Mars sample return

When will the dream come true?

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FFIORD Seminar – March 7th, 2012

International Mars Sample Return Conference

An International Conference co-hosted by
ESA and CNES in cooperation with
NASA and the
International Mars Exploration Working Group (IMEWG)
9 - 10 July 2008
Auditorium, Bibliotheque Nationale de France, Par

Why MSR?

There are three primary reasons why MSR would be of such high value to science.

1. Complex sample preparation, sample decisions

Image courtesy Carl Allen

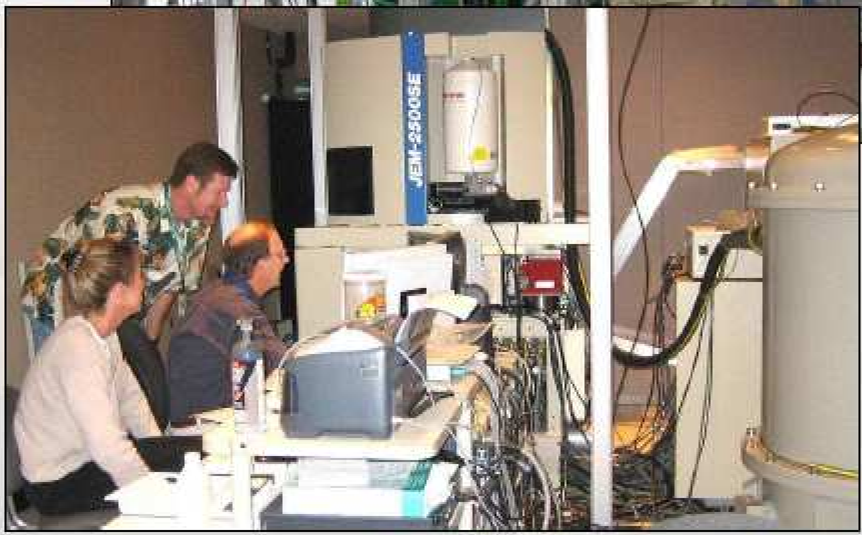
Image courtesy Dimitri Papanastassiou

Why MSR?

2. Analysis Adaptability

- Not limited by advance hypotheses

UCLA MegaSIMS lab, courtesy Kevin McKeegan



JSC TEM lab, courtesy Lisa Vidonic

3. Instrumentation

- Best accuracy/precision
- Diversity—results could be confirmed by alternate methods
- Instruments not limited by mass, power, V, T, reliability, etc.
- Calibration, positive and negative control standards
- Future instrument developments

MSR: Candidate Science Objectives

Ref.	MEPAG Goal	Objective Nickname	Viable Candidate for 1st MSR*
1	I	Habitability	YES
2	I	Pre-biotic, life	YES
3	I, III	water/ rock	YES
4	III	Geochronology	YES
5	II, III	Sedimentary record	YES
6	III	Planetary evolution	YES
7	III	Regolith Processes	YES
8	IV	Risks to human explorers	YES
9	I, III	Oxidation	YES
10	II	Gas Chemistry	YES
11	II	Polar	NO

