MEPAG Goals Document, 2015, supplemental summary table.

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Objectives are in order of priority. Sub-objectives are listed in order of priority within the parent objective. Investigations are listed in order of priority within the parent sub-objective. Prioritization is based on criteria explained in text within main document. The list of cross-cutting Investigations is intended to assist with seeing interdependencies, etc., but may not be complete.

Objectives	Sub-objectives	Investigations	Cross-cutting w/i goal	Cross-cutting btwn goals
GOAL I: Determine if Mars ever supported life.				
A. Determine if environments having high potential for prior habitability and preservation of biosignatures contain evidence of past life.	**A1.** Identify environments that were habitable in the past, and characterize conditions and processes that may have influenced the degree or nature of habitability therein.	1. Establish overall geological context.		GIII: A1.1-6, A2.1-3, B2.3
		2. Constrain prior water availability with respect to duration, extent, and chemical activity.		GII: B1.1, C2.1-3; GIII: A1.1-2
		3. Constrain prior energy availability with respect to type (e.g., light, specific redox couples), chemical potential (e.g., Gibbs energy yield), and flux.		GIII: A1.2
		4. Constrain prior physicochemical conditions, emphasizing temperature, pH, water activity, and chemical composition.		GIII: A1.2
		5. Constrain the abundance and characterize potential sources of bioessential elements.		GIII: A1.2
	A2. Assess the potential of conditions and processes to have influenced preservation or degradation of biosignatures and evidence of habitability, from the time of formation to the time of observation. Identify specific deposits and subsequent geological conditions that have high potential to have preserved individual or multiple types of biosignatures.	1. Identify conditions and processes that would have aided preservation and/or degradation of complex organic compounds, focusing particularly on characterizing: redox changes and rates in surface and near-surface environments; the prevalence, extent, and type of metamorphism; and potential processes that influence isotopic or stereochemical information.		GIII: A1.1-3, B2.3
		2. Identify the conditions and processes that would have aided preservation and/or degradation of physical structures on micron to meter scales.		GIII: A1.1-3
		3. Characterize the conditions and processes that would have aided preservation and/or degradation of environmental imprints of metabolism, including blurring of chemical or mineralogical gradients and changes to stable isotopic composition and/or stereochemical configuration.		GIII: A1.2
	A3. Determine if biosignatures of a prior ecosystem are present.	1. Characterize organic chemistry, including (where possible) stable isotopic composition and stereochemical configuration. Characterize co-occurring concentrations of possible bioessential elements.		GIII: A1.2
		2. Test for the presence of possibly biogenic physical structures, from microscopic (micron-scale) to macroscopic (meter-scale), combining morphological, mineralogical, and chemical information where possible.		GIII: A1.2-3
		3. Test for the presence of prior metabolic activity, including: stable isotopic composition of possible metabolic reactants and products (i.e. metabolites); mineral or other indicators of prior chemical gradients; localized concentrations or depletions of potential metabolites (e.g. biominerals); and evidence of catalysis in chemically sluggish systems.		GIII: A1.2
B. Determine if environments with high potential for current habitability and expression of biosignatures contain evidence of extant life.	**B1.** Identify environments that are presently habitable, and characterize conditions and processes that may influence the nature or degree of habitability therein.	1. Identify areas where liquid water (including brines) presently exists, with emphasis on reservoirs that are relatively extensive in space and time.		GII: A1.1, A3.3
		2. Identify areas where liquid water (including brines) may have existed at or near the surface in the relatively recent past including periods of significant different obliquity.		GIII: A3.1, A3.3
		3. Establish general geological context (such as rock-hosted aquifer or sub-ice reservoir; host rock type).		GIII: A2.3
		4. Identify and constrain the magnitude of possible energy sources (e.g., water-rock reactions, ionizing and non-ionizing radiation) associated with occurrences of liquid water.		
		5. Assess the variation through time of physical and chemical conditions, (particularly temperature, pH, and fluid composition) in such environments and potential processes responsible for observed variations.		
		6. Identify possible supplies of bioessential elements to these environments.		

