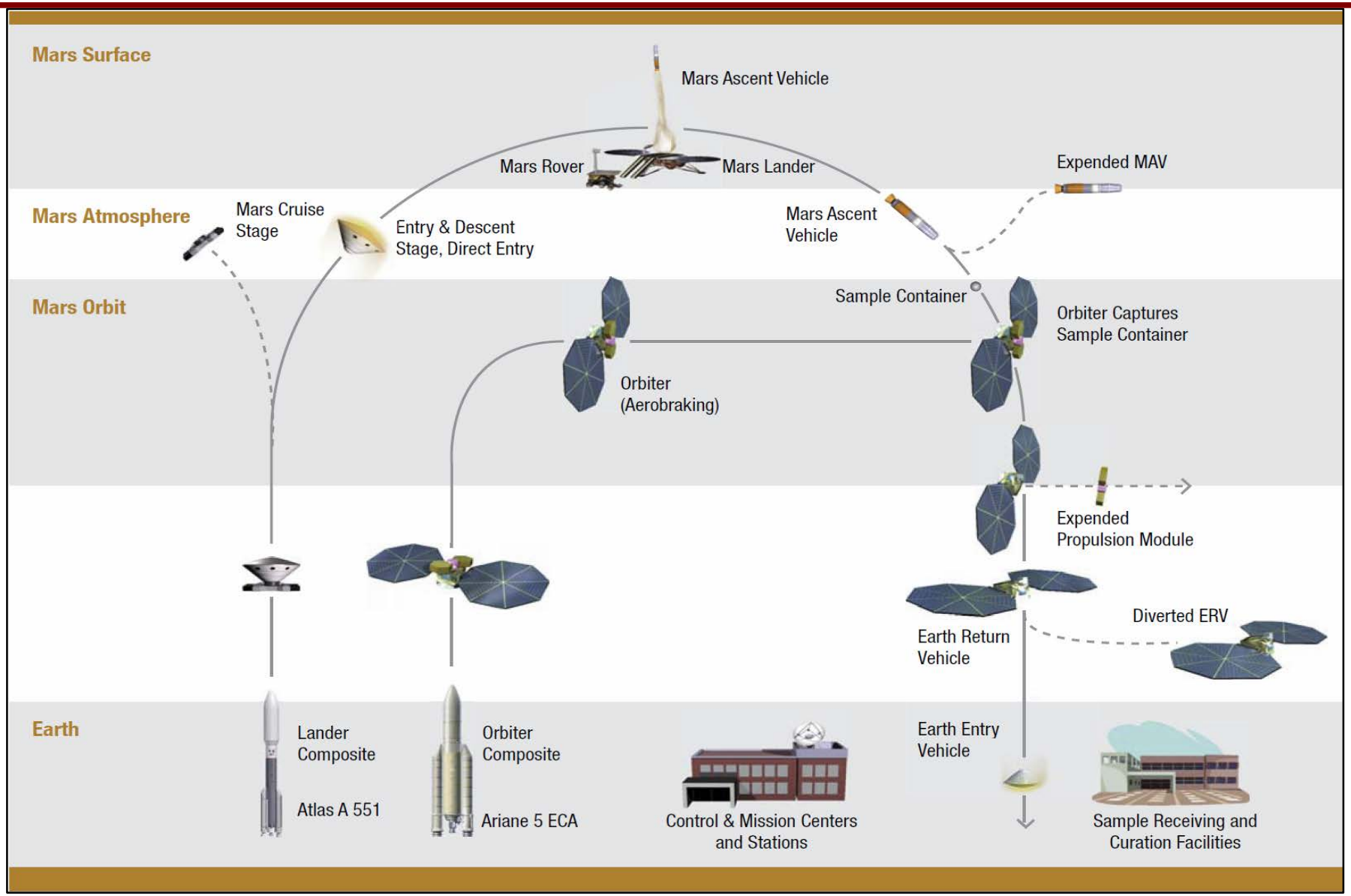
Proposed MSR Architecture Options

Jet Propulsion Laboratory
California Institute of Technology



Proposed MSR 3+1 Architecture

Jet Propulsion Laboratory