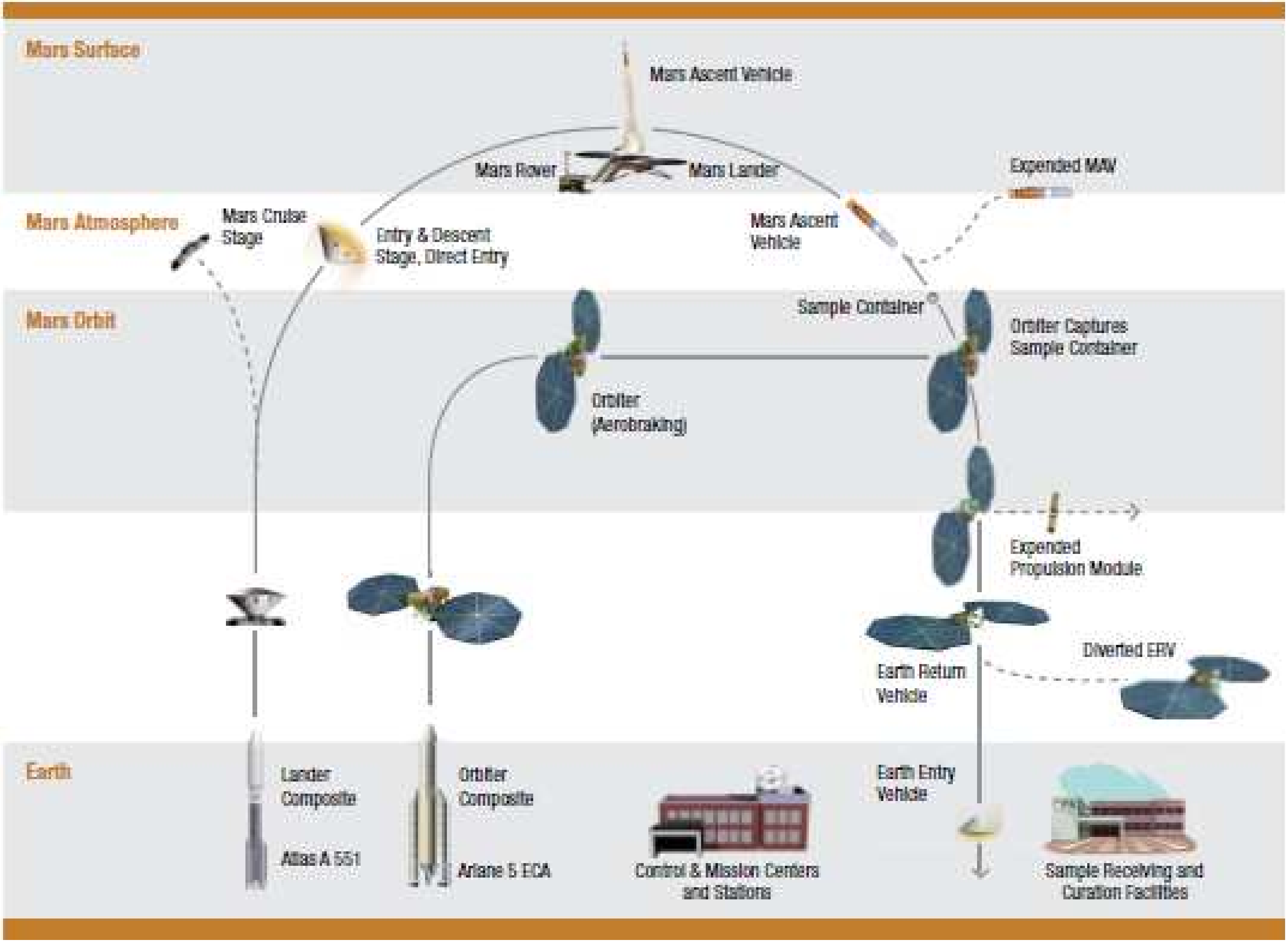
*NOTE: Contingent on landing site selection.

