

Generalizable Skills and Knowledge
for Exploration Class Missions
NNX15AW34G / NNX16AQ86G

Jack Stuster

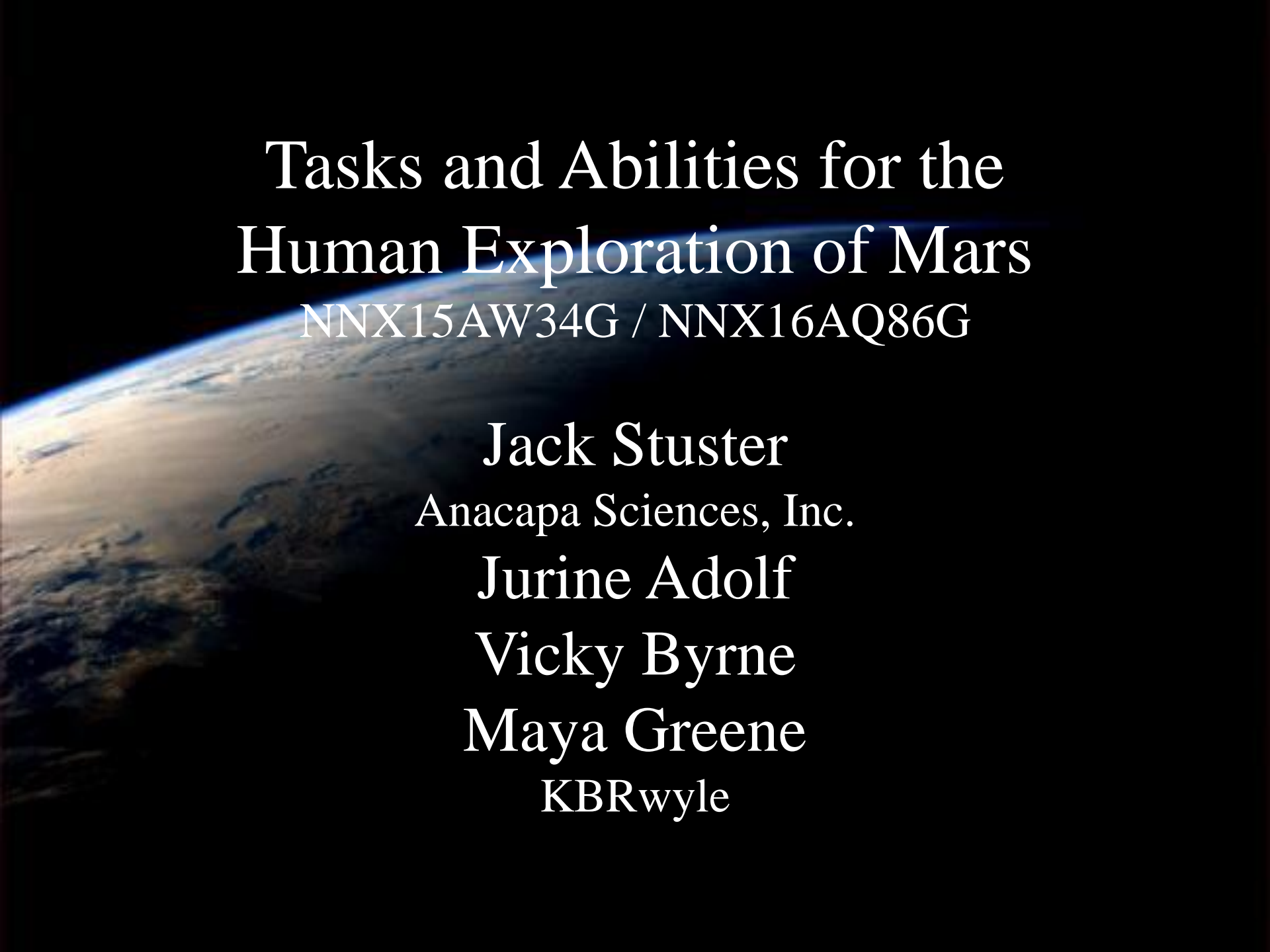
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Maya Greene

KBRwyle



Tasks and Abilities for the
Human Exploration of Mars
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NASA Risks



NASA's Human Research Program (HRP) is composed of five elements:


- ❖ Human Factors and Behavioral Performance;
- ❖ Exploration Medical Capability;
- ❖ Human Health Countermeasures;
- ❖ ISS Medical Project; and,
- ❖ Space Radiation.

The HRP Elements are responsible for 30 major risks concerning crew.



HFBP Risks



- ✦ Risk of Incompatible Vehicle/Habitat Design.
 - ✦ Risk of Inadequate Human-Computer Interaction.
 - ✦ Risk of Inadequate Mission, Process and Task Design.
 - ✦ Risk of Performance Errors Due to Training Deficiencies.
 - ✦ Risk of Injury from Dynamic Loads (occupant protection).
 - ✦ Risk of Inadequate Design of Human and Automation/Robotic Integration.
 - ✦ Risk of Adverse Cognitive or Behavioral Conditions/Psychiatric Disorders.
 - ✦ Risk of Performance Decrements and Adverse Health Outcomes Resulting from Sleep Loss, Circadian Desynchronization, and Work Overload.
 - ✦ Risk of Performance and Behavioral Health Decrements Due to Inadequate Cooperation Coordination, Communication, and Psychosocial Adaptation within a Team.
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Project Purpose

This study addresses the Risk of Inadequate Mission, Process, and Task Design and the Risk of Performance Errors Due to Training Deficiencies by identifying the work that will be performed during an expedition to Mars and the abilities, skills, and knowledge that will be required of crew members.

Conducted For: The Human Factors & Behavioral Performance (HFBP) Element.

Image: Earth and moon from HiRISE near Mars.

Project Tasks



Assumptions

- Conjunction-class;
- 12 mission phases;
- 6-month Cruise to Mars;
- 500-day Surface Operations;
- Communications Lag/Autonomous;
- 6-month Cruise to Earth followed by;
- 5-day Earth Approach and Direct Descent.

Launch

Trans-Mars Injection

Cruise to Mars

Mars Orbit Injection

Mars Orbit

Mars Surface Descent

Mars Surface Operations

Mars Surface Ascent

Trans-Earth Injection

Cruise to Earth

Earth Approach

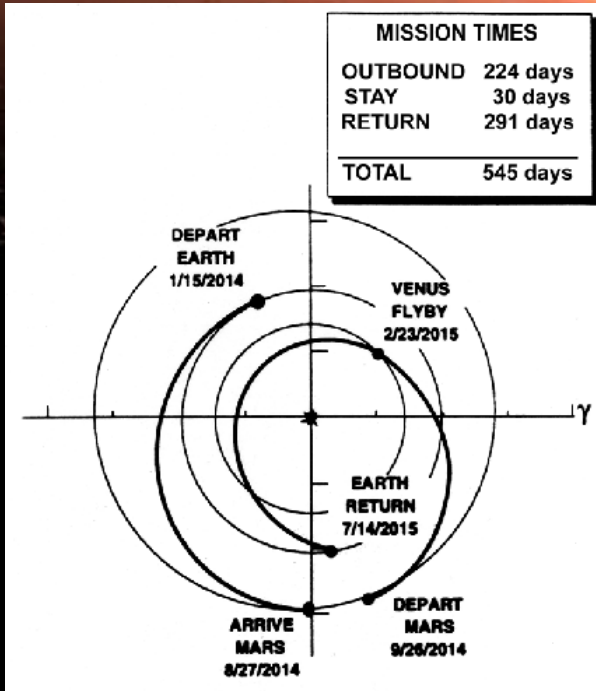
Earth Surface Descent

Assumptions

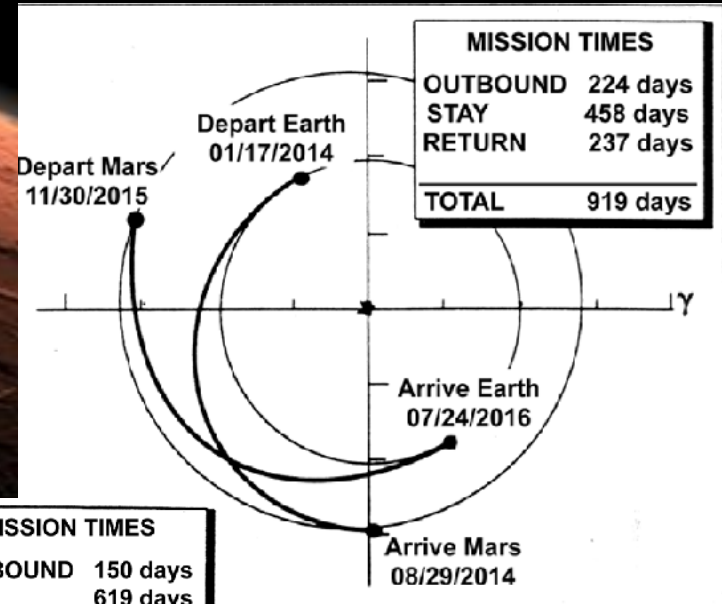
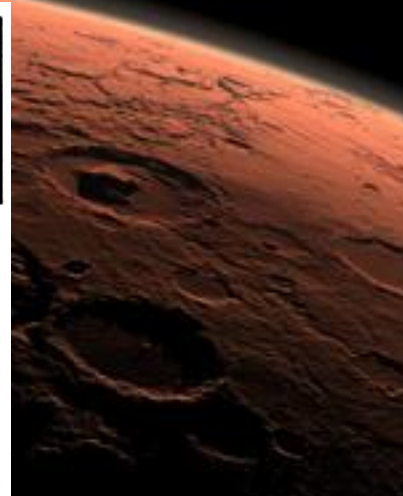
Conjunction and Opposition

The terms “conjunction class” and “opposition class” refer to the position of Mars relative to Earth during the expedition. In the former, Mars moves behind the Sun as seen from Earth (i.e., it reaches conjunction) halfway through the expedition; in the latter, Mars is opposite the Sun in Earth’s skies (i.e., at opposition) at the expedition’s halfway point. A 600-day opposition-class expedition (with 30 days on the surface) can require as much as ten times the fuel as a 1,000-day conjunction-class expedition (with 500 days on the surface).