California Institute of Technology



MSR 3+1 Architecture Benefits

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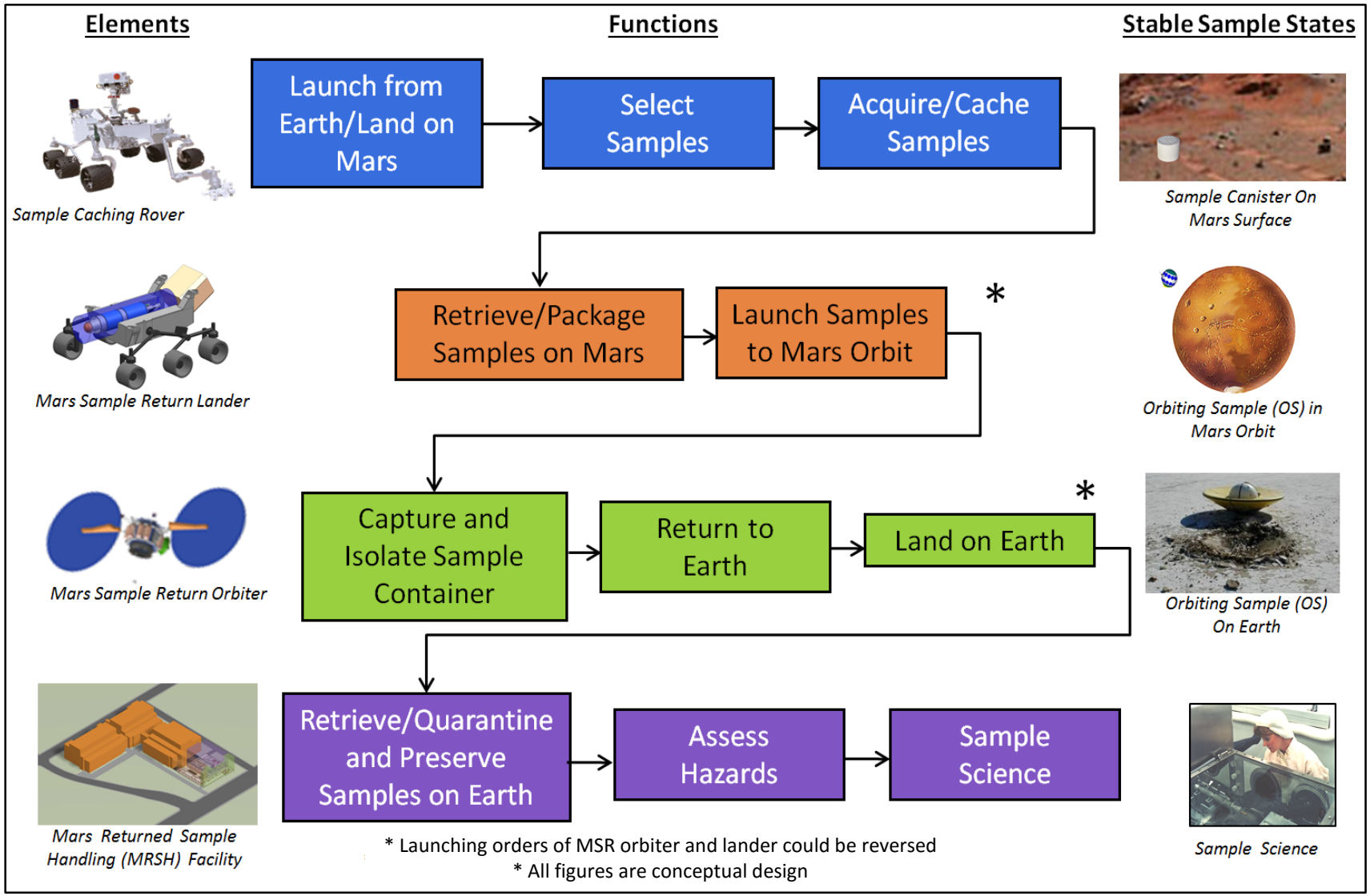
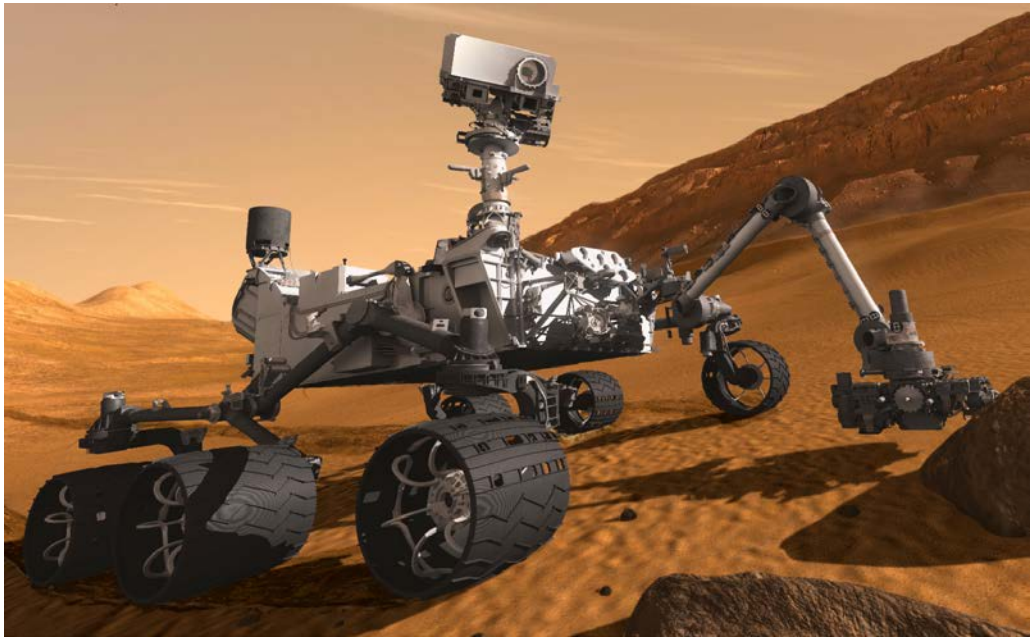