Relationship between Candidate Science Objectives and Sample types

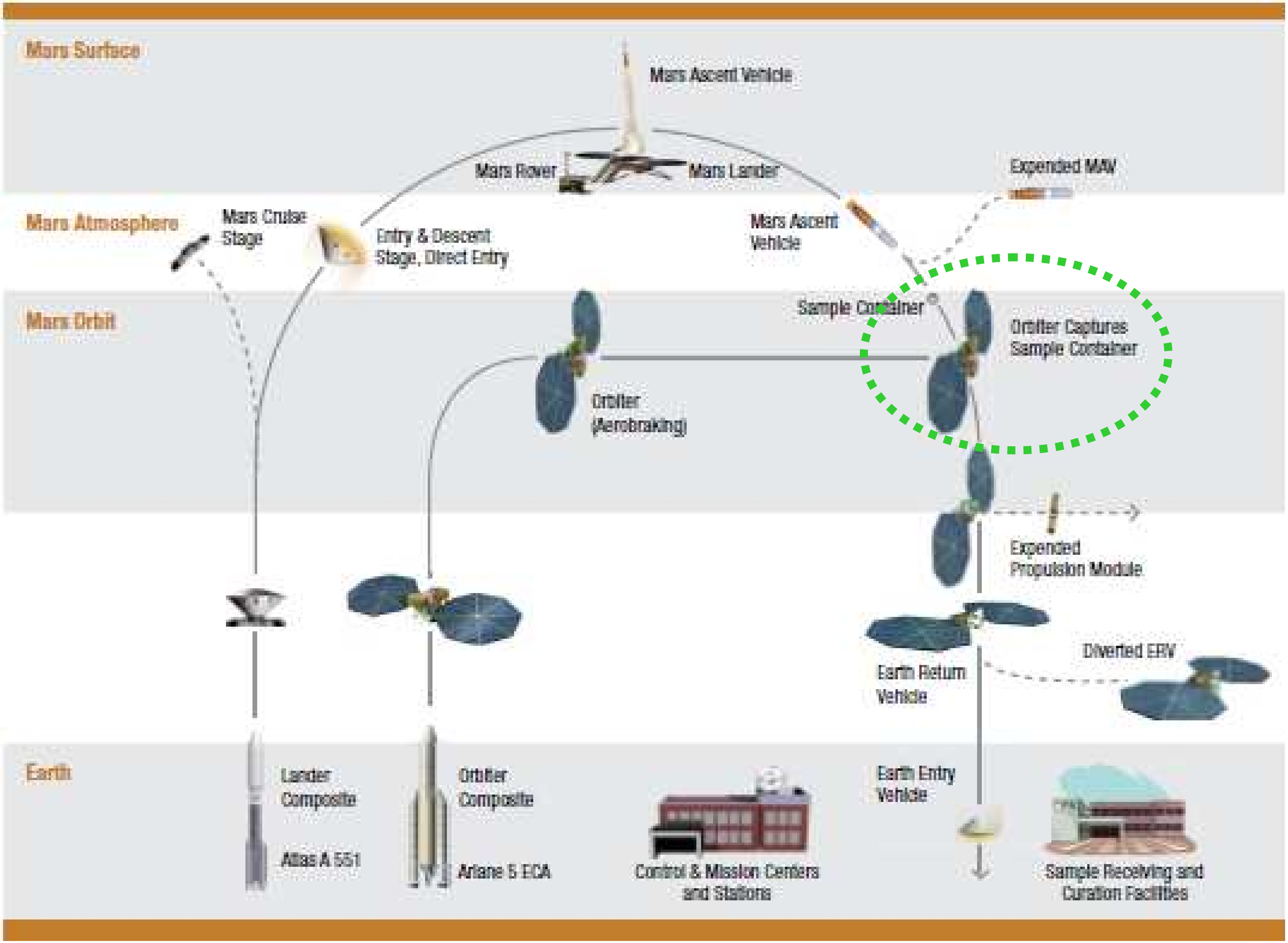
			main types of required samples								
			Rocks					Other			
Ref.	Goal	Objective Nickname	Sedimentary suite	Hydrothermal suite	Low-T W/R suite	Igneous Suite	Depth-Resolved Suite	Regolith	Dust	Ice	Atmospheric Gas
1	I	Habitability	H	H	L	L	M	L		L	L
2	I	Pre-biotic, life	H	H	L		M			M	L
3	I, III	water/ rock	H	H	H			M			
4	III	Geochronology	M	M		H					
5	II, III	Sedimentary record	H		M						
6	III	Planetary evolution				H		M			M
7	III	Regolith					M	H	M		
8	IV	Risks to human explorers					L	H	H	M	
9	I, III	Oxidation			H		H	M	M		
10	II	Gas Chemistry	M	M		M					H
11	II	Polar							M	H	M

Model of minimum number and mass of samples

		Number	Mass	
Sample Type	Mechanical Properties	Proposed science floor, 1st MSR	Mass/ sample (gm)	Total Sample Mass
Case B. Cache from a previous mission is NOT returned				
Sedimentary suite	rock	20	10	200
Hydrothermal suite	rock			
Low-T W/R suite	rock			
Igneous Suite	rock			
Other	rock			
Lander-based sample	rock or reg.	4	20	80
Regolith	granular	4	15	60
Dust	granular	1	5	5
Ice	ice or liquid	0		
Atmospheric Gas	gas	1	0.001	
Cache from previous mission	rocks			0
TOTAL		**30**		**345**



Mars Surface
Mars Ascent Vehicle
Mars Rover
Mars Lander
Expended MAV
Mars Atmosphere
Mars Cruise Stage
Entry & Descent Stage, Direct Entry
Mars Ascent Vehicle
Mars Orbit
Sample Container
Orbiter Captures Sample Container
Orbiter (Aerobraking)
Expended Propulsion Module
Diverted ERV
Earth Return Vehicle
Earth
Lander Composite
Atlas A 551
Orbiter Composite
Ariane 5 ECA
Control & Mission Centers and Stations
Earth Entry Vehicle
Sample Receiving and Curation Facilities



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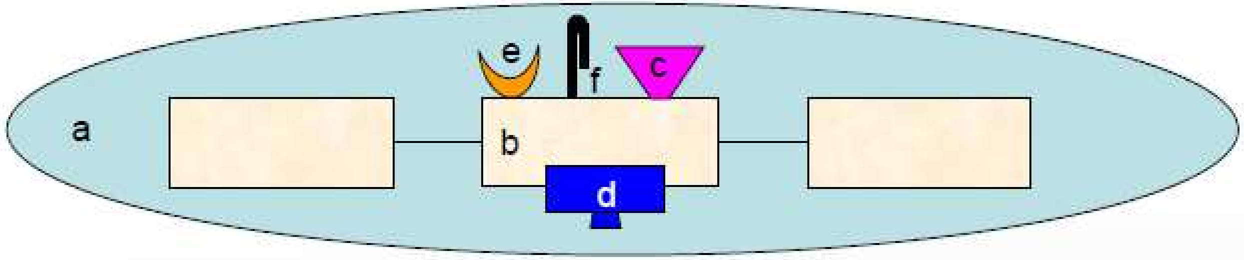
BASELINE COMPOSITE 2 (orbiting & return parts)