	B2. Assess the potential of specific conditions and processes to affect the expression and/or degradation of signatures of extant life.	1. Evaluate the physicochemical conditions and processes of surface regolith or rock environments in terms of their potential for preserving or degrading biosignatures, and the effects of these conditions and processes on specific types of potential biosignatures.		
		2. Evaluate the potential rate of physical degradation from processes such as wind abrasion, dust storms, dust devils, and frost action.		GII: A4.1; GIII: A3.2, GIII: A1
		3. Evaluate the physicochemical conditions and processes at depth in regolith, ice, or rock environments in terms of their potential for preserving or degrading biosignatures.		
	B3. Determine if biosignatures of an extant ecosystem are present.	1. Test for the presence of ongoing metabolism (e.g., in the form of rapid catalysis of chemically sluggish reactions, stable isotopic fractionation, and/or strong chemical gradients), or potential biogenic gases that could migrate from habitable deep subsurface environments to surface environments.		
		2. Characterize organic chemistry and co-occurring concentrations of bioessential elements, including stable isotopic composition and stereochemistry. Analyses might include but should not be limited to known molecular markers of terrestrial life, such as membrane lipids, proteins, nucleic acid polymers, and complex carbohydrates.		
		3. Test for the presence of organic and mineral structures or assemblages that might be associated with life. Seek evidence of mineral transformations bearing evidence of biological catalysis.		GIII: A1.3

GOAL II: Understand the processes and history of climate on Mars.

A. Characterize the state of the present climate of Mars' atmosphere and surrounding plasma environment, and the underlying processes, under the current orbital configuration.	**A1.** Constrain the processes that control the present distributions of dust, water, and carbon dioxide in the lower atmosphere, at daily, seasonal and multi-annual timescales.	1. Measure the state and variability of the lower atmosphere from turbulent scales to global scales.	A1.2-3, A4.1	GI: B1.1; GIV: A1, B1
		2. Characterize dust, water vapor, and clouds in the lower atmosphere.	A1.1, A1.3, A3.4, A4.1	GIV: A1.2, B1.1
		3. Measure the forcings that control the dynamics and thermal structure of the lower atmosphere.	A1.1-2, A4.1	
	A2. Constrain the processes that control the dynamics and thermal structure of the upper atmosphere and surrounding plasma environment.	1. Measure the spatial distribution of aerosols, neutral species, and ionized species in the upper atmosphere.	A2.2-4, C1.1-2	GIV: A1.2
		2. Measure temperatures of neutral and ionized species in the upper atmosphere.	A2.1-2, A2.4, C1.1-2	
		3. Measure the forcings that control the dynamics and thermal structure of the upper atmosphere.	A2.1-2, A2.4, C1.1-2	
		4. Measure velocities of neutral and ionized species in the upper atmosphere.	A2.1-3	
	A3. Constrain the processes that control the chemical composition of the atmosphere and surrounding plasma environment.	1. Measure globally the vertical profiles of key chemical species.	A1.1, A3.2-4	
		2. Map spatial and temporal variations in the column abundances of species that play important roles in atmospheric chemistry or are transport tracers.	A1.1, A3.1, A3.2-4	
		3. Determine the significance of heterogeneous chemical reactions (i.e., those involving atmospheric gases and solid bodies such as aerosols or surface materials) for the chemical composition of the atmosphere.	A3.1-2, A3.4	
		4. Measure key electrochemical species.	A1.2, A3.1-3	GIV: A1.2
	A4. Constrain the processes by which volatiles and dust exchange between surface and atmospheric reservoirs.	1. Measure the turbulent fluxes of dust and volatiles between surface and atmospheric reservoirs.	A1.1-3, A3.4	GI: B2.2; GIII: A3.2-3
		2. Determine how the exchange of volatiles and dust between surface and atmospheric reservoirs has affected the present distribution of surface and subsurface water and CO2 ice.	A4.1	GIII: A3.2-3
		3. Determine how the exchange of volatiles and dust between surface and atmospheric reservoirs has affected the Polar Layered Deposits (PLD).	A4.1-2, B1.1, B2.1	GIII: A1.4, A3.2