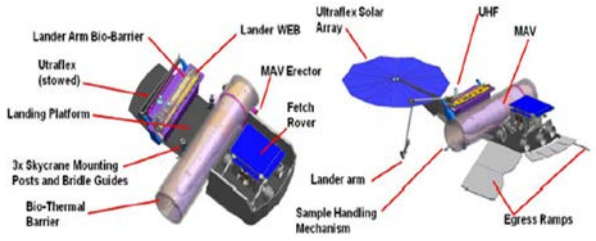
Sample Caching Rover

- SCR Functions:
  - Land in close proximity to science regions of interest (2)
  - Identify and collect scientifically selected samples (≥ 31)
  - Place the samples on the surface for recovery by subsequent mission
  - Maintain the scientific integrity of the samples

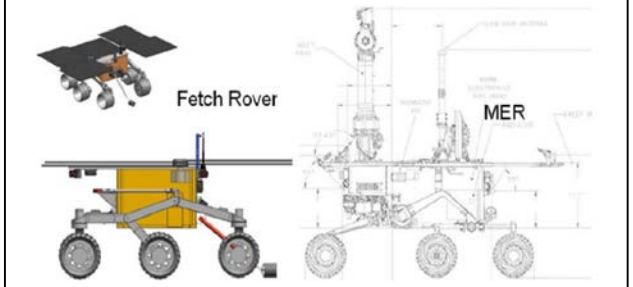


- SCR Implementation:
  - Based on an MSL rover, with MSL heritage cruise/EDL stage
  - New payload for in-situ science, sample selection, sample collection and site survey
    - Samples are rock cores and regolith
  - Capability to traverse ~20 km and sample in at least two different regions of interest
  - Ability to collect a superset of samples and downselect to final 'cache'
- Key Challenges:
  - Entry, Descent and Landing – Sufficient capability to deliver a capable rover to a landing site with enough accuracy and mass capability to access the regions of interest and collect the required samples
  - Traverse Capability – Ability to traverse from the achieved landing site to the regions of interest

Sample Retrieval and Launch



* All figures are conceptual design



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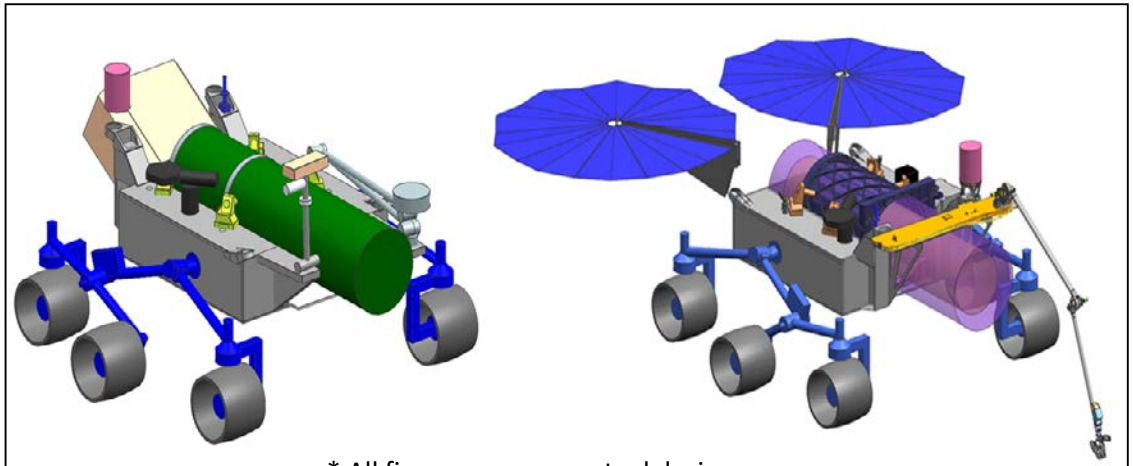