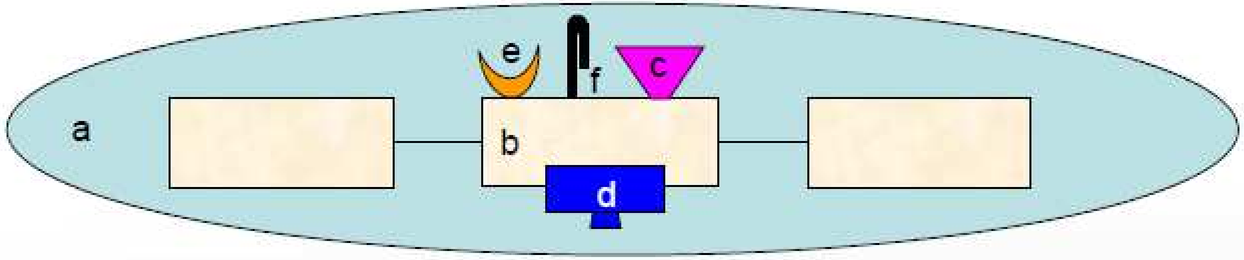
Part 1



Building blocks	*Functional description*	*Tech. Development need*
a) Orbiter	• Performs data relay with the Lander and rover from Mars orbit • Carries rendezvous and capture system and Earth return vehicle with Earth Entry Vehicle • Captures sample container in Mars orbit • Releases ERV/EEV with the Lander and the rover	• Autonomous rendezvous in Mars orbit (sensors, GNC, algorithms and operations)
b) Earth Return Vehicle (ERV)	• Carries and released the EEV. • Diverts to a non-Earth impact trajectory from Mars orbit	None
c) Earth Entry Vehicle (EEV)	• Is carried by the ERV • Re-enters Earth's atmosphere and lands with samples returned from Mars	• Sample thermal protection • End-to-end system: no entry ever done from Mars

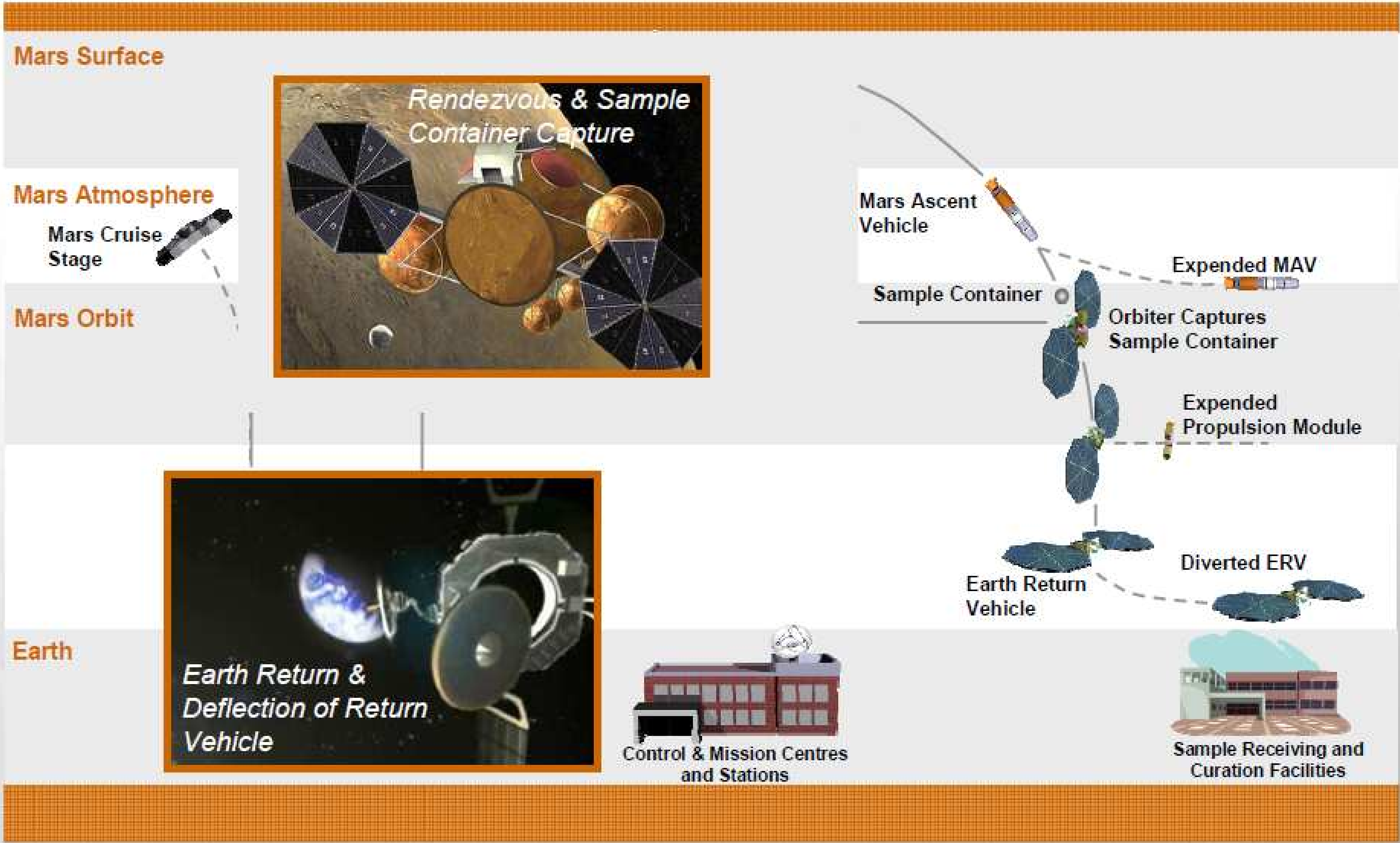
BASELINE COMPOSITE 2 (orbiting & return parts)

