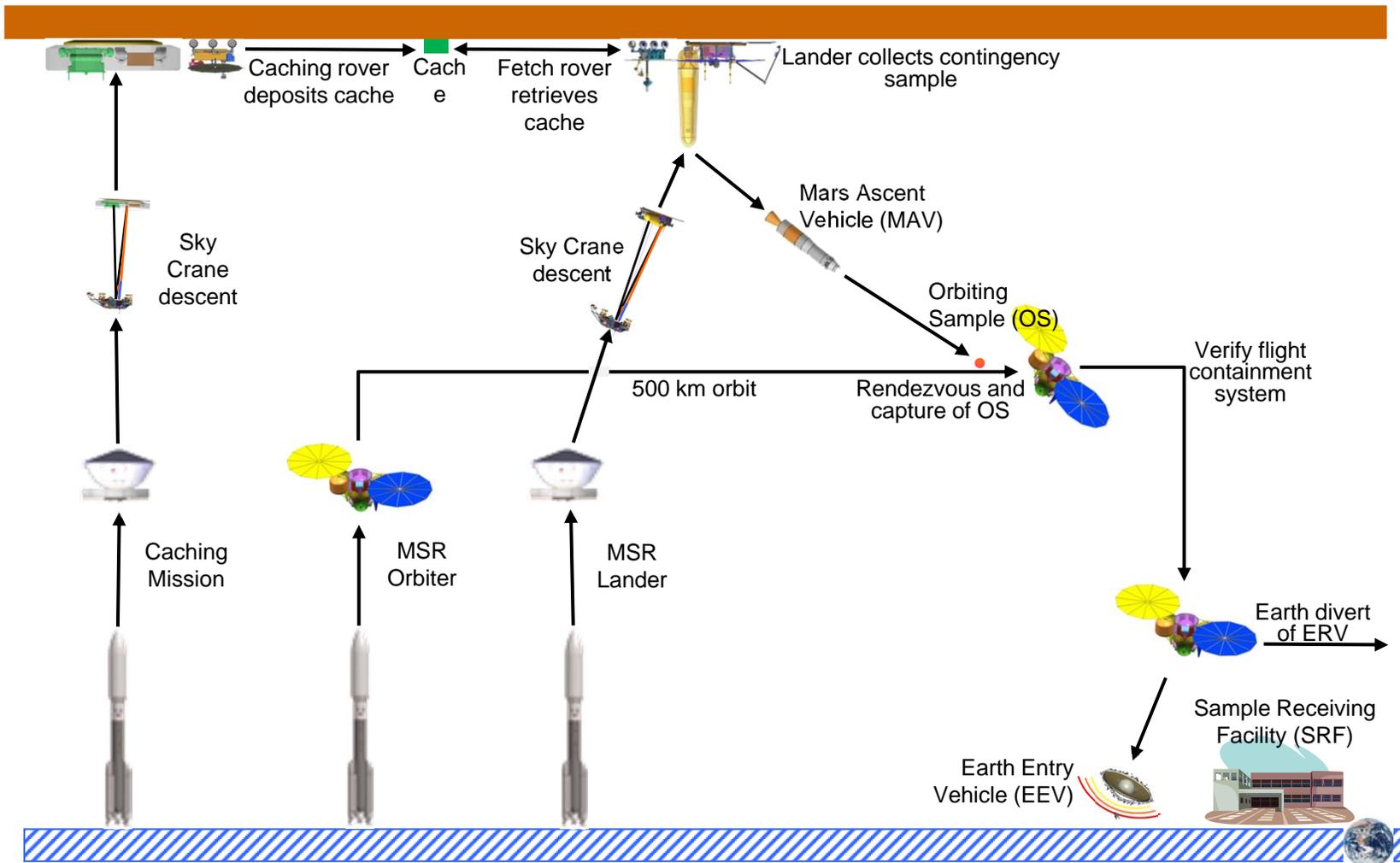


Planetary Protection For Mars Sample Return

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iMARS Sample Return Campaign



MSR Campaign-Level Planetary Protection Requirements



- Campaign level categorization and individual mission-phase requirements:
 - All flight elements of a Mars Sample Return effort that contact or contain materials or hardware that have been exposed to the martian environment to be returned to Earth are designated “Planetary Protection Category V, Restricted Earth Return”
 - Landed elements receive requirements equivalent to Planetary Protection Category IVb Mars missions. Planetary Protection Category IVc requirements also apply should the landed element be intended to access a ‘special region’
 - Orbital elements, including hardware launched from Mars, receive requirements equivalent to Planetary Protection Category III Mars mission