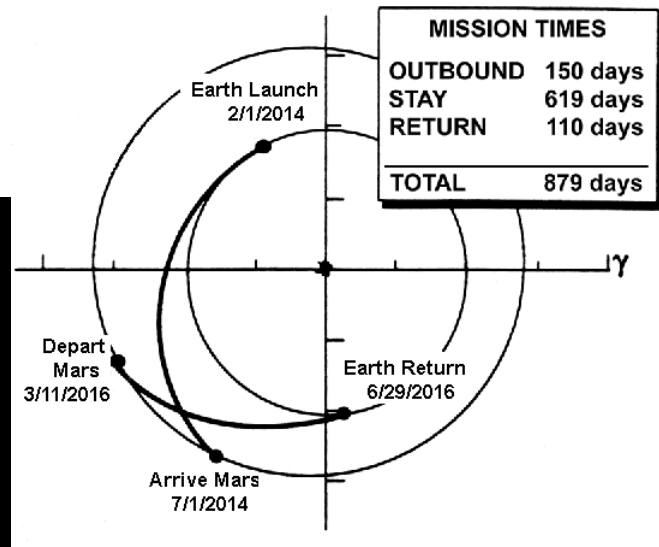
Assumptions



Opposition

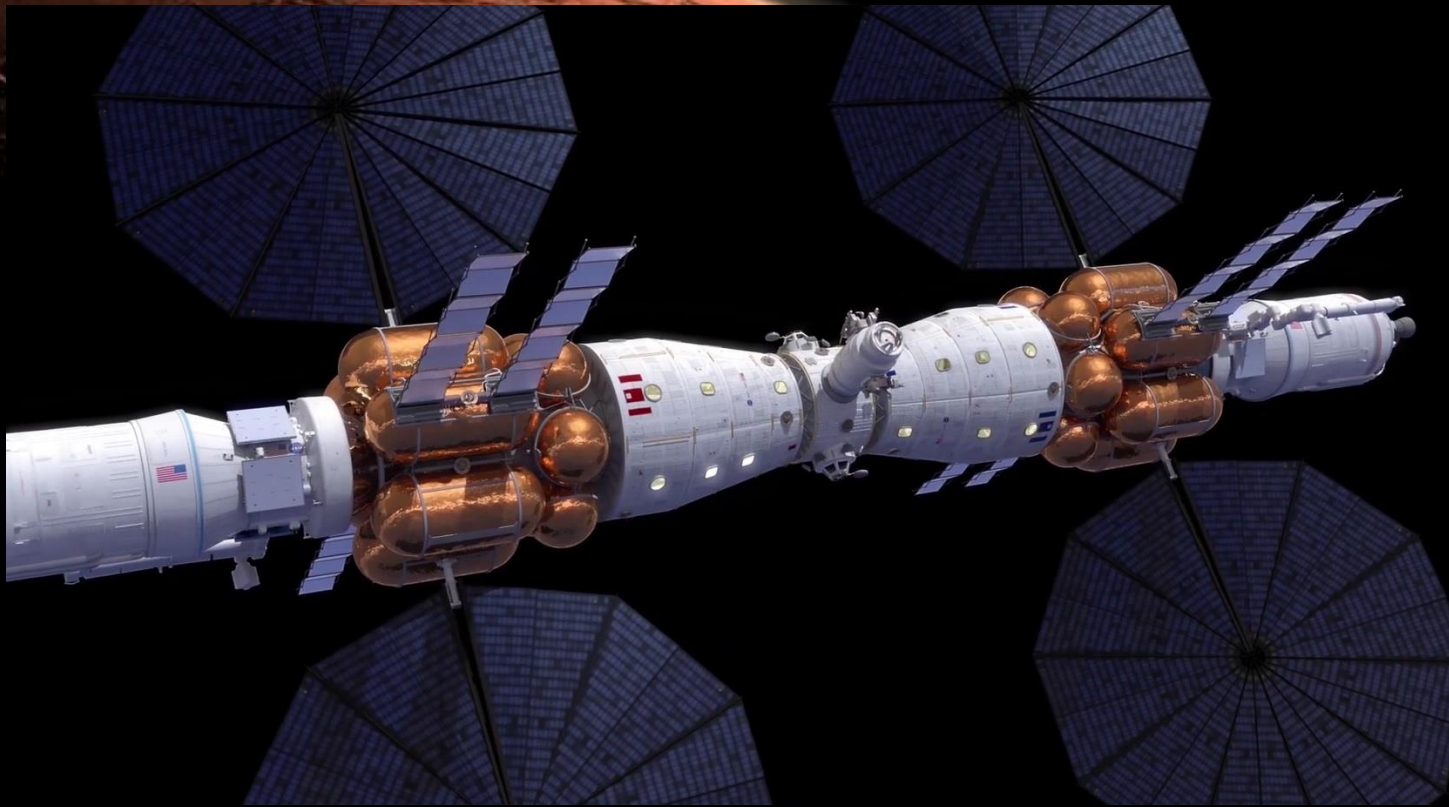


Conjunction



Conjunction / Fast Track

Key Mission Phases



Mars Transit (Cruise)