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B. Characterize the history of Mars' climate in the recent past, and the underlying processes, under different orbital configurations.	**B1.** Determine how the chemical composition and mass of the atmosphere has changed in the recent past.	1. Measure isotopic composition of gases trapped in the PLD and near-surface ice.	A4.2-3, B2.1	GI: A1.2; GIII: A2.1, A2.3
	B2. Determine the record of the recent past that is expressed in geological and mineralogical features of the polar regions.	1. Map the ice and dust layers of the PLD and determine the absolute ages of the layers.		GIII: A2.3
		2. Obtain compositional and isotopic measurements of gases trapped within the PLD.	B1.1	GIII: A1.4, A2.1
	B3. Determine the record of the climate of the recent past that is expressed in geological and mineralogical features of low- and mid-latitudes.	1. Identify and map the location, age, and extent of glacial and peri-glacial features and quantify the depth to any remnant glacial ice.	B2.1	GIII: A1.4, A2.2-3, A3.2
C. Characterize Mars' ancient climate and underlying processes.	**C1.** Determine how the chemical composition and mass of the atmosphere have evolved from the ancient past to the present.	1. Measure the composition and absolute ages of trapped gases.		GIII: A2.1
	C2. Find and interpret physical and chemical records of past climates and factors that affect climate.	1. Determine the atmospheric environment required by observed geochemical and geophysical features.	A2.1, A2.3-4	GI: A1.2; GIII: A3.1
		2. Identify the extent of any oceans or large lakes and determine the absolute ages of associated features.	A2.1-2, A2.4	GI: A1.2; GIII: A3.1
		3. Determine boundary conditions necessary for climate modeling, including topography, state of polar caps, and state of the magnetic field.	A2.1-3	GI: A1.2; GIII: A2.3, A3.1
	C3. Determine present escape rates of key species and constrain the processes that control them.	1. Measure spatial and temporal variations in the escape rates of key species.	A2.1-4	
		2. Measure the forcings that drive escape processes.	A2.1-4	
GOAL III: Understand the origin and evolution of Mars as a geological system.				
A. Document the geologic record preserved in the crust and interpret the processes that have created that record.	**A1.** Identify and characterize past and present geologic environments and processes relevant to the crust.	1. Determine the role of water and other processes in the sediment cycle.	A2.3	GI: A1.1-2, A2.1-2, B1.1-2, B2.2; GII: C2.2
		2. Identify the geochemical and mineralogic constituents of crustal materials and the processes that have altered them.	feeds into A1.1, A1.3-6	GI: A1.1-5, A2.1-3, A3.1-3, B1.5-6; GII: C2.1
		3. Characterize the textural and morphologic features of rocks and outcrops.	A2.3	GI: A1.1, A2.1-2, A3.2, B3.3
		4. Identify ice-related processes and characterize when and how they have modified the Martian surface.	A2.3	GI: A1.1; GII: B2.1
		5. Document the surface manifestations of igneous processes and their evolution through time.	A1.2, A2.3, B2.1, A4.1	G1: A1.1
		6. Evaluate the effect of large- and small-scale impacts on the nature and evolution of the Martian crust and establish their production rates.		GI: A1.1
	A2. Determine the absolute and relative ages of geologic units and events through Martian history.	1. Quantitatively constrain the absolute ages of the surface and accessible crustal layers.	A1	GI: A1.1
		2. Assess the characteristics of Martian craters and document their distribution.	A1	GI: A1.1
		3. Identify and characterize the distribution, nature, and age relationships of rocks, faults, strata, and other geologic features, via comprehensive and topical geologic mapping.	A1, A3, B1.3	GI: A1.1
	A3. Constrain the magnitude, nature, timing, and origin of past planet-wide climate change.	1. Identify paleoclimate indicators in the geologic record and estimate the climate timing and duration.	A1, A2	
		2. Characterize surface-atmosphere interactions as recorded by aeolian, glacial/periglacial, fluvial, lacustrine, chemical and mechanical erosion, cratering and other processes.	A1, B1.1	GI: B2.2; GII: B3
		3. Determine the present state, 3-dimensional distribution, and cycling of water on Mars including the cryosphere and possible deep aquifers.	A1.1, B1.1	GI: B1.1-2; GII: A1.2
B. Determine the structure, composition, and dynamics of the Martian interior and how it has evolved.	**B1.** Identify and evaluate manifestations of crust-mantle interactions.	1. Determine the types, nature, abundance and interaction of volatiles in the mantle and crust.	A3	
		2. Seek evidence of plate tectonics-style activity and metamorphic activity, and measure modern tectonic activity.		