Part 2



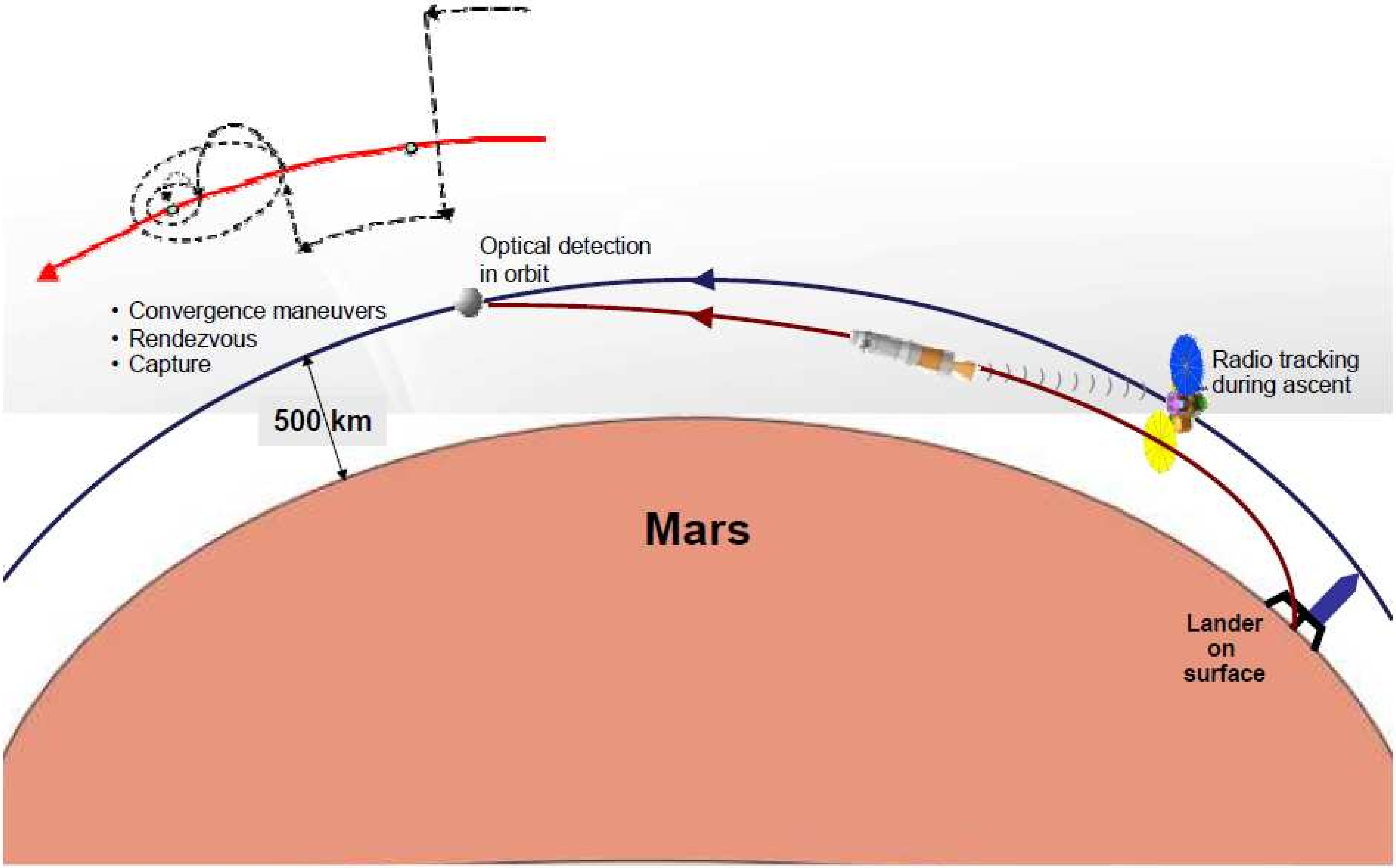
Building blocks	*Functional description*	*Tech. Development need*
d) Propulsion Module	• Provides propulsion/fuel to reach Mars and insert into orbit • Perform rendezvous manoevers and propels the ERV from Mars orbit (?)	None
e) Rendezvous & Capture System	• Detects and captures the sample container in Mars orbit	• Low light detection • Autonomy
f) Sample containment & verification	• Seals sample container and verifies flight containment on return trip	• Robust sealing and containment verification technologies