Key Mission Phases



Mars Surface Descent

Key Mission Phases



Mars Surface Operations

Key Mission Phases



Mars Surface Operations

Key Mission Phases



Mars Surface Operations

Key Mission Phases



Mars Surface Operations

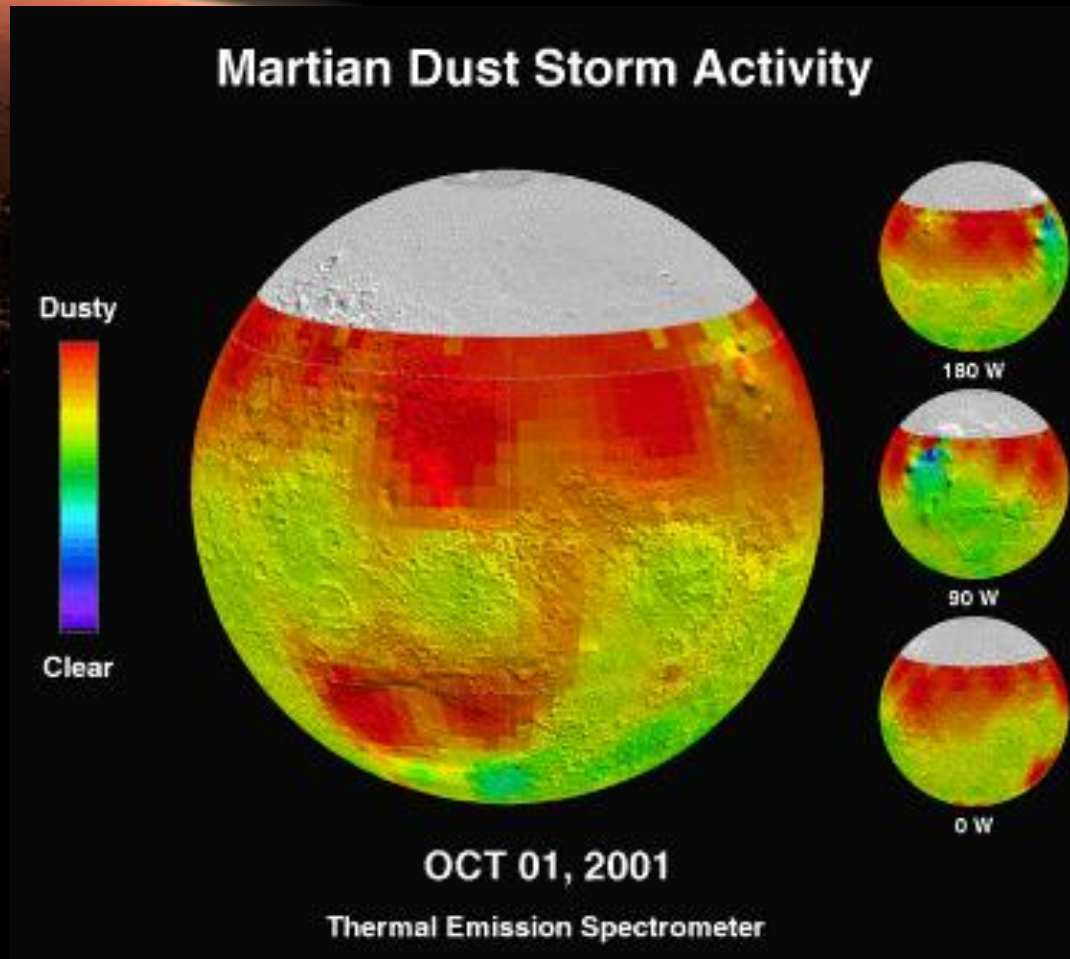
Key Mission Phases



“Weather affects everything.” – Douglas Mawson, Explorer/Scientist

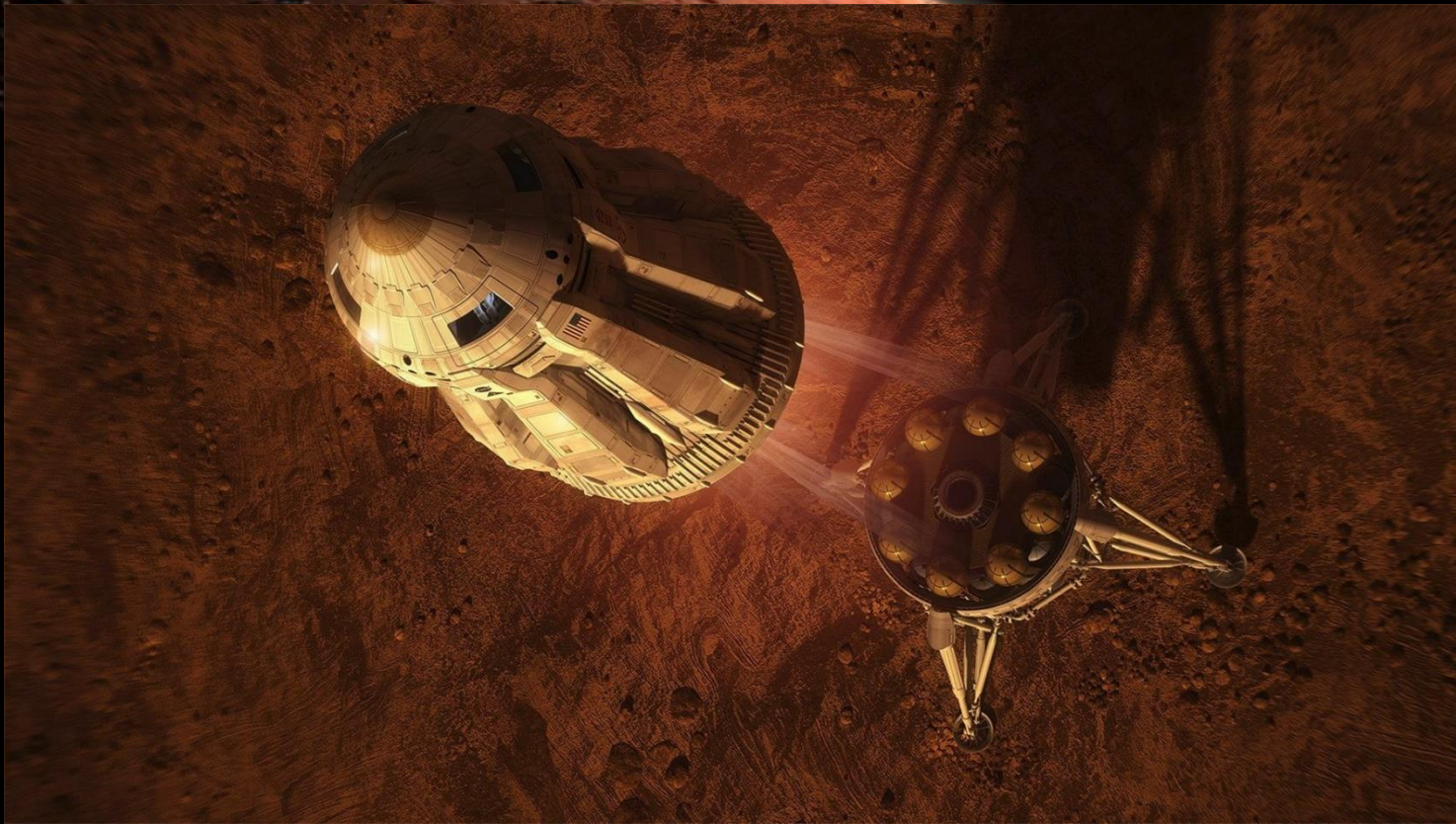
Mars Surface Operations

Key Mission Phases



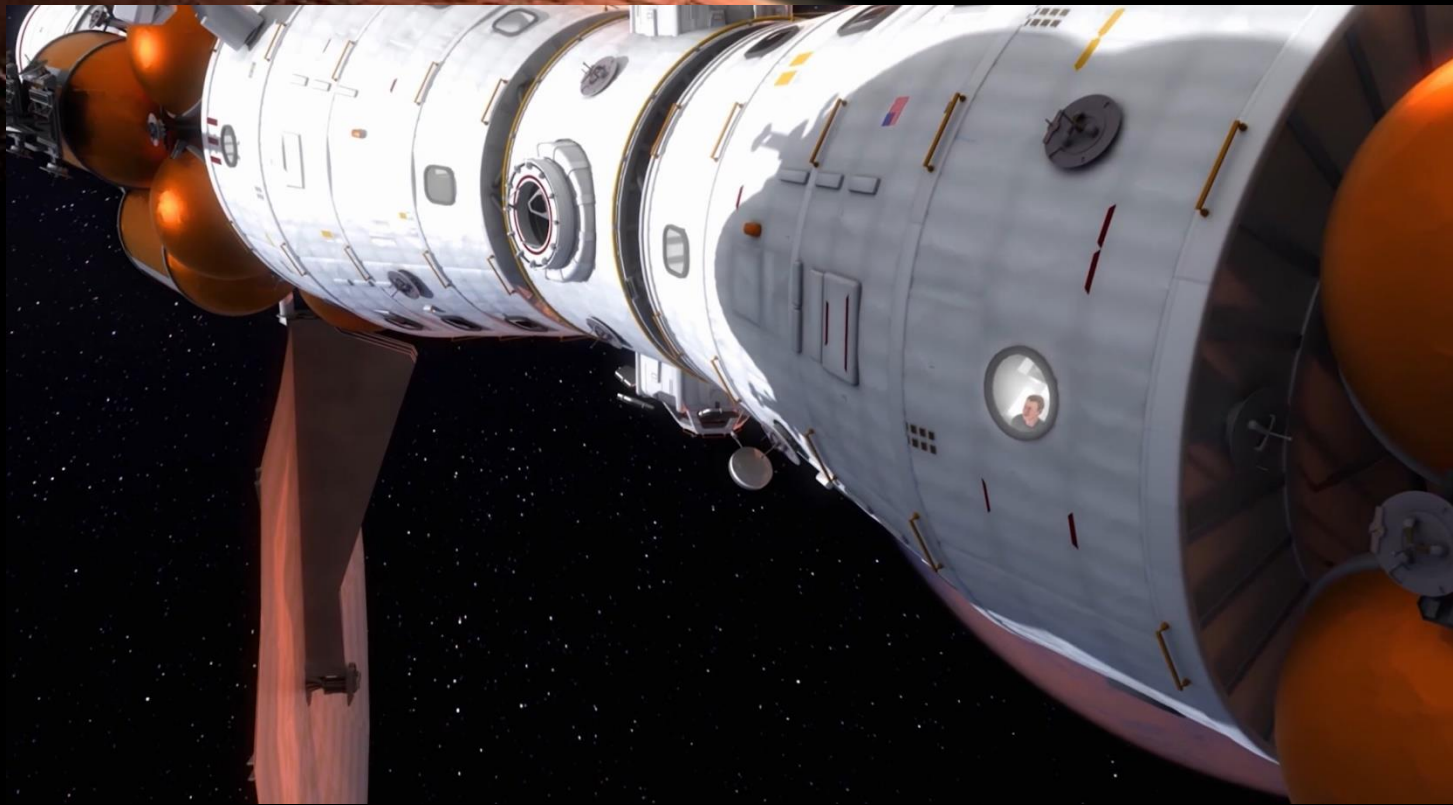
Mars Surface Operations

Key Mission Phases



Mars Surface Ascent

Key Mission Phases



Earth Transit (Cruise)

Key Mission Phases



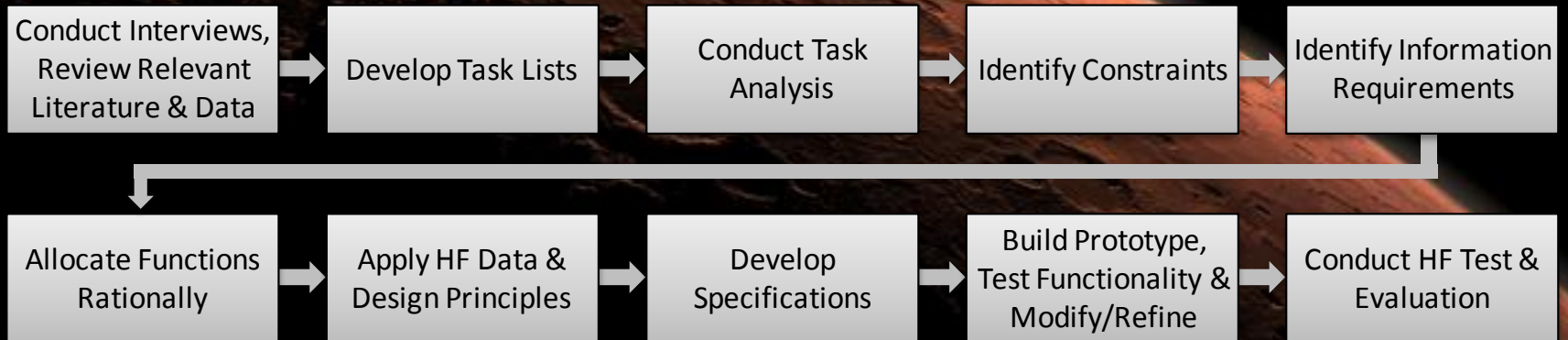
“All the conditions necessary for murder are met if you shut two men in a cabin measuring 18 feet by 20 and leave them together for two months.”

- Valery Ryumin, Cosmonaut

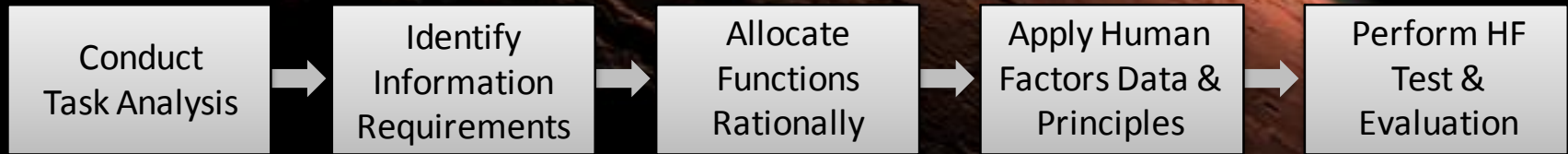
Imagine living in a motor home with five other people for six months, followed by 18 months in a cabin on Mars. You may go outside occasionally, but must wear a space suit. Then, there is the six-month trip home in the motor home.

An expedition to Mars would be a lot like this.

Human Factors Method



Human Factors Method



Mars Mission Plans

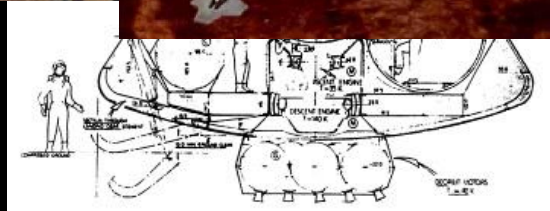
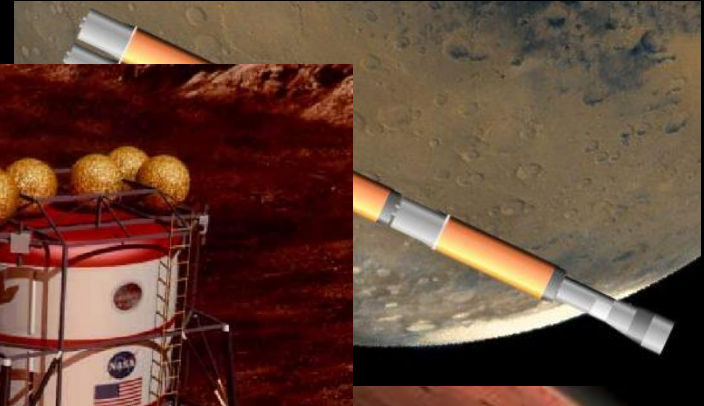
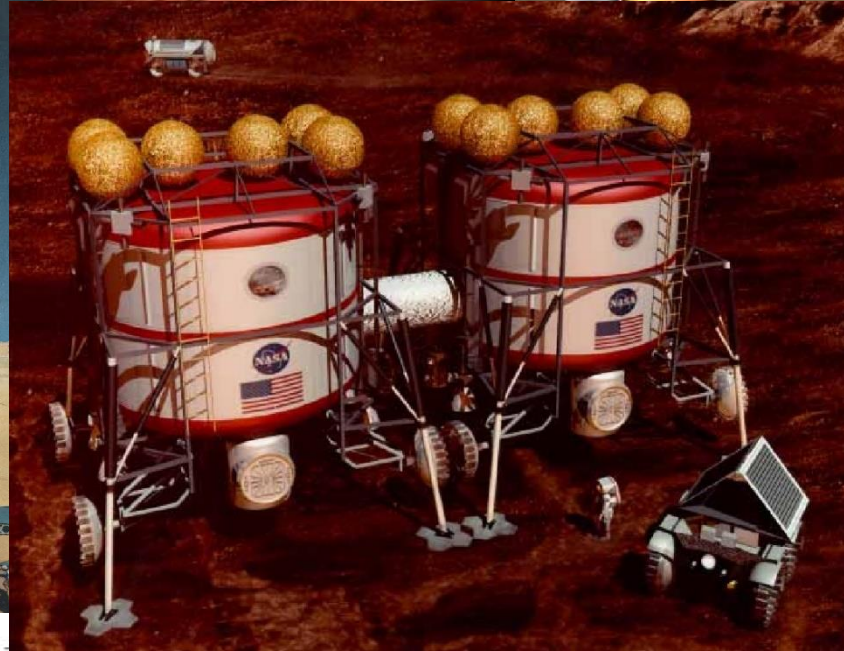


Our review began with von Braun's *The Mars Project*, 1952.