	B2. Quantitatively constrain the age and processes of accretion, differentiation, and thermal evolution of Mars.	1. Characterize the structure and dynamics of the interior.		
		2. Measure the thermal state and heat flow of the Martian interior.		
		3. Determine the origin and history of the magnetic field.		GI: A1.1, A2.1
C. Determine the manifestations of Mars' evolution as recorded by its moons.	**C1.** Constrain the planetesimal density and type within the Mars neighborhood during Mars formation, as implied by the origin of the Mars moons.	1. Interpret the geologic history of the moons, by identification of geologic units and relationship(s) between them (time-order, weathering, etc.).	C1.2	
		2. Determine composition of rock and regolith on the moons, including elemental and mineralogical compositions.	C1.1, C2.1-2	
		3. Characterize the interior structure of the moons to determine the reason for their bulk density and the source of density variations within the moon (e.g., micro- vs. macroporosity).	C2.2	
	C2. Determine the material and impactor flux within the Mars neighborhood, throughout Mars' history, as recorded on the Mars moons.	1. Measure the character and rate of material exchange between Mars and the two moons.	C1.1-2	GIV: A2.1
		2. Understand the flux of impactors in the Martian system, as observed outside the Martian atmosphere.	C1.1, A2.2	

GOAL IV: Prepare for human exploration.

A. Obtain knowledge of Mars sufficient to design and implement a human mission to Mars orbit with acceptable cost, risk, and performance.	**A1.** Determine the aspects of the atmospheric state that affect aerocapture and aerobreaking for human-scale missions at Mars.	1. At all local times, make long-term (> 5 Mars years) observations of the global atmospheric temperature field from the surface to ~80 km.	B1.2	GII: A1.1, A1.3, A2.2-3
		2. At all local times, make long-term global measurements of the vertical profile of aerosols between the surface and >60 km.	B1.1	GII: A1.2, A2.1
		3. Make long-term observations of global winds and wind direction at all local times over altitudes 15 to >60 km, and including a planetary scale dust event.	B1.4	GII: A1.3
	A2. Determine the orbital particulate environment in high Mars orbit that may impact the delivery of cargo and crew to the Martian system.	1 . Determine spatial variation in size-frequency distribution of Phobos/ Deimos ejecta particles in Mars orbit.		GIII: C2.1
B. Obtain knowledge of Mars sufficient to design and implement a human mission to the Martian surface with acceptable cost, risk, and performance.	**B1.** Determine the aspects of the atmospheric state that affect Entry, Descent, and Landing (EDL) design, or atmospheric electricity that may pose a risk to ascent vehicles, ground systems, and human explorers.	1. Globally monitor the dust and aerosol activity, especially large dust events, to create a long-term dust activity climatology (> 10 Mars years) capturing the frequence of all events and defining the duration, horizontal extent, and evolution of extreme events.	A1.2	
		2. Monitor surface pressure and near surface meterology over various temporal scales (diurnal, seasonal, annual), and if possible in more than one locale.		GII: A1
		3. Make temperature and aerosol profile observations under dusty conditions (including within the core of a global dust storm) from the surface to 20 km (40 km in a great dust storm) with a vertical resolution of <5 km.	A1.1-2	
		4. Profile the near-surface winds (<15 km) in representative regions (e.g., plains, up/down wind of topography, canyons), simultaneous with the global wind observations.	A1.3	GII: A1.3
		5. Obtain temperature or profiles from all landed missions between the surface and 20 km.		
		6. Combine the characterization of atmospheric electricity with surface meteorological and dust measurements to correlate electric forces and their causative meteorological source for more than 1 Martian year, both in dust devils and large dust storms.		GII: A3.4
	B2. Determine if the Martian environments to be contacted by humans are free, to within acceptable risk standards, of biohazards that might have adverse effects on the crew that might be directly exposed while on Mars, and on other terrestrial species if uncontained Martian material would be returned to Earth.	1. Determine if extant life is widely present in the Martian near-surface regolith, and if the air-borne dust is a mechanism for its transport. If life is present, assess whether it is a biohazard.		G1: B3
	B3. Determine the Martian environmental niches that meet the definition of "Special Region."	1. Map the distribution of both naturally occurring Special Regions, and regions with the potential for spacecraft-induced Special Regions, as defined by COSPAR5.		GIII: A1.1-2, A1.4, A2.2-3, A3.3