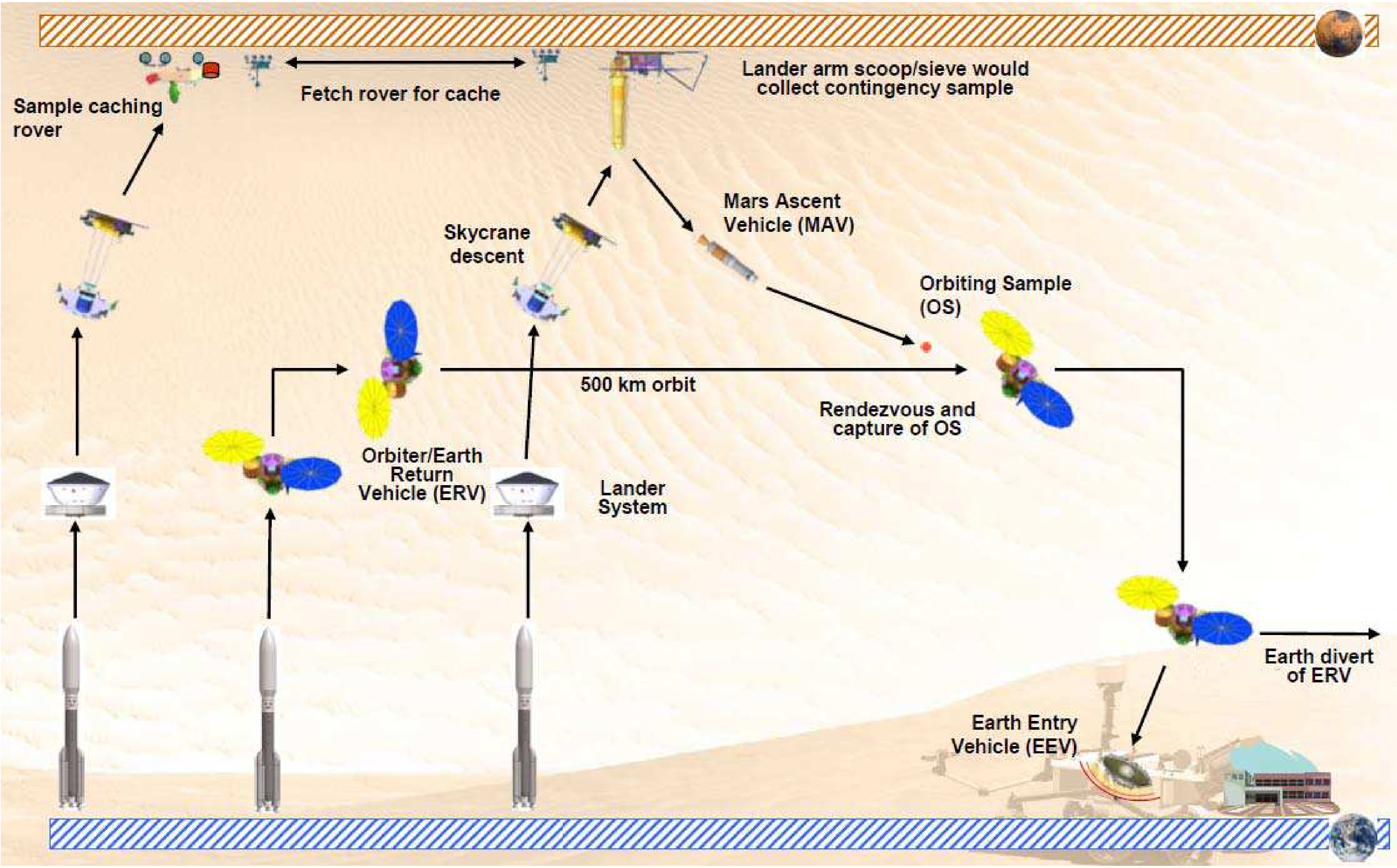
PROPOSED MSR ARCHITECTURE - RETURN

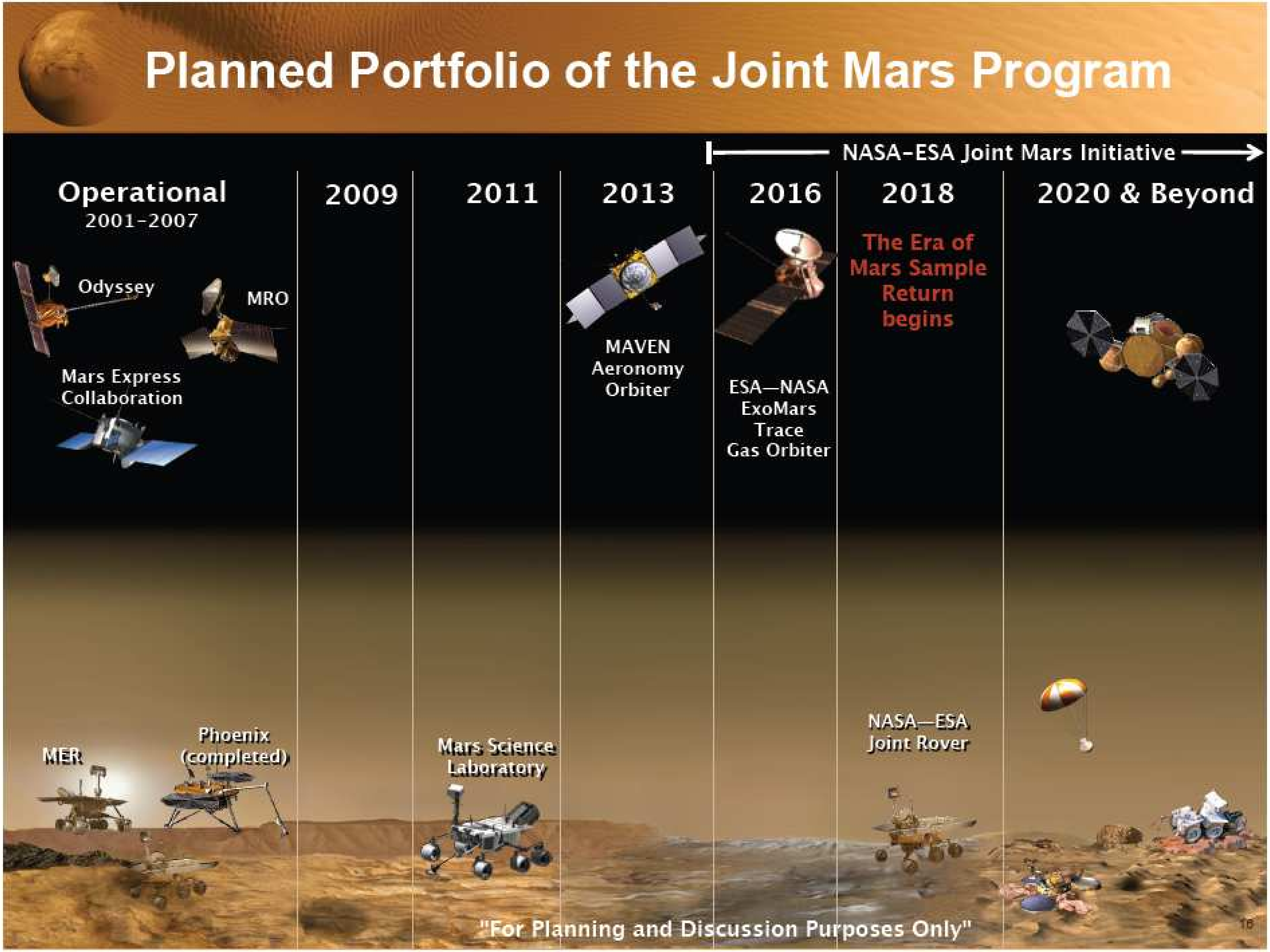


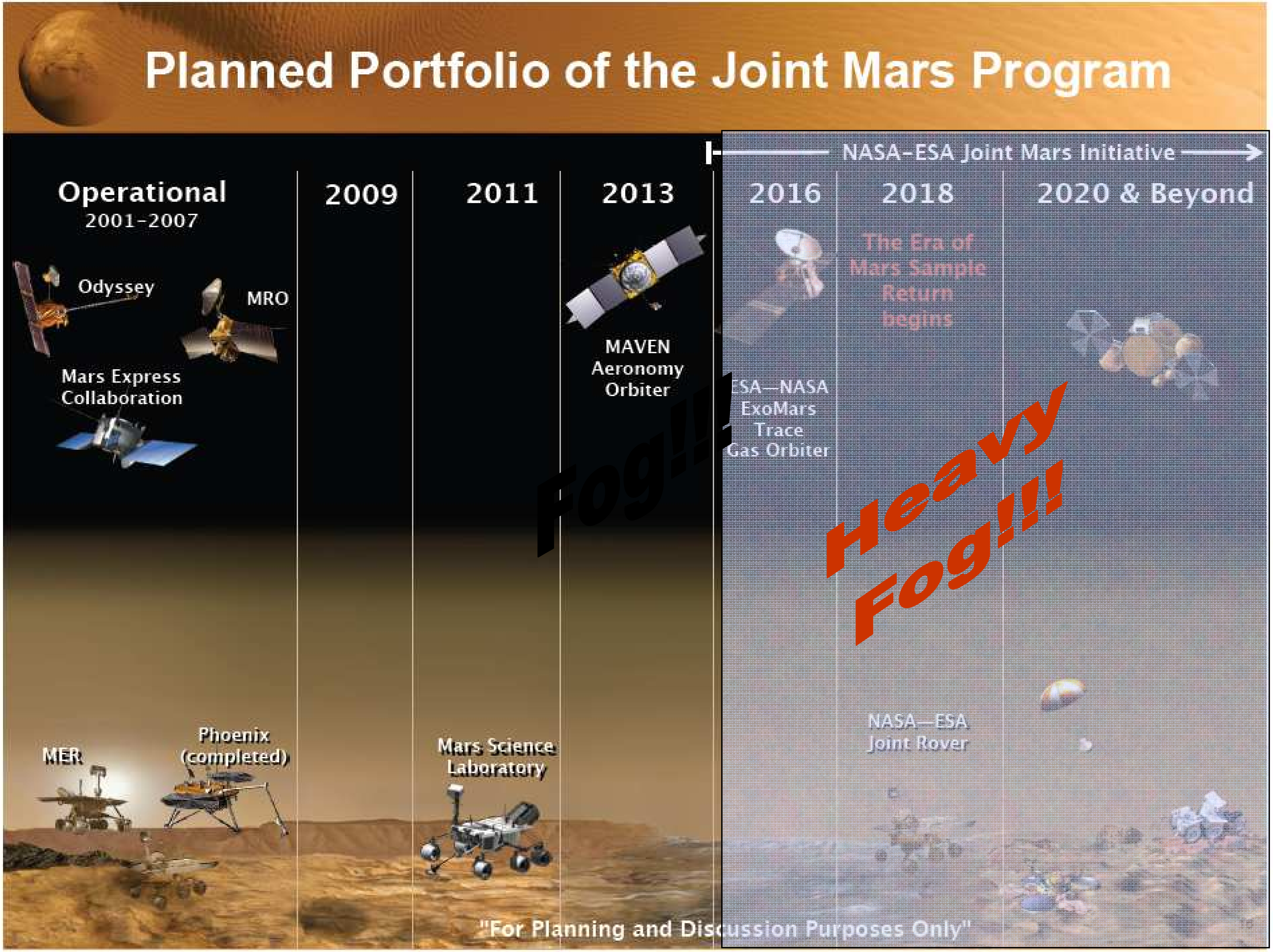

Rendezvous & Sample
Container Capture

Achieving Orbit




Sample caching rover
Fetch rover for cache
Lander arm scoop/sieve would collect contingency sample
Mars Ascent Vehicle (MAV)
Skycrane descent
Orbiting Sample (OS)
500 km orbit
Rendezvous and capture of OS
Orbiter/Earth Return Vehicle (ERV)
Lander System
Earth divert of ERV
Earth Entry Vehicle (EEV)


Planned Portfolio of the Joint Mars Program
NASA-ESA Joint Mars Initiative
Operational
2001-2007
2009
2011
2013
2016
2018
2020 & Beyond
Odyssey
MRO
Mars Express Collaboration
MAVEN Aeronomy Orbiter
ESA—NASA ExoMars Trace Gas Orbiter
The Era of Mars Sample Return begins
MER
Phoenix (completed)
Mars Science Laboratory
NASA—ESA Joint Rover
"For Planning and Discussion Purposes Only"



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Heavy
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MER
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Joint Rover
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Do we need to sleep now to live our dreams later?

NO!!

AVIATION WEEK & SPACE TECHNOLOGY

05/03/2012

"There are three or four technologies that stick out—sample handling with planetary protection, the Mars ascent vehicle, the Earth-based receiving facility and **the autonomous on-orbit rendezvous**," says Scott Hubbard of Stanford University, who served as NASA's first Mars program director. "All are needed to make a sample-return viable."