Mars Mission Plans

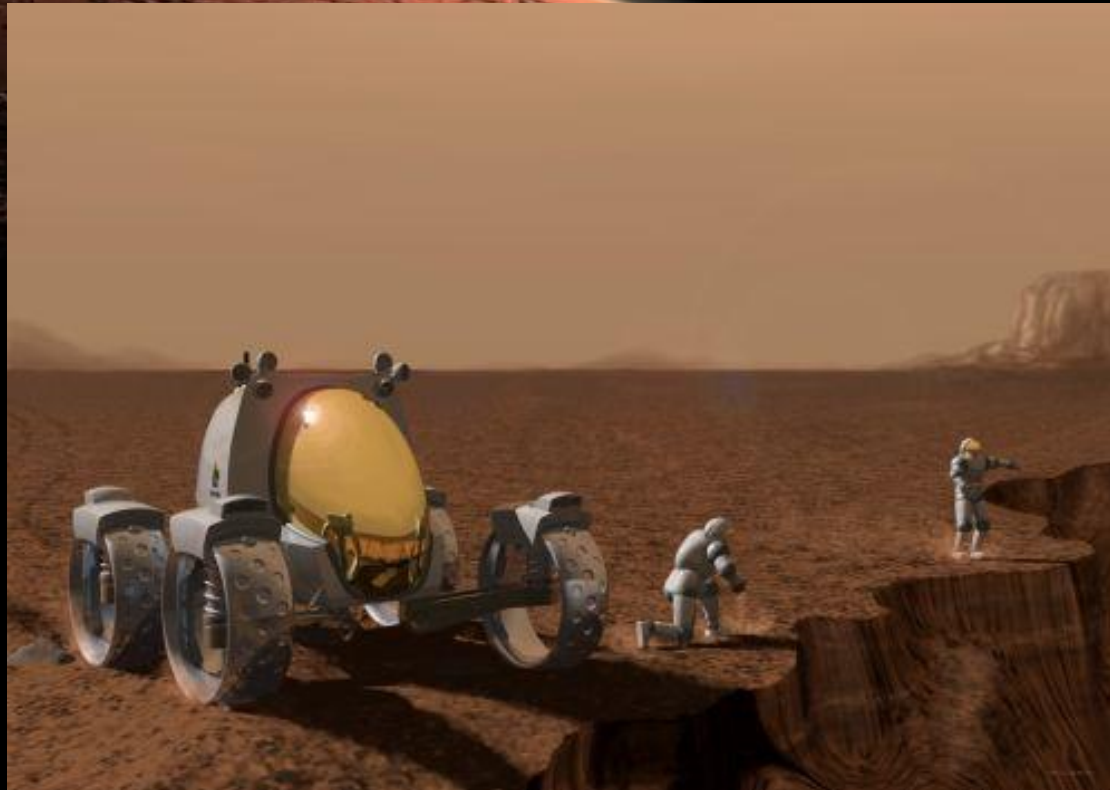


13-month exploration, the Mars mission prepares for return flight with two landing planes, one with wings and landing gear and one with wings and landing gear. They will meet back in the orbit orbit on first leg of journey.



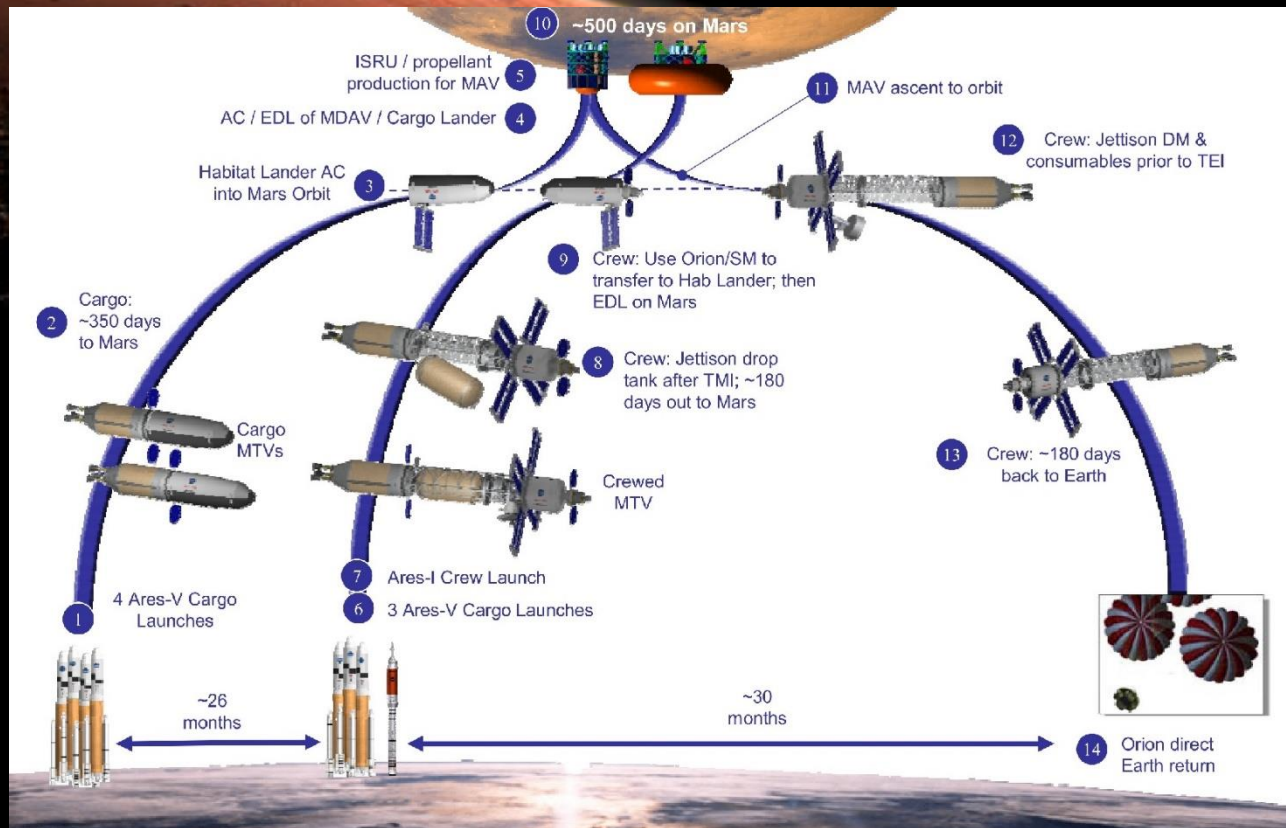
Review included all major mission plans, reference missions, and other sources.

Mars Mission Plans



Assumptions are consistent with Design Reference Architecture 5.0.

Mars Mission Plans



Assumptions are consistent with Design Reference Architecture 5.0 (2009).

Task Example

Adjust attitude control thrusters, manually wearing pressure suit/gloves, to dock Earth Ascent Vehicle (EAV) to space craft in LEO/CLO.



Task statements are formatted systematically to eliminate syntax as a variable.

Task Example

Walk on planetary surface while carrying hand tools and wearing surface EVA suit to conduct geological research.



Some tasks have human performance implications.

Task Example

Dig loose regolith from around surface rover wheel, manually using shovel while wearing surface EVA suit, to regain traction to proceed.



Some tasks have design implications (e.g., flexible surface EVA suits).

Task Example

Use space craft waste management system for solid waste (i.e., toilet/bodily function).



Some tasks have procedural implications.

Research Products

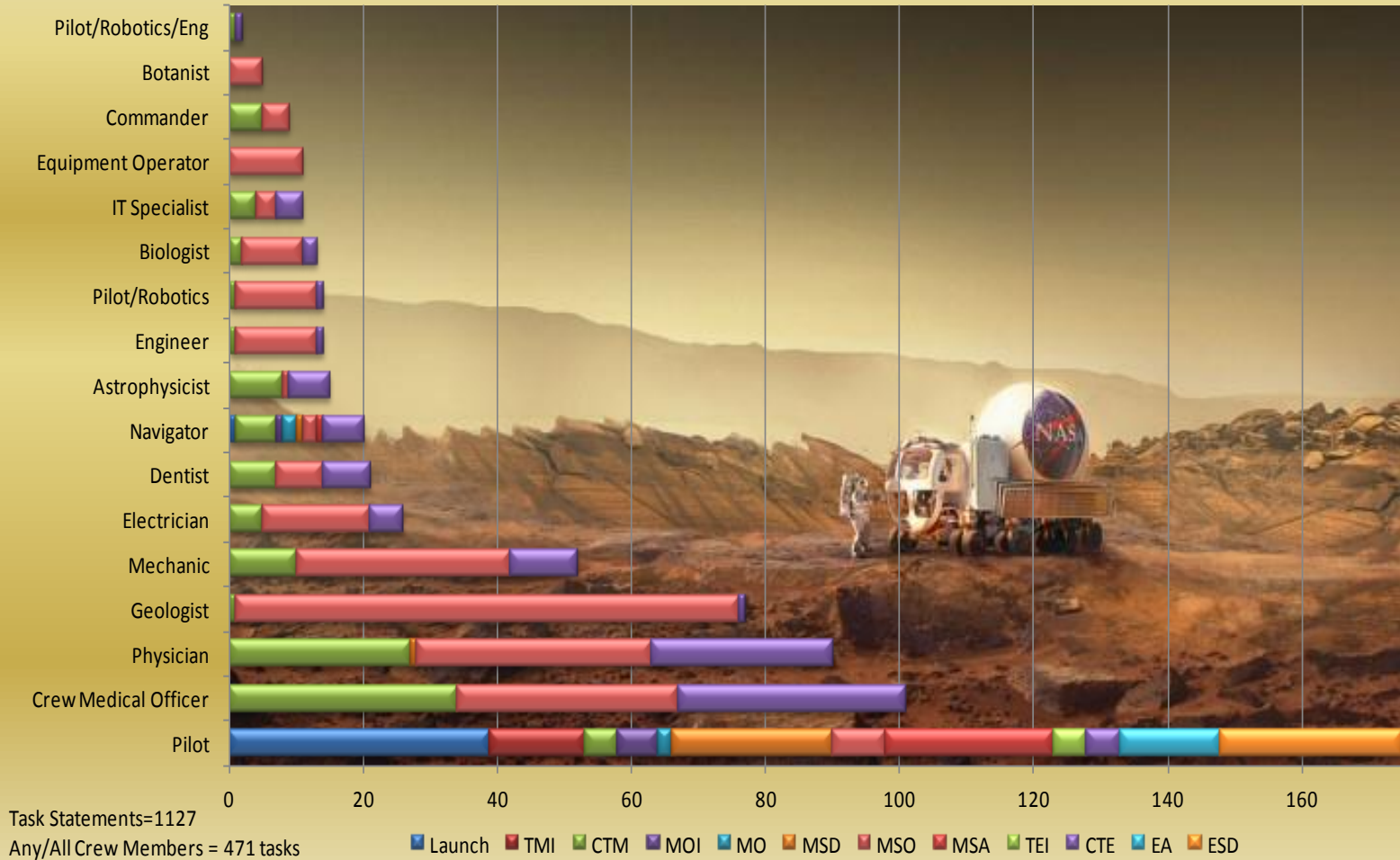
- A rating of expedition tasks by (likely) frequency, difficulty to learn, importance, and overall criticality;
- A rank-ordered list of the physical, cognitive, and social abilities necessary;
- Identification of the abilities, skills, and knowledge that can be retained and generalized across tasks and specialties;

Research Products

- Recommendations for optimum training strategies;
- Recommendations for crew size and composition; and,
- Recommendations for the design of equipment, habitats, and procedures for exploration-class space missions.