	B4. Understand the resilience of atmospheric In Situ Resource Utilization (ISRU) processing systems to variations in Martian near-surface environmental conditions.	1. Test ISRU atmospheric processing system to measure resilience with respect to dust and other environmental challenge performance parameters that are critical to the design of a full-scale system.		
	B5. Assess landing site-related hazards, including those related to safe landing and safe operations (including trafficability) within the possible area to be accessed by elements of a human mission.	1. Image selected potential landing sites to sufficient resolution to detect and characterize hazards to both landing and trafficability at the scale of the relevant landed systems.		
		2. Determine regolith physical properties and structure, gas permeability of the regolith and the chemistry and mineralogy of the regolith, including ice contents.		GIII: A1
	B6. Assess risks to crew health and performance by characterizing in detail the ionizing radiation environment at the Martian surface and determining the possible toxic effects of Martian dust on humans.	1. Measure neutrons with directionality.		
		2. Measure the charged particle spectra, neutral particle spectra, and absorbed dose at the martian surface throughout the solar cycle, and over more than one solar cycle.		
		3. Assay for chemicals with known toxic effect on humans, particularly oxidizing species, in samples containing dust-sized particles that could be ingested.		
		4. Assay for chemicals with known toxic effect on humans.		
		5. Fully characterize soluble ion concentrations, and chemical reactions that occur upon humidification.		
		6. Analyze the shapes of Martian dust grains to assess their possible impact on human soft tissue.		
	B7. Characterize the particulates that could be transported to hardware and infrastructure through the air (including natural aeolian dust and other materials that could be raised from the Martian regolith by ground operations), and that could affect engineering performance and in situ lifetime.	1. Analyze regolith and surface aeolian fines, with a priority placed on the characterization of the electrical and thermal conductivity, triboelectric and photoemission properties, and chemistry of samples of regolith from depths that might be reached by human surface operations.		
		2. Determine the electrical conductivity of the ground, measure the magnitude and dynamics of any quasi-DC electric fields, and determine the charge on individual dust grains.		
		3. Determine the column abundance and size-frequency distribution, resolved at less than scale height, of dust particles in the Martian atmosphere.		GII: A4.1
C. Obtain knowledge of Mars sufficient to design and implement a human mission to the surface of either Phobos or Deimos (P/D) with acceptable cost, risk, and performance.	**C1.** Understand the geological, compositional, and geophysical properties of P/D sufficient to establish specific scientific objectives, operations planning, and any potentially available resources.	1. Determine the elemental and mineralogical composition of the surface and near-surface of P/D.		GIII: C1
		2. Identify geologic units for science and exploration and materials for future in situ resource utilization operations.		GIII: C1.1-2
		3. Determine the gravitational field to a sufficiently high degree and order to make inferences regarding the internal structure and mass concentrations of P/D.		GIII: C1.3
	C2. Understand the conditions at the surface and the low orbital environment for P/D sufficiently well so as to be able to design an operations plan, including close proximity and surface interactions.	1. Measure and characterize the physical properties and structure of regolith on P/D.		
		2. Determine the gravitational field to a sufficiently high degree to be able to carry out proximity orbital operations.		
		3.Measure the electrostatic charge and plasma fields near the surface of P/D.		GIII: C1.1
		4. Measure the surface and subsurface temperature regime of P/D to constrain the range of thermal environments of these moons.		
D. Obtain knowledge of Mars sufficient to design and implement sustained human presence at the Martian surface with acceptable cost, risk, and performance.	**D1.** Characterize potentially extractable water resources to support ISRU for long-term human needs.	1. Identify a set of candidate water resource deposits that have the potential to be relevant for future human exploration.		
		2. Prepare high spatial resolution maps of at least one high-priority water resource deposit, that include the information needed to design and operate an extraction and processing system with adequate cost, risk, and performance.		
		3. Measure the energy required to excavate/drill and extract water the H-bearing material from either shallow water ice or hydrated minerals as appropriate for the resource.		