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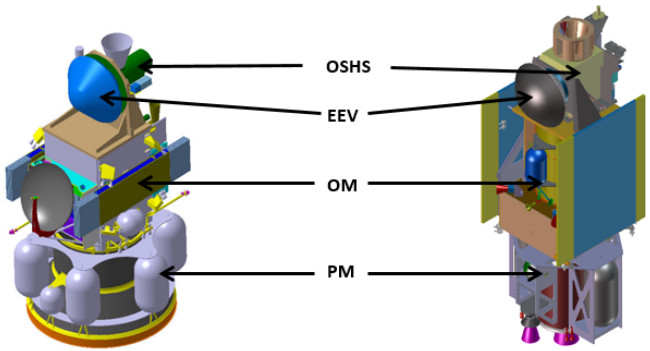
- SRL Proposed Functions:
  - Land in close proximity the cached samples
  - Retrieve the samples and place them into the MAV
  - Collect an atmospheric sample
  - Inject the samples into low Mars orbit

- SRL Implementation:
  - Two Conceptual Options:
    - Platform based lander with a fetch rover
      - Fixed platform lander with the MAV
      - Small (MER class) rover to fetch the samples and return them to MAV
      - Separate platform based sample handling system to place sample in MAV
    - 'Mobile MAV' concept based on an MSL rover platform
      - MAV would be the payload on the rover
      - MAV would be taken to the sample collection site
      - Samples would be collected and placed in the MAV for launch

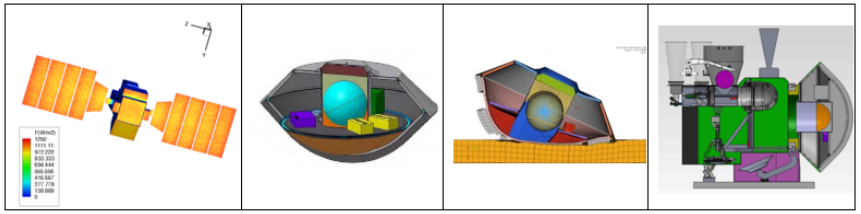
- Key Challenges:
  - Entry, Descent and Landing – Need to deliver to a landing site with enough accuracy and mass capability collect the cached samples
  - Traverse Capability – Ability to traverse from the achieved landing site to the samples (and back, for a fetch rover)

Sample Proposed Return Orbiter

- Proposed SRO Functions:
  - Achieve selected orbit which would track and/or find OS in orbit
  - Maneuver to rendezvous with the OS
  - Capture and seal the OS and place it into an EEV
  - Return to the Earth, releasing the EEV for entry at selected landing site



Design 1 *Design 2*



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- Multiple studies by US, ESA teams
  - Chemical and Electric propulsion concepts have been studied for orbit injection, rendezvous and trans-Earth Injection
    - Chemical propulsion usually augmented with aeroassist technologies (aerocapture or aerobraking) to achieve delta-V
  - Long range OS location/tracking via optical techniques
  - Close proximity tracking and capture via optical, LIDAR, autonomous terminal capture and transfer
  - OS encapsulation and EEV return requires high reliability to meet planetary protection requirements
- Key Challenges:
  - OS location, tracking, rendezvous and capture requires new capabilities, potential autonomous operations
  - Planetary protection requirements for Break the Chain of contact with Mars material presents significant challenges in containment, high reliability EDL

Mars Returned Sample Handling

- MRSH Proposed Functions:
  - Retrieve the EEV, stabilize and encapsulate for transport
  - Transport to the SRF
  - Perform sample assessment for Planetary Protection
  - Prepare samples and perform science investigations
  - Provide sample curation

- Key Challenges:
  - Developing and Understanding requirements
  - Providing architectural options for science team structure, access to samples
  - Safe, reliable transport for samples
  - Long term curation

* All figures are conceptual design

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MSR Caching Scenarios

Participation by:

Mars Program Formulation Office

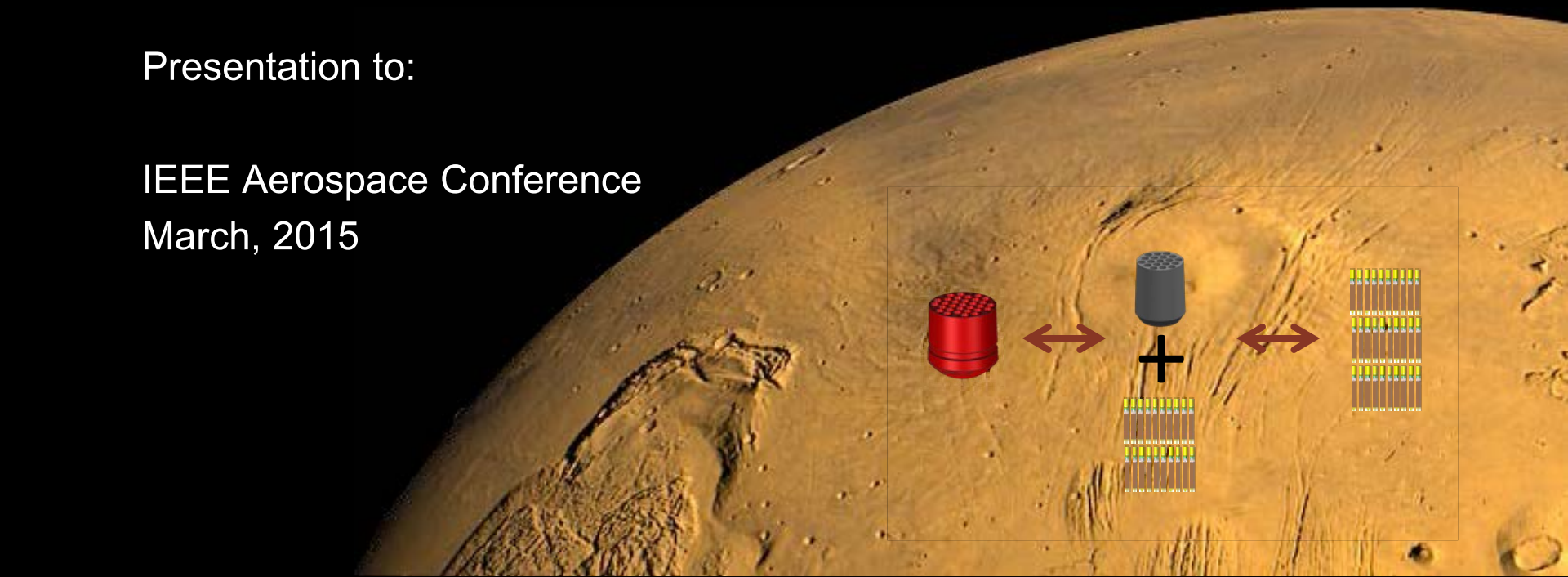
Mars 2020 Project Office

Mars Program Science Office

Presentation to:

IEEE Aerospace Conference

March, 2015



Introduction

In Summer 2014, it was suggested (Rob Manning white paper) that "cacheless" sampling may offer important benefits to MSR in comparison to a single monolithic cache:

1. **Alleviation of failure mode protection requirements on M2020**
2. **Reduction in pressure to steer clear of interesting sampling locations**
3. **Reduction in pressure to grab and drop**
4. **Go-to walkabouts are OK**
5. **Many eggs, no basket**

note: the term "cacheless" was subsequently changed to "adaptive"

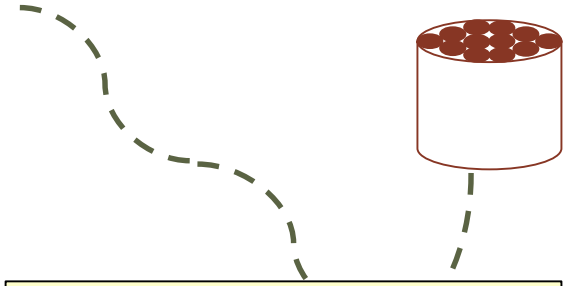
Sample 'Caching' Approaches

- M2020 "single cache" baseline:
  1. Sampling capacity: Acquire ≥31 samples; container has 31 slots.
  2. Mission success: Acquire scientifically compelling sample set from at least two regions of interest (ROI) during prime mission (one Mars year).
  3. "Returnable cache", envisioned as (but not required to be) a single container into which samples are placed.
  4. Cache would be self-extractable from M2020 (with timing determined during ops) AND by a subsequent rover in case M2020 dies before that happens.
  5. In current M2020 concept, ***delivery of the cache to the ground (i.e. self-extraction) terminates sampling operations***

- Adaptable cache eliminates the monolithic container with all samples contained as a unit
  - Samples are collected and stored on the rover
  - When 'sufficient' samples are collected, they are placed on Mars surface for later collection
  - M2020 may leave multiple sample deposits at various locations on the surface (≥31 total samples)
  - Subsequent mission would select which deposits to collect, and in what order to collect them

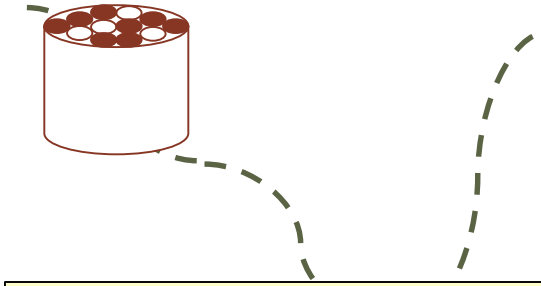
Sample Caching Alternatives

1: Full Cache



Full container, 31 samples

2: Minimum Mission Success Cache



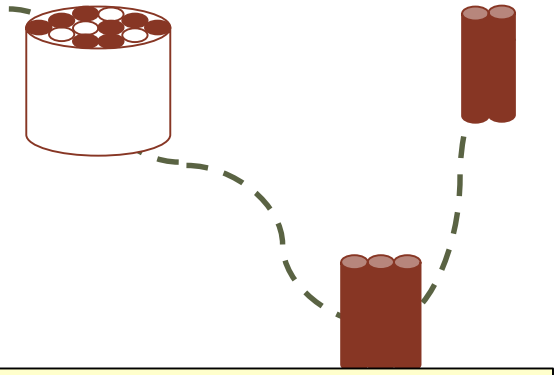
Partly full container, ~20 samples

Segmented or Redundant Cache(s)