Returning Martian Samples to Earth



Planetary Protection



NASA/CP—2002–211842



A DRAFT TEST PROTOCOL
FOR DETECTING POSSIBLE BIOHAZARDS IN
MARTIAN SAMPLES RETURNED TO EARTH

- Previous requirements developed over a decade of MSR preparation and adopted by COSPAR

- ESA and NASA are continuing a program of requirements refinement

- Key recommendations from NRC-SSB 2009:

- "...samples returned from Mars by spacecraft should be contained and treated as though potentially hazardous until proven otherwise.

- No uncontained martian materials, including spacecraft surfaces that have been exposed to the martian environment, should be returned to Earth unless sterilized."



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What Does 'Potentially Hazardous' Imply?

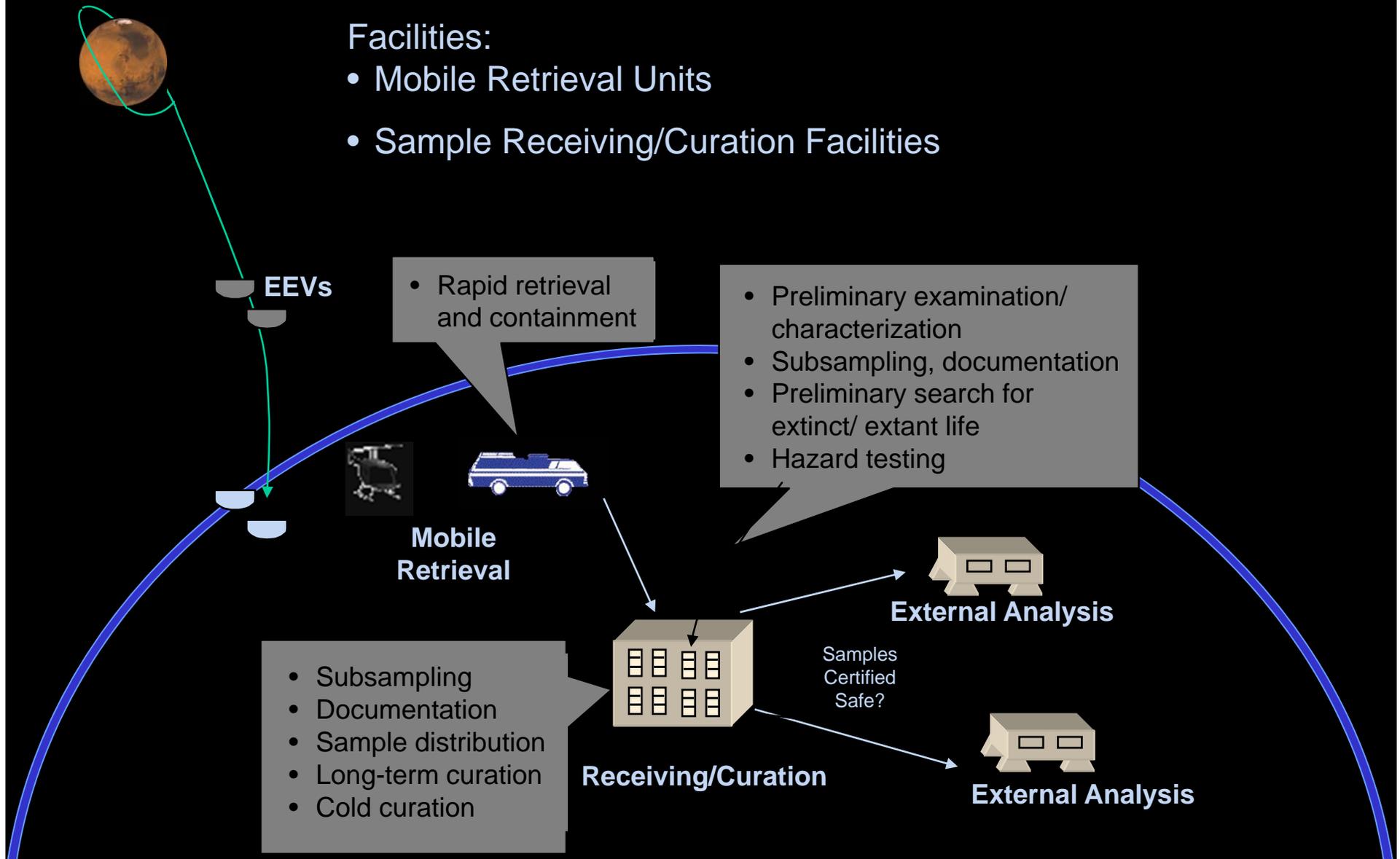


- Hazards must be either destroyed or contained
 - Contain Mars samples or sterilize them, to ensure safety of Earth
- Must have sufficient confidence on containment
 - Requirements involve the probability of releasing a single particle of unsterilized Mars material into the Earth environment
- Must have approved protocols for containment and testing
 - Review and update Draft Test Protocol using best available advice
 - Requirements on flight system contamination flow back from life detection protocols
- Technical requirements flow from the hazard assessment
 - Impact on design and operation
 - Impact on flight and ground system (C&C)
 - Impact on hardware and software
 - Impact on qualification and acceptance margins

Backward Contamination: A Candidate Mars Sample Handling Scenario

Facilities:

- Mobile Retrieval Units
- Sample Receiving/Curation Facilities



COSPAR Guidelines for Mars Sample Return

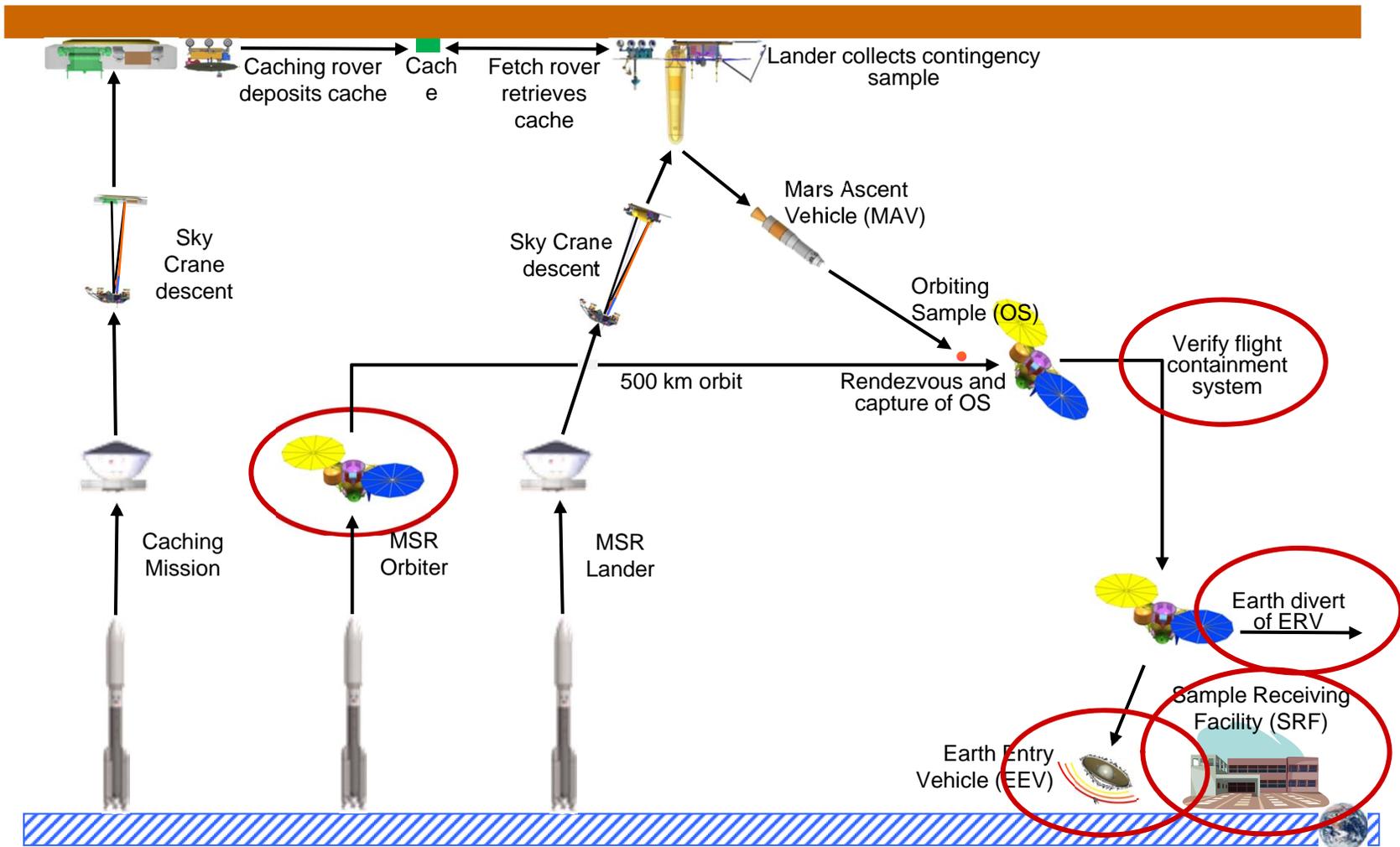


Planetary Protection



- “... the outbound leg of the mission shall meet Category IVb requirements...”
- “... the canister(s) holding the samples returned from Mars shall be closed, with an appropriate verification process, and the samples shall remain contained ... transport to a receiving facility ... opened under containment.”
- “The mission and the spacecraft design must provide a method to “break the chain of contact” with Mars. ...”
- “Reviews and approval of the continuation of the flight mission shall be required ...”
- “For unsterilized samples returned to Earth, a program of life detection and biohazard testing, or a proven sterilization process, shall be undertaken as an absolute precondition for the controlled distribution of any portion of the sample.”

Protecting the Earth



Evolution of Requirements - Status



Planetary Protection



ESF guidance: The probability that a single unsterilized particle of 10 nanometers or greater in diameter is released into the Earth environment shall be less than 1×10^{-6} .

Size limit: The previous limit of 200nm was based on an NRC-SSB report “Size limit for very small microorganisms”. The European Science Foundation (ESF) study on “MSR backward contamination – Strategic advice and requirements” determined that new discoveries of small microbes, viruses, and Gene Transfer Agents elevate the level of concern for particles in the range of 10-50 nm.

Probability limit: The ESF study confirmed that a probability of ‘1 in a million’ is a level of risk consistent with a range of other significant societal risks, and recommended that this level be accepted as the requirement for containment of particles of martian material brought deliberately to Earth.

Next steps: Numerical limits of 10nm and 1×10^{-6} are being used in ESA technical studies for a possible containment system for MSR. The ESF recommendations will be proposed for acceptance by the COSPAR Panel on Planetary Protection at the next General Assembly in May 2014.

Evolution of Requirements - Future



Planetary Protection



ESF guidance: The probability that a single unsterilized particle of 10 nanometers or greater in diameter is released into the Earth environment shall be less than 10^{-6} .