Task Analysis

Numbers of Task Statements by Crew Role and Mission Phase



Task Analysis

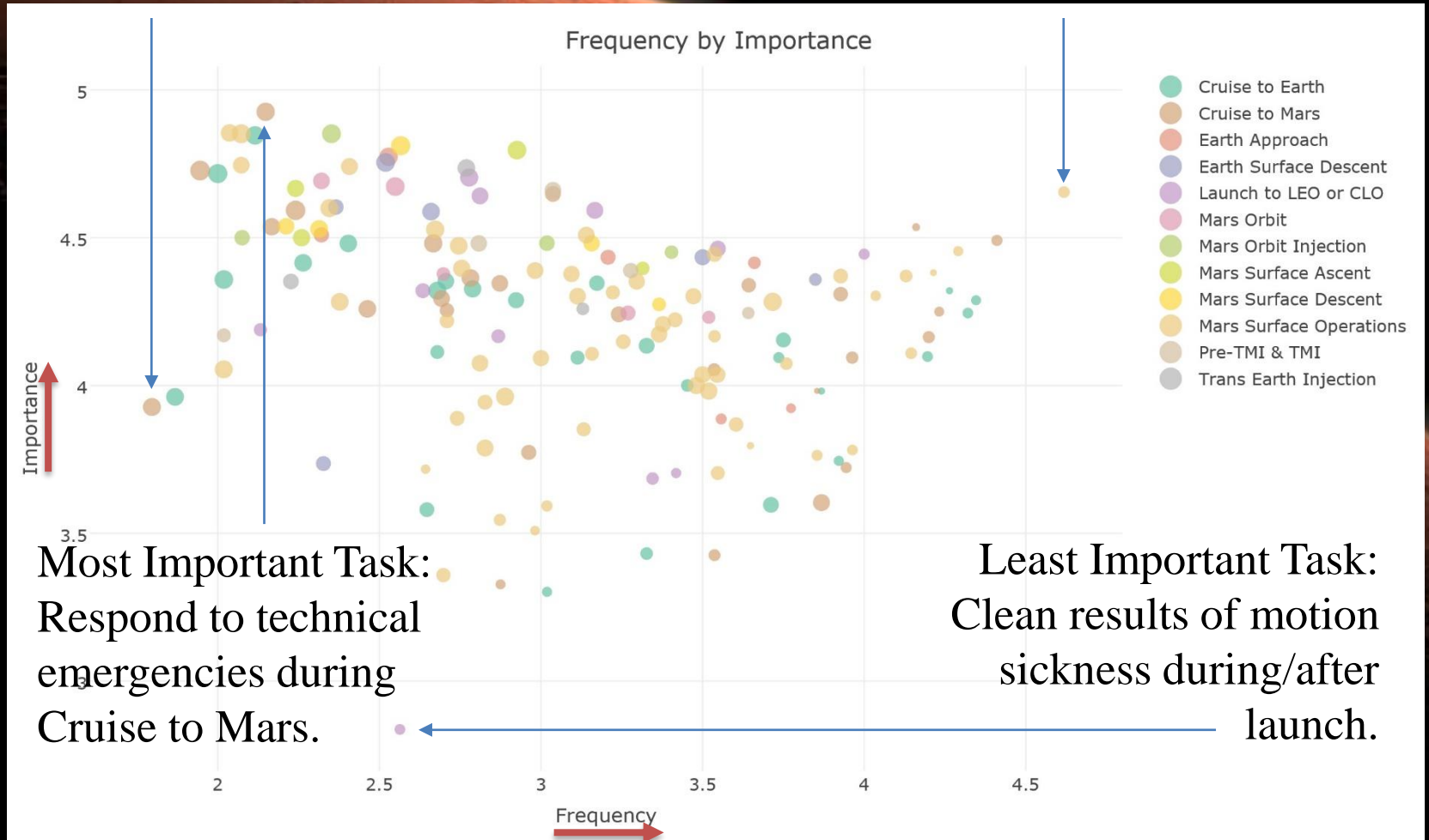
Task #	Task	How frequently is the task performed?	How difficult is it to learn the task?	How important is the task to mission success?
		Not at all -- -- -- Very	Not at all -- -- -- Very	Not at all -- -- -- Very
25	Perform surface rover maintenance functions during Mars Surface Operations.	○ ○ ○ ○ ○	○ ○ ○ ○ ○	○ ○ ○ ○ ○
	<i>Remove accumulated dust from surface rover windows, manually while wearing surface EVA suit, to maintain optimal visibility.</i>	Comments?		
	<i>Conduct troubleshooting, manually/visually using schematics, procedures, and hand tools while wearing surface EVA suit, to identify fault in surface rover.</i>			
	<i>Remove/replace faulty component/connector manually/visually using hand tools and spare parts while wearing surface EVA suit to restore surface rover to operation.</i>			

Example from the task-rating form.

Least Frequent Task:
Respond to dental
emergencies during
Cruise to Mars.

Task Analysis

Most Frequent Task:
Communicate with other
crew members during
Mars Surface Operations.



Dot Color = Mission Phase
Dot Size = Difficulty

The positions and values reflect internal
validity of study results.

Crew Roles

The task analysis identified 8 primary crew specialties/roles and 4 ancillary crew roles:

CMO

Botanist

Astrophysicist

Equipment Operator



Leader



Biologist



Geologist



Physician



Electrician



Pilot/Navigator



Mechanic/Engineer



Computer Specialist

Objective:

Develop cross-training and/or personnel-selection strategies to achieve a crew size of 5 or 6 astronauts.

Difficulty to Learn

	Summary Task Statement	Frequency	Difficulty	Importance	Criticality	Function
1	Respond to medical emergencies, following procedures and with equipment provided, during Cruise to Mars (CTM).	1.948	4.509	4.724	11.181	Medical
2	Conduct Extra-Vehicular Activity (EVA) to perform maintenance or retrieve items from outside the interplanetary space vehicle during Cruise to Mars.	2.246	4.491	4.596	11.333	EVA
3	Perform piloting functions during Mars Surface Descent.	2.589	4.375	4.821	11.786	Piloting
4	Respond to medical emergencies, following procedures and with equipment provided, during Cruise to Earth.	2.000	4.327	4.696	11.024	Medical
5	Perform piloting functions during Earth Descent.	2.545	4.268	4.750	11.563	Piloting
6	Respond to medical emergencies, following procedures and with equipment provided, during Mars Surface Operations (MSO).	2.069	4.263	4.825	11.157	Medical
7	Perform piloting functions during Mars Orbit Injection.	2.386	4.246	4.860	11.491	Piloting
8	Perform piloting functions during Mars Orbit operations	2.556	4.241	4.691	11.487	Piloting
9	Conduct EVA to perform maintenance or retrieve items from outside the interplanetary space vehicle during Cruise to Earth.	2.036	4.196	4.357	10.589	EVA
10	Monitor systems and perform piloting functions during Mars Surface Ascent.	2.912	4.158	4.807	11.877	Piloting
11	Perform piloting functions during Earth Approach.	2.518	4.107	4.786	11.411	Piloting
12	Perform medical diagnoses and evaluations, cognitively, during Cruise to Mars.	2.649	4.055	4.491	11.195	Medical
13	Respond to technical emergencies, following procedures and with equipment provided, during Cruise to Mars.	2.109	4.055	4.818	10.982	Technical
14	Perform medical diagnoses and evaluations, cognitively, during Mars Surface Operations.	2.690	4.053	4.517	11.260	Medical
15	Respond to technical emergencies, following procedures and with equipment provided, during Cruise to Mars.	2.140	4.053	4.930	11.123	Technical
16	Perform science-related EVA functions during Mars Surface Operations.	3.679	4.036	4.286	12.000	EVA
17	Enter control inputs, manually/visually with gloved hand, to pilot Earth Ascent Vehicle (EAV) during launch and cruise to LEO/CLO.	2.772	4.000	4.702	11.474	Piloting
18	Perform medical treatments during Mars Surface Operations.	2.328	3.965	4.586	10.879	Medical
19	Perform science-related EVA functions with heavy equipment during Mars Surface	2.877	3.964	3.946	10.788	EVA
20	Perform medical diagnoses and evaluations, cognitively, during Cruise to Earth	2.696	3.964	4.321	10.981	Medical
21	Respond to dental emergencies, following procedures and with equipment provided, during Cruise to Mars.	1.807	3.947	3.948	9.703	Medical
22	Conduct piloting functions during Cruise to Mars.	2.509	3.930	4.298	10.737	Piloting
23	Respond to dental emergencies during Mars Surface Operations.	2.018	3.929	4.052	9.998	Medical
24	Perform construction-related EVA functions with heavy equipment during MSO.	2.375	3.911	4.286	10.571	EVA
25	Perform post-Mars Descent maneuver functions.	2.333	3.907	4.556	10.796	Piloting
26	Monitor systems and perform piloting functions during Trans Earth Injection.	2.800	3.893	4.732	11.425	Piloting
27	Respond to dental emergencies, following procedures and with equipment provided, during Cruise to Earth.	1.875	3.891	3.964	9.730	Medical
28	Perform tests and examinations, physically, to support medical diagnoses during Cruise to Mars.	2.759	3.877	4.362	10.998	Medical
29	Adjust system controls, manually during buffeted descent, in response to displayed information.	2.673	3.870	4.585	11.128	Piloting
30	Perform medical treatments during Cruise to Earth.	2.273	3.870	4.436	10.579	Medical
31	Perform tests and examinations, physically, to support medical diagnoses during Mars Surface Operations.	2.741	3.860	4.483	11.084	Medical
32	Conduct piloting functions during Cruise to Earth.	2.407	3.852	4.500	10.759	Piloting

← Medical
← EVA

← Piloting

← Technical

Functional Category	Number of Task Statements
Medical	13
Piloting	12
EVA	5
Technical	2