NOT VIABLE

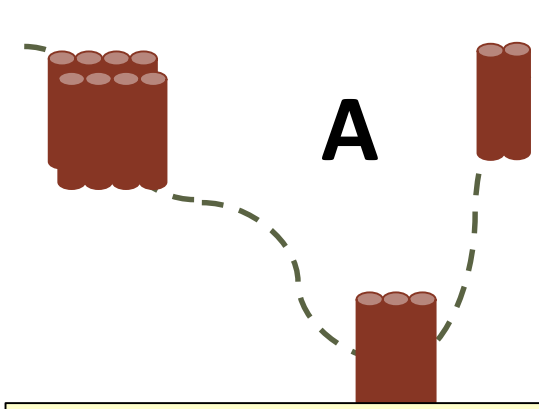
Redunaant caches (from DS)

3: Hybrid Cache

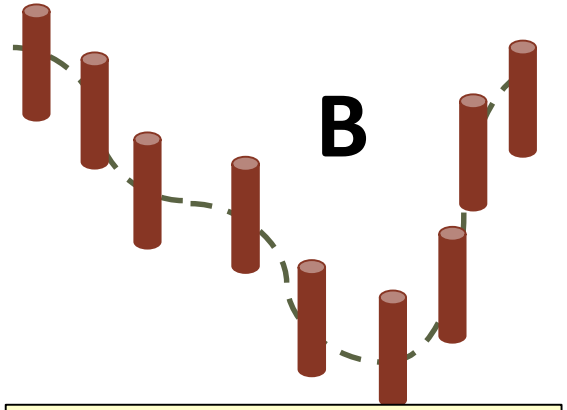


Small container + groups of singles

4: Adaptable Cache

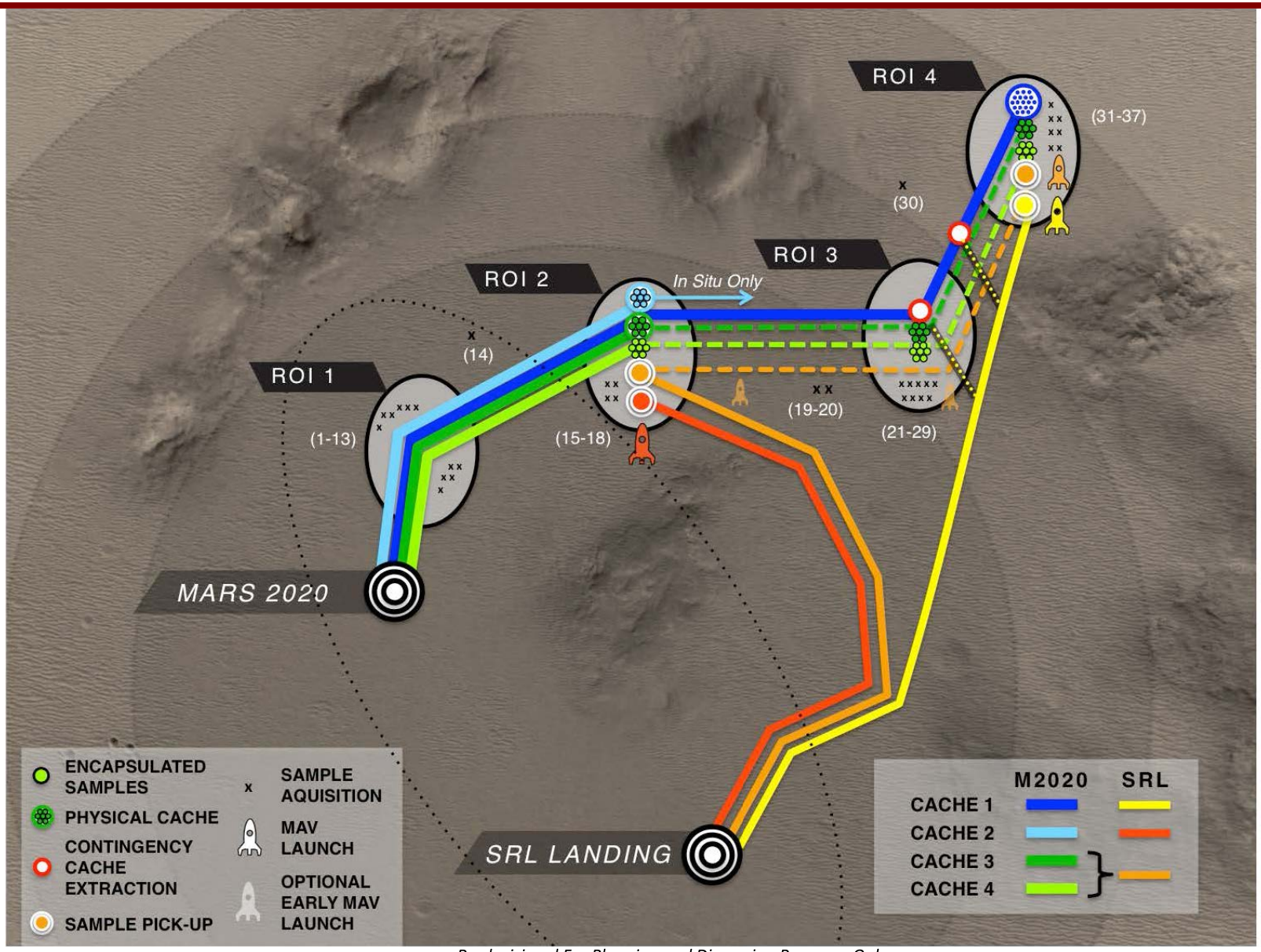