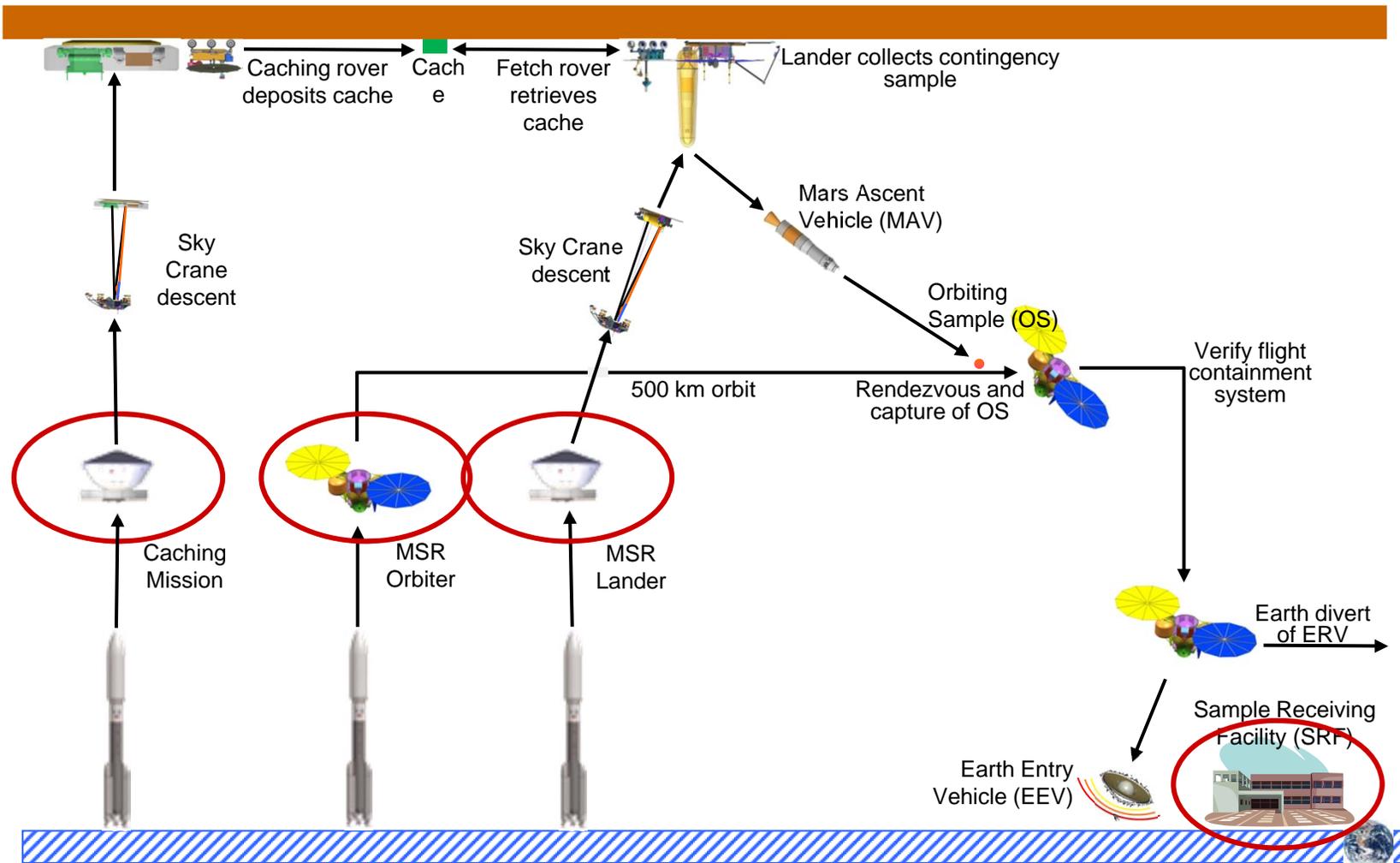
Critical planetary protection task for MSR at campaign level: Allocate reliability of safety critical functions for hardware and mission phases over the entire campaign.

Critical design approach to meet planetary protection requirements: **Risk based design, accounting also for common cause/mode failures, drives redundancy and diversity of system design.** Consequences go beyond occupational risk of astronauts, potentially also affecting general public.

Orbiter System: Sub-systems affected are data handling, GNC, power, propulsion to support safety critical functions, i.e., verification of biological containment system, Earth divert manoeuvre.

Earth Return Capsule: Sub-systems affected are heat shield and stability during entry.

Protecting the Samples



Evolution of Requirements - Bioburden



Planetary Protection



Campaign level requirement according to Planetary Protection Category V, restricted Earth return:

The subsystems of one or several missions which are involved in the acquisition, delivery and storage, and analysis of samples used for life detection must be sterilized or cleaned to levels of bioburden reduction driven by the nature and sensitivity of the particular life-detection experiments driven by the life detection and biohazard assessment protocol, and a method of preventing recontamination of the sterilized subsystems and the contamination of the material to be analyzed is in place.

Refinement of MSR Campaign-Level Planetary Protection Requirements



- Campaign level requirements:
 - all items returned from Mars shall be treated as potentially hazardous until demonstrated otherwise: *how close to Mars?*
 - release of unsterilized martian material shall be prohibited: <10nm particle at $<1 \times 10^{-6}$ probability: *ESF study inputs*
 - **subsystems sterilized/cleaned to levels driven by the nature and sensitivity of life-detection experiments and the planetary protection test protocol:** *protocol update ongoing*
 - **life-detection measurements dictate limits on contamination/recontamination of the samples:** *what instruments, sensitivity?*
 - need methods for preventing recontamination of the sterilized and cleaned subsystems and returned material: *technology development*
 - presence of a long-term heat source (RTG) would impose additional landing site restrictions to prevent both nominal and off-nominal spacecraft-induced “special regions”: *what features are of concern?*