Frequency

	Summary Task Statement	Frequency	Difficulty	Importance	Criticality	Function
1	Interact/communicate with other crew members directly during Mars Surface Operations (MSO).	4.638	2.298	4.672	11.609	Comms
2	Exercise daily using onboard equipment during Cruise to Mars (CTM).	4.390	2.179	4.500	11.068	Exercise
3	Prepare/eat meal, manually, using interplanetary space vehicle food hydration/heating equipment/galley during Cruise to Earth (CTE).	4.345	1.963	4.291	10.599	Habitability
4	Prepare and consume meals in surface habitat during MSO.	4.293	1.982	4.466	10.741	Habitability
5	Exercise daily using onboard equipment during Cruise to Earth.	4.286	2.073	4.232	10.591	Exercise
6	Sleep for approximately 8 hours each 24-hour period during CTE.	4.250	1.545	4.321	10.117	Habitability
7	Prepare/eat meal, manually, using interplanetary space vehicle food hydration/heating equipment/galley during Cruise to Mars.	4.237	1.982	4.254	10.474	Habitability
8	Sleep for approximately 8 hours each 24-hour period during MSO.	4.203	1.483	4.397	10.083	Habitability
9	Use interplanetary space vehicle waste management systems for liquid/solid waste (i.e., toilet/bodily function) during Cruise to Earth.	4.185	2.113	4.093	10.391	Habitability
10	Use interplanetary space vehicle waste management systems for liquid/solid waste (i.e., toilet/bodily function) during Cruise to Mars.	4.172	2.375	4.172	10.720	Habitability
11	Sleep for approximately 8 hours each 24-hour period during CTM.	4.153	1.621	4.542	10.316	Habitability
12	Use surface habitat waste management systems for liquid/solid waste (i.e., toilet/bodily function) during Mars Surface Operations.	4.138	2.281	4.103	10.522	Habitability
13	Conduct communications checks/communicate observations/evaluations to crew/MCC, verbally using communications system during MSO.	4.123	2.500	4.368	10.991	Comms
14	Perform exercise in surface habitat to maintain cardiovascular, muscle, and bone conditioning during Mars Surface Operations.	4.017	2.035	4.322	10.374	Exercise
15	Conduct communications checks/communicate observations/evaluations to crew/MCC verbally using communications system during CTM.	3.982	2.429	4.107	10.518	Comms
16	Conduct communications checks/communicate observations/evaluations to crew/MCC, verbally using comms system, during Launch to Orbit.	3.965	2.158	4.421	10.544	Comms
17	Use surface habitat hygiene systems for cleaning during MSO.	3.948	2.105	3.793	9.847	Habitability
18	Use interplanetary space vehicle hygiene systems for cleaning during CTM.	3.947	2.161	3.719	9.827	Habitability
19	Use interplanetary space vehicle hygiene systems for cleaning during CTE.	3.926	2.000	3.759	9.685	Habitability
20	Perform monitoring functions in surface habitat or modules to ensure crew and system health during Mars Surface Operations.	3.897	3.000	4.386	11.283	Monitoring
21	Monitor systems to ensure proper functioning during Cruise to Mars.	3.897	2.983	4.328	11.207	Monitoring
22	Conduct communications checks/communicate observations/evaluations to crew and MCC personnel during Earth Surface Descent.	3.855	2.473	4.364	10.691	Comms
23	Conduct recreational activities, individually and as a crew, during CTM.	3.828	1.411	3.966	9.204	Habitability
24	Conduct science and planning functions during Cruise to Mars.	3.821	3.625	3.607	11.054	Planning
25	Conduct recreational activities, individually and as a crew, during CTE.	3.821	1.537	3.982	9.341	Habitability
26	Perform surface habitat housekeeping functions during MSO.	3.810	2.158	3.759	9.727	Habitability
27	Prepare/eat meals during Earth Approach.	3.786	1.907	3.945	9.639	Habitability
28	Monitor systems to ensure proper functioning during Cruise to Earth.	3.778	3.074	4.185	11.037	Monitoring
29	Conduct communications checks/communicate observations/evaluations to crew and MCC, verbally using communications system during CTE.	3.768	2.161	4.107	10.036	Comms
30	Perform planning and administrative functions, individually and with other crew members during Mars Surface Operations.	3.754	2.526	4.070	10.351	Planning
31	Conduct science and planning functions during Cruise to Earth.	3.722	3.278	3.593	10.593	Planning
32	Perform science-related EVA functions during Mars Surface Operations.	3.679	4.036	4.286	12.000	EVA

← Communicate

← Habitability

← Exercise

← Monitoring

← Planning

Functional Category	Number of Task Statements
Habitability	16
Communicating	6
Exercise	3
Monitoring	3
Planning	3
EVA	1

Importance

	Summary Task Statement	Frequency	Difficulty	Importance	Criticality	Function
1	Respond to technical emergencies, following procedures and with equipment provided, during Cruise to Mars.	2.140	4.053	4.930	11.123	Technical
2	Perform piloting functions during Mars Orbit Injection.	2.386	4.246	4.860	11.491	Piloting
3	Perform emergency functions in surface habitat or modules during MSO.	2.052	3.810	4.845	10.707	Technical
4	Respond to medical emergencies, following procedures/with equipment provided, during Mars Surface Operations.	2.069	4.263	4.825	11.157	Medical
5	Perform piloting functions during Mars Surface Descent.	2.589	4.375	4.821	11.786	Piloting
6	Respond to technical emergencies, following procedures and with equipment provided, during Cruise to Earth.	2.109	4.055	4.818	10.982	Technical
7	Monitor systems/perform piloting functions during Mars Surface Ascent.	2.912	4.158	4.807	11.877	Piloting
8	Perform piloting functions during Earth Approach.	2.518	4.107	4.786	11.411	Piloting
9	Perform piloting functions during Earth Descent.	2.545	4.268	4.750	11.563	Piloting
10	Prepare for Mars Surface Ascent during Mars Surface Operations.	2.069	3.586	4.741	10.397	Technical
11	Perform initial installation/activation/inspection of surface habitat systems during Mars Surface Operations.	2.386	3.649	4.737	10.772	Technical
12	Monitor systems/perform piloting functions during Trans Earth Injection.	2.800	3.893	4.732	11.425	Piloting
13	Respond to medical emergencies during Cruise to Mars.	1.948	4.509	4.724	11.181	Medical
14	Configure systems for Mars Orbit operations and descent.	2.321	3.625	4.709	10.656	Technical
15	Enter control inputs, manually/visually with gloved hand, to pilot Earth Ascent Vehicle (EAV) during launch and cruise to LEO/CLO.	2.772	4.000	4.702	11.474	Piloting
16	Respond to medical emergencies, following procedures and with equipment provided, during Cruise to Earth.	2.000	4.327	4.696	11.024	Medical
17	Perform piloting functions during Mars Orbit operations	2.556	4.241	4.691	11.487	Piloting
18	Prepare for Mars Surface Ascent maneuver.	2.263	3.737	4.684	10.684	Technical
19	Interact/communicate with other crew members directly during MSO.	4.638	2.298	4.672	11.609	Comms
20	Assess displayed and aural information, cognitively, to determine appropriate course of action during Cruise to Mars.	3.018	3.298	4.649	10.965	Technical
21	Assess displayed information, cognitively, to determine readiness for TMI	3.018	3.571	4.643	11.232	Technical
22	Enter control inputs, manually/visually with gloved hand, to configure and operate Earth Ascent Vehicle (EAV) before and after launch.	2.821	3.614	4.625	11.060	Piloting
23	Prepare for Earth Surface Descent.	2.370	3.200	4.600	10.170	Technical
24	Conduct Extra-Vehicular Activity (EVA) to perform maintenance or retrieve items from outside the interplanetary space vehicle during Cruise to Mars.	2.246	4.491	4.596	11.333	EVA
25	Perform medical treatments during Mars Surface Operations.	2.328	3.965	4.586	10.879	Medical
26	Adjust system controls, manually during buffeted descent, in response to displayed information.	2.673	3.870	4.585	11.128	Piloting
27	Assess displayed information, cognitively, to determine readiness to launch to LEO/CLO.	3.123	3.632	4.579	11.333	Technical
28	Prepare for Mars Surface Descent maneuver.	2.236	3.527	4.564	10.327	Technical
29	Perform post-Mars Descent maneuver functions.	2.333	3.907	4.556	10.796	Piloting
30	Sleep for approximately 8 hours each 24-hour period during CTM.	4.153	1.621	4.542	10.316	Habitability
31	Perform post-Mars Ascent maneuver functions.	2.286	3.772	4.526	10.584	Piloting
32	Perform medical treatments during Cruise to Mars.	2.158	3.786	4.526	10.470	Medical

← Technical
← Piloting
← Medical

Functional Category	Number of Task Statements
Technical	12
Piloting	12
Medical	5
Communicating	1
Habitability	1
EVA	1

Criticality

	Summary Task Statement	Frequency	Difficulty	Importance	Criticality	Function
1	Perform science-related EVA functions during Mars Surface Operations (MSO).	3.679	4.036	4.286	12.000	Science EVA
2	Monitor systems/perform piloting functions during Mars Surface Ascent.	2.912	4.158	4.807	11.877	Piloting
3	Perform piloting functions during Mars Surface Descent.	2.589	4.375	4.821	11.786	Piloting
4	Interact/communicate with crew members directly during MSO.	4.638	2.298	4.672	11.609	Comms
5	Perform piloting functions during Earth Descent.	2.545	4.268	4.750	11.563	Piloting
6	Perform piloting functions during Mars Orbit Injection.	2.386	4.246	4.860	11.491	Piloting
7	Perform piloting functions during Mars Orbit operations	2.556	4.241	4.691	11.487	Piloting
8	Enter control inputs, manually/visually with gloved hand, to pilot Earth Ascent Vehicle (EAV) during launch and cruise to LEO/CLO.	2.772	4.000	4.702	11.474	Piloting
9	Monitor systems/perform piloting functions during Trans Earth Injection.	2.800	3.893	4.732	11.425	Piloting
10	Perform piloting functions during Earth Approach.	2.518	4.107	4.786	11.411	Piloting
11	Assess displayed information, cognitively, to determine readiness to launch to LEO/CLO.	3.123	3.632	4.579	11.333	Piloting
12	Conduct Extra-Vehicular Activity (EVA) to perform maintenance or retrieve items from outside the interplanetary space vehicle during Cruise to Mars.	2.246	4.491	4.596	11.333	EVA
13	Monitor displays/verify configurations before/during launch to LEO/CLO	3.554	3.333	4.439	11.326	Monitoring
14	Monitor systems during Earth Descent.	3.481	3.382	4.436	11.300	Monitoring
15	Perform monitoring functions in surface habitat or modules to ensure crew and system health during Mars Surface Operations.	3.897	3.000	4.386	11.283	Monitoring
16	Enter/exit surface habitat, manually while wearing pressure suit and helmet, during Mars Surface Operations.	3.544	3.246	4.474	11.263	EVA
17	Perform medical diagnoses and evaluations, cognitively, during MSO.	2.690	4.053	4.517	11.260	Medical
18	Perform robot operations-related functions during MSO.	3.527	3.750	3.982	11.259	Robotics
19	Perform geology-related science functions in surface habitat or modules during Mars Surface Operations.	3.491	3.754	4.000	11.245	Science
20	Assess displayed information, cognitively, to determine readiness for TMI.	3.018	3.571	4.643	11.232	Piloting
21	Monitor crew behavioral health/respond to behavioral health issues during Mars Surface Operations.	3.133	3.559	4.517	11.209	Medical
22	Monitor systems to ensure proper functioning during Cruise to Mars.	3.897	2.983	4.328	11.207	Monitoring
23	Perform medical diagnoses/evaluations, cognitively, during Cruise to Mars.	2.649	4.055	4.491	11.195	Medical
24	Respond to medical emergencies, following procedures and with equipment provided, during Cruise to Mars.	1.948	4.509	4.724	11.181	Medical
25	Perform surface rover piloting/driving functions during MSO.	3.464	3.411	4.304	11.179	Piloting
26	Respond to medical emergencies, following procedures and with equipment provided, during Mars Surface Operations.	2.069	4.263	4.825	11.157	Medical
27	Perform surface EVA physical functions on foot during MSO.	3.298	3.482	4.368	11.149	EVA
28	Adjust system controls, manually during buffeted descent, in response to displayed information.	2.673	3.870	4.585	11.128	Piloting
29	Respond to technical emergencies, following procedures and with equipment provided, during Cruise to Mars.	2.140	4.053	4.930	11.123	Technical
30	Monitor systems during Mars Surface Descent.	3.148	3.444	4.509	11.102	Piloting
31	Perform tests and examinations, physically, to support medical diagnoses during Mars Surface Operations.	2.741	3.860	4.483	11.084	Medical
32	Perform biology-related science functions in surface habitat or modules during Mars Surface Operations.	3.474	3.579	4.018	11.070	Science