Groups of singles

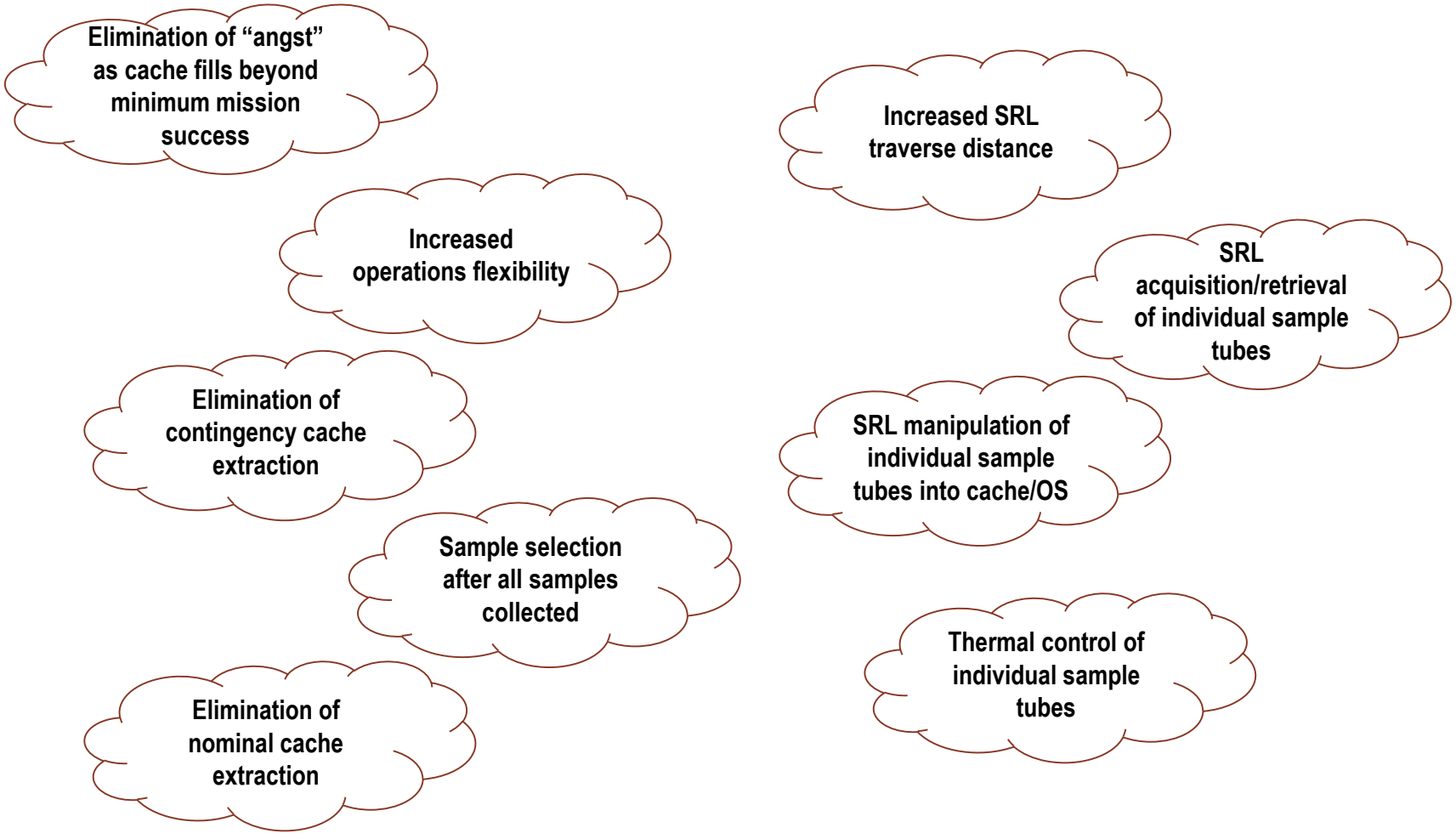


Isolated single samples

Traverse & Sampling Scenarios



Program-Level Issues Surrounding Sampling and Caching



What are the effects on M2020? SRL? Overall science and operations?