← Criticality

← Frequency

← Difficulty

← Importance

Ability Analysis

Leader (n=42)	Mean	Pilot/Navigator (n=10)	Mean	Physician (n=11)	Mean	Biologist (n=12)	Mean	Geologist (n=15)	Mean	Computer Specialist (n=10)	Mean	Electrician (n=11)	Mean	Mechanic/Engineer (n=10)	Mean
More Important (21)	1.00	More Important (18)	1.00	More Important (18)	1.00	More Important (21)	1.00	More Important (14)	1.00	More Important (4)	1.00	More Important (15)	1.00	More Important (13)	1.00
Teamwork	7.17	Reaction Time	10.30	Problem Sensitivity	6.00	Inductive Reasoning	9.17	Inductive Reasoning	9.93	Inductive Reasoning	7.10	Inductive Reasoning	9.09	Inductive Reasoning	11.40
Confidence	8.17	Control Precision	10.80	Inductive Reasoning	7.55	Confidence	10.00	Deductive Reasoning	12.60	Deductive Reasoning	7.80	Problem Sensitivity	10.55	Problem Sensitivity	11.40
Problem Sensitivity	8.45	Spatial Orientation	12.10	Deductive Reasoning	8.09	Deductive Reasoning	10.67	Teamwork	12.80	Problem Sensitivity	8.80	Confidence	10.64	Deductive Reasoning	11.90
Patience	10.14	Rate Control	15.30	Confidence	12.36	Information Ordering	12.25	Patience	15.80	Information Ordering	15.50	Deductive Reasoning	11.45	Manual Dexterity	14.00
Emotional Control	10.98	Time Sharing	16.90	Patience	15.36	Patience	12.42	Confidence	15.87	Important	18.80	Information Ordering	16.18	Patience	17.70
Oral Expression	12.00	Confidence	17.00	Speed of Closure	15.55	Selective Attention	12.58	Spatial Orientation	16.80	Mathematical Reasoning	19.10	Visual Color Discrimination	17.18	Written Comprehension	17.70
Tolerance	12.10	Emotional Control	17.50	Teamwork	16.18	Problem Sensitivity	14.00	Originality	17.33	Written Comprehension	19.40	Finger Dexterity	18.09	Originality	18.60
Inductive Reasoning	12.48	Response Orientation	18.30	Oral Comprehension	17.82	Arm-Hand Steadiness	17.75	Oral Expression	17.47	Oral Comprehension	20.20	Manual Dexterity	18.91	Visualization	19.30
Speech Clarity	12.88	Teamwork	19.00	Manual Dexterity	17.91	Finger Dexterity	17.75	Selective Attention	19.07	Time Sharing	20.70	Originality	19.09	Mathematical Reasoning	22.20
Deductive Reasoning	13.19	Speed of Closure	20.50	Finger Dexterity	19.00	Originality	18.17	Visualization	19.40	Oral Expression	21.80	Selective Attention	20.27	Teamwork	22.30
Oral Comprehension	13.71	Near Vision	20.60	Originality	19.00	Written Comprehension	18.50	Flexibility of Closure	20.67	Confidence	20.00	Mathematical Reasoning	20.82	Confidence	23.00
Affability	14.71	Perceptual Speed	21.00	Written Comprehension	20.18	Manual Dexterity	18.83	Problem Sensitivity	21.40	Near Vision	21.10	Visualization	20.91	Information Ordering	23.80
Fluency of Ideas	16.98	Multi-Limb Coordination	23.00	Affability	20.45	Near Vision	19.25	Emotional Control	22.07	Selective Attention	21.20	Patience	21.55	Arm-Hand Steadiness	24.00
Time Sharing	17.26	Far Vision	23.80	Emotional Control	20.55	Flexibility of Closure	19.58	Stamina	22.60	Memorization	22.00	Near Vision	21.73	Important	24.10
Originality	17.60	Visualization	23.80	Information Ordering	20.55	Time Sharing	20.67	Important	22.67	Speed of Closure	22.20	Speed of Closure	22.09	Rate Control	24.30
Information Ordering	18.86	Information Ordering	24.40	Fluency of Ideas	21.00	Speed of Closure	21.50	Fluency of Ideas	22.67	Fluency of Ideas	23.70	Originality	23.70	Control Precision	25.90
Speech Hearing	19.10	Manual Dexterity	24.70	Selective Attention	21.00	Fluency of Ideas	22.08	Written Comprehension	23.33	Speech Clarity	24.00	Patience	25.30	Auditory Attention	26.40
Written Comprehension	19.43	Deductive Reasoning	25.50	Oral Expression	22.00	Written Expression	22.75	Affability	23.47	Teamwork	25.30	Night Vision	25.09	Finger Dexterity	26.50
Written Expression	21.93	Important	25.90	Important	24.91	Visual Color Discrimination	23.17	Far Vision	23.53	Teamwork	25.80	Oral Expression	26.27	Reaction Time	26.50
Speed of Closure	23.02	Arm-Hand Steadiness	26.00	Arm-Hand Steadiness	25.18	Mathematical Reasoning	23.92	Visual Color Discrimination	24.40	Finger Dexterity	28.00	Time Sharing	26.27	Speed of Closure	26.70
Category Flexibility	23.60	Depth Perception	26.10	Tolerance	25.36	Wrist-Finger Speed	24.08	Speech Clarity	25.67	Visualization	28.10	Written Comprehension	26.55	Flexibility of Closure	26.80
Important	24.17	Selective Attention	26.10	Visualization	25.55	Important	24.50	Tolerance	25.93	Fluency of Ideas	28.80	Number Facility	26.73	Static Strength	27.60
Visualization	25.07	Problem Sensitivity	27.10	Time Sharing	25.82	Teamwork	24.50	Speed of Closure	26.13	Perceptual Speed	29.00	Perceptual Speed	26.73	Multi-Limb Coordination	28.50
Auditory Attention	25.81	Night Vision	27.90	Speech Clarity	26.00	Oral Expression	24.75	Near Vision	26.33	Flexibility of Closure	30.00	Memorization	26.82	Dynamic Strength	29.70
Selective Attention	27.19	Speech Hearing	28.30	Flexibility of Closure	26.18	Category Flexibility	25.17	Oral Comprehension	26.33	Manual Dexterity	30.10	Flexibility of Closure	28.45	Oral Comprehension	30.00
Memorization	27.62	Patience	28.60	Speech Hearing	27.00	Number Facility	25.42	Manual Dexterity	27.07	Emotional Control	30.50	Perceptual Speed	28.91	General Hearing	30.50
Perceptual Speed	28.93	Oral Comprehension	28.70	Perceptual Speed	27.91	Oral Comprehension	25.50	Written Expression	27.20	Control Precision	30.90	Oral Comprehension	29.00	Gross Body Coordination	30.90
Reaction Time	29.07	Inductive Reasoning	28.80	Spatial Orientation	29.18	Control Precision	26.17	Information Ordering	27.20	Number Facility	31.60	General Hearing	29.73	Tolerance	31.10
Flexibility of Closure	30.38	Glare Sensitivity	29.10	Reaction Time	29.64	Memorization	26.75	Gross Body Coordination	28.53	Wrist-Finger Speed	31.90	Reaction Time	29.82	Fluency of Ideas	31.60
General Hearing	31.00	Peripheral Vision	29.30	Depth Perception	30.00	Visualization	27.25	Gross Body Equilibrium	28.87	Reaction Time	32.00	Speech Clarity	29.91	Sound Localization	32.60
Mathematical Reasoning	32.17	Speech Clarity	29.80	Auditory Attention	31.91	Emotional Control	27.58	Time Sharing	29.87	Category Flexibility	32.10	Auditory Attention	31.09	Emotional Control	34.10
Spatial Orientation	35.12	Visual Color Discrimination	29.90	Written Expression	32.18	Perceptual Speed	29.67	Category Flexibility	30.80	Arm-Hand Steadiness	32.50	Sound Localization	31.73	Visual Color Discrimination	34.10
Stamina	35.38	Finger Dexterity	30.80	Near Vision	32.36	Speech Clarity	30.17	Dynamic Strength	31.20	Speech Hearing	32.60	Fluency of Ideas	32.18	Speech Hearing	34.30
Number Facility	35.57	Auditory Attention	31.00	Perceptual Speed	32.79	Tolerance	33.17	Memorization	31.87	Response Orientation	32.80	Dynamic Flexibility	32.73	Time Sharing	34.40
Response Orientation	37.05	Gross Body Equilibrium	33.80	Spatial Orientation	29.18	Affability	33.25	Information Ordering	27.20	General Hearing	33.00	Control Precision	32.91	Number Facility	34.70
Sound Localization	38.76	Memorization	34.80	Reaction Time	29.64	Depth Perception	34.25	Gross Body Coordination	28.53	Sound Localization	33.00	Extent Flexibility	33.36	Oral Expression	34.70
Near Vision	39.98	General Hearing	35.10	Depth Perception	30.00	Reaction Time	34.42	Time Sharing	29.87	Rate Control	33.30	Written Expression	33.82	Response Orientation	34.70
Less Important	40.81	Affability	35.20	Auditory Attention	31.91	Control Precision	34.42	Perceptual Speed	33.33	Visual Color Discrimination	34.40	Affability	34.82	Spatial Orientation	34.90
Depth Perception	41.88	Oral Expression	35.40	Written Expression	32.18	Response Orientation	36.27	Mathematical Reasoning	33.87	Auditory Attention	34.60	Category Flexibility	36.36	Memorization	35.10
Rate Control	42.52	Tolerance	35.60	Near Vision	32.36	Stamina	36.91	Trunk Strength	33.93	Multi-Limb Coordination	35.60	Multi-Limb Coordination	36.40	Near Vision	35.30
Control Precision	42.57	Stamina	37.40	Memorization	33.64	Mathematical Reasoning	37.36	Arm-Hand Steadiness	36.40	General Hearing	33.00	Emotional Control	37.00	Gross Body Equilibrium	35.50
Manual Dexterity	42.83	Number Facility	37.80	Multi-Limb Coordination	34.27	General Hearing	37.45	Extent Flexibility	36.67	Response Orientation	33.00	Speech Hearing	37.09	Selective Attention	35.70
Far Vision	42.88	Wrist-Finger Speed	37.90	Number Facility	34.82	Auditory Attention	38.73	Speech Hearing	36.80	Depth Perception	33.47	Tolerance	37.80	Speech Clarity	35.70
Gross Body Equilibrium	43.83	Mathematical Reasoning	38.50	Control Precision	35.09	Written Expression	41.82	Number Facility	37.60	Perceptual Speed	33.47	Written Expression	38.10	Affability	36.20
Dynamic Strength	44.33	Dynamic Flexibility	40.60	Response Orientation	36.27	Spatial Orientation	43.00	Multi-Limb Coordination	39.40	Mathematical Reasoning	33.87	Extent Flexibility	39.60	Stamina	36.70
Gross Body Coordination	44.33	Gross Body Coordination	41.70	Stamina	36.91	Response Orientation	43.33	Control Precision	41.60	Dynamic Strength	39.80	Response Orientation	38.09	Gross Body Equilibrium	36.70
Peripheral Vision	44.83	Written Comprehension	41.80	Mathematical Reasoning	37.36	General Hearing	43.58	Dynamic Flexibility	41.80	Less Important	41.50	Gross Body Equilibrium	38.27	Near Vision	37.20
Multi-Limb Coordination	45.69	Flexibility of Closure	42.10	General Hearing	37.45	Gross Body Coordination	42.18	Less Important	44.67	Depth Perception	41.80	Rate Control	38.73	Explosive Strength	37.20
Visual Color Discrimination	45.74	Originality	42.10	Auditory Attention	38.73	Gross Body Equilibrium	42.18	Extent Flexibility	44.75	Perceptual Speed	41.60	Glare Sensitivity	40.73	Wrist-Finger Speed	37.30
Finger Dexterity	48.02	Category Flexibility	42.40	Written Expression	39.64	Visual Color Discrimination	42.55	Stamina	45.75	Dynamic Flexibility	42.60	Depth Perception	41.09	Perceptual Speed	38.60
Night Vision	48.02	Extent Flexibility	43.50	Visual Color Discrimination	42.55	Peripheral Vision	43.00	Trunk Strength	45.83	Reaction Time	45.40	Night Vision	42.40	Trunk Strength	39.20
Static Strength	48.21	Dynamic Strength	43.60	Peripheral Vision	43.00	Dynamic Flexibility	44.91	Dynamic Flexibility	47.83	Rate Control	46.20	Glare Sensitivity	43.60	Dynamic Flexibility	39.40
Arm-Hand Steadiness	49.00	Sound Localization	44.30	Dynamic Flexibility	44.91	Dynamic Strength	45.00	Gross Body Equilibrium	47.83	Explosive Strength	46.40	Stamina	43.80	Written Expression	40.40
Trunk Strength	49.43	Trunk Strength	46.80	Dynamic Strength	45.00	Less Important	45.64	Peripheral Vision	47.83	General Hearing	48.27	Gross Body Equilibrium	44.20	Category Flexibility	41.20
Dynamic Flexibility	50.36	Less Important	47.90	Less Important	45.64	Extent Flexibility	45.75	Sound Localization	48.08	Response Orientation	48.27	Response Orientation	44.20	Extent Flexibility	42.80
Extent Flexibility	51.00	Speed of Limb Movement	48.30	Rate Control	46.09	Stamina	45.75	Dynamic Strength	48.67	Written Expression	49.33	Written Expression	44.20	Night Vision	44.50
Speed of Limb Movement	51.14	Fluency of Ideas	50.20	Far Vision	46.45	Trunk Strength	45.83	Night Vision	48.75	Perceptual Speed	49.33	Speed of Limb Movement	50.64	Less Important	46.10
Wrist-Finger Speed	51.38	Written Expression	50.90	Sound Localization	47.36	Dynamic Flexibility	47.83	Speed of Limb Movement	50.42	Auditory Attention	49.73	Far Vision	50.91	Peripheral Vision	46.60
Explosive Strength	52.00	Static Strength	51.50	Extent Flexibility	47.45	Dynamic Flexibility	47.83	Sound Localization	51.50	Speed of Limb Movement	50.53	Static Strength	51.09	Far Vision	49.30
Glare Sensitivity	52.17	Explosive Strength	52.90	Static Strength	51.50	Gross Body Equilibrium	47.83	Peripheral Vision	53.47	Sound Localization	51.40	Trunk Strength	51.36	Speed of Limb Movement	50.40
				Explosive Strength	52.90	Peripheral Vision	47.83	Night Vision	55.27	Explosive Strength	53.30	Explosive Strength	58.18	Glare Sensitivity	55.00

Ability Analysis

Inductive Reasoning	Flexibility of Closure	Depth Perception
Deductive Reasoning	Fluency of Ideas	General Hearing
Problem Sensitivity	Mathematical Reasoning	Response Orientation
Confidence	Arm-Hand Steadiness	Stamina
Patience	Reaction Time	Gross Body Coordination
Teamwork	Affability	Wrist-Finger Speed
Information Ordering	Perceptual Speed	Gross Body Equilibrium
Originality	Memorization	Sound Localization
Speed of Closure	Control Precision	Far Vision
Selective Attention	Tolerance	Dynamic Strength
Written Comprehension	Visual Color Discrimination	Dynamic Flexibility
Visualization	Speech Hearing	Extent Flexibility
Oral Comprehension	Spatial Orientation	Night Vision
Time Sharing	Number Facility	Peripheral Vision
Manual Dexterity	Written Expression	Glare Sensitivity
Oral Expression	Auditory Attention	Static Strength
Emotional Control	Category Flexibility	Trunk Strength
Speech Clarity	Rate Control	Speed of Limb Movement
Near Vision	Multi-Limb Coordination	Explosive Strength
Finger Dexterity		

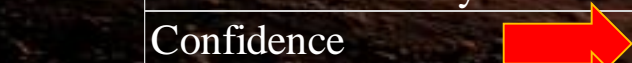


Ability Analysis

Inductive Reasoning	Flexibility of Closure	Depth Perception
Deductive Reasoning	Fluency of Ideas	General Hearing
Problem Sensitivity	Mathematical Reasoning	Response Orientation
Confidence	Arm-Hand Steadiness	Stamina
Patience	Reaction Time	Gross Body Coordination
Teamwork	Affability	Wrist-Finger Speed
Information Ordering	Perceptual Speed	Gross Body Equilibrium
Originality	Memorization	Sound Localization
Speed of Closure	Control Precision	Far Vision
Selective Attention	Tolerance	Dynamic Strength
Written Comprehension	Visual Color Discrimination	Dynamic Flexibility
Visualization	Speech Hearing	Extent Flexibility
Oral Comprehension	Spatial Orientation	Night Vision
Time Sharing	Number Facility	Peripheral Vision
Manual Dexterity	Written Expression	Glare Sensitivity
Oral Expression	Auditory Attention	Static Strength
Emotional Control	Category Flexibility	Trunk Strength
Speech Clarity	Rate Control	Speed of Limb Movement
Near Vision	Multi-Limb Coordination	Explosive Strength
Finger Dexterity		

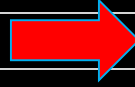
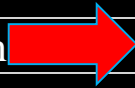
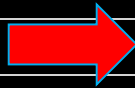
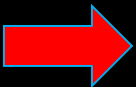
Ability Analysis

Inductive Reasoning	Flexibility of Closure	Depth Perception
Deductive Reasoning	Fluency of Ideas	General Hearing
Problem Sensitivity	Mathematical Reasoning	Response Orientation
Confidence	Arm-Hand Steadiness	Stamina
Patience	Reaction Time	Gross Body Coordination
Teamwork	Affability	Wrist-Finger Speed
Information Ordering	Perceptual Speed	Gross Body Equilibrium
Originality	Memorization	Sound Localization
Speed of Closure	Control Precision	Far Vision
Selective Attention	Tolerance	Dynamic Strength
Written Comprehension	Visual Color Discrimination	Dynamic Flexibility
Visualization	Speech Hearing	Extent Flexibility
Oral Comprehension	Spatial Orientation	Night Vision
Time Sharing	Number Facility	Peripheral Vision
Manual Dexterity	Written Expression	Glare Sensitivity
Oral Expression	Auditory Attention	Static Strength
Emotional Control	Category Flexibility	Trunk Strength
Speech Clarity	Rate Control	Speed of Limb Movement
Near Vision	Multi-Limb Coordination	Explosive Strength
Finger Dexterity		



Ability Analysis

Inductive Reasoning	Flexibility of Closure	Depth Perception
Deductive Reasoning	Fluency of Ideas	General Hearing
Problem Sensitivity	Mathematical Reasoning	Response Orientation
Confidence	Arm-Hand Steadiness	Stamina
Patience	Reaction Time	Gross Body Coordination
Teamwork	Affability	Wrist-Finger Speed
Information Ordering	Perceptual Speed	Gross Body Equilibrium
Originality	Memorization	Sound Localization
Speed of Closure	Control Precision	Far Vision
Selective Attention	Tolerance	Dynamic Strength
Written Comprehension	Visual Color Discrimination	Dynamic Flexibility
Visualization	Speech Hearing	Extent Flexibility
Oral Comprehension	Spatial Orientation	Night Vision
Time Sharing	Number Facility	Peripheral Vision
Manual Dexterity	Written Expression	Glare Sensitivity
Oral Expression	Auditory Attention	Static Strength
Emotional Control	Category Flexibility	Trunk Strength
Speech Clarity	Rate Control	Speed of Limb Movement
Near Vision	Multi-Limb Coordination	Explosive Strength
Finger Dexterity		



Ability Analysis

Top 15 Skills/Abilities by Crew Specialty/Role								
	Leader	Pilot/Nav	Physician	Biologist	Geologist	Computer	Electrician	Mechanic
Inductive Reasoning	8		2	1	1	1	1	1
Deductive Reasoning	10		3	3	2	2	4	3
Problem Sensitivity	3		1	7	12	3	2	2
Confidence	2	6	4	2	5	10	3	11
Patience	4		5	5	4		13	5
Teamwork	1	9	7		3			10
Information Ordering			15	4		4	5	12
Originality	15		11	10	7	15	9	7
Speed of Closure		10	6			14	15	
Selective Attention				6	9	12	10	
Written Comprehension			12	11		6		6
Visualization		15			10		12	8
Oral Comprehension	11		8			7		
Time Sharing	14	5		15		8		
Oral Expression	6				8	9		
Manual Dexterity			9	12			8	4
Emotional Control	5	7	14		13			
Speech Clarity	9							
Near Vision		11		13		11	14	
Finger Dexterity			10	9			7	
Flexibility of Closure				14	11			
Fluency of Ideas	13				15			
Mathematical Reasoning						5	11	9
Affability	12		13					
Arm-Hand Steadiness				8				13
Reaction Time		1						
Perceptual Speed		12						
Memorization						13		
Control Precision		2						15
Tolerance	7							
Visual Color Discrimination							6	
Spatial Orientation		3			6			
Rate Control		4						