Issues addressed by Adaptive Caching

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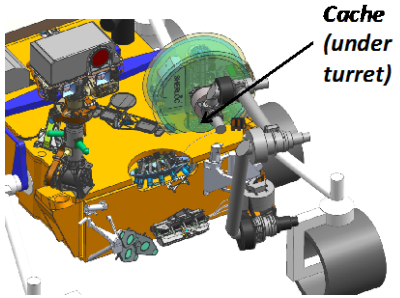
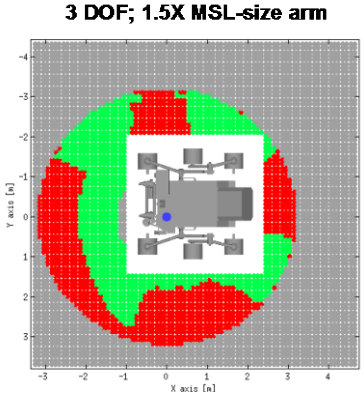
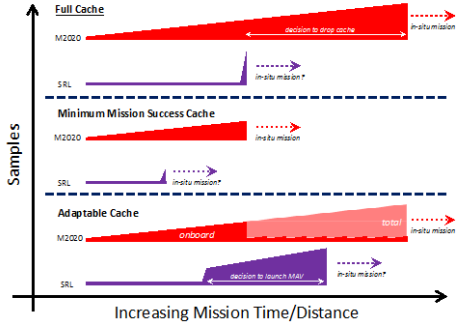


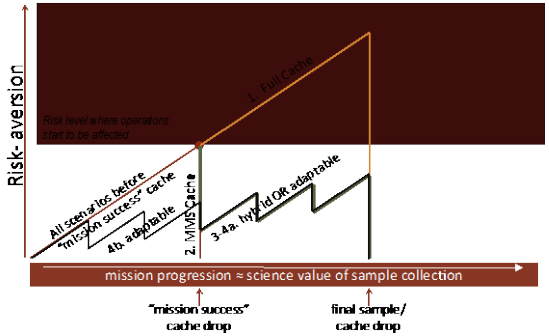
Nominal Cache Extraction



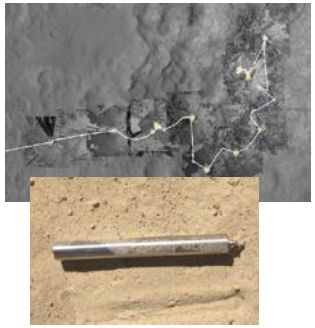
Contingency Cache Extraction



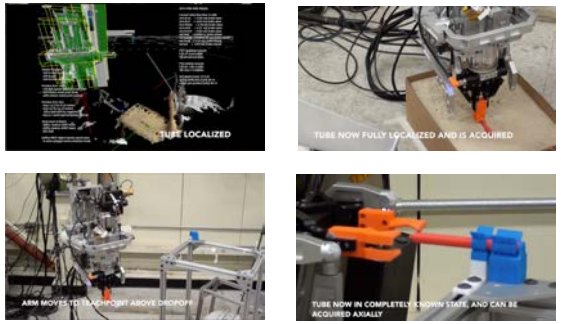
SRL Traverse Distance



Post "Mission-Success Angst"



Finding Sample Tubes on Surface



SRL Acquisition/Manipulation of Sample Tubes

Conclusions

1. It appears that the monolithic cache (full or minimum mission success) and single-tube (adaptable) caching approaches are ***viable with no show-stopper issues***
   a) Single-tube approaches do transfer complexity from M2020 to SRL
   b) Single-tube thermal control is not yet completely resolved, but appears to be workable
   c) Elimination of nominal and/or contingency cache extraction from M2020 may offer significant reduction in design complexity for both M2020 and SRL
2. Element level assessments (M2020, SRL, Science) rank ***adaptable cache approach highest or next-highest***
   a) Hybrid cache approach, while offering maximum flexibility, also involves greatest design/verification/operations burden and therefore is not favored at element level
3. Non-technical factors of single-tube approach (e.g., selling M2020 and SRL without monolithic cache) appear to be workable; ***science community can be powerful advocate*** for increased sample selectability and intensive sample selection discussions during post-M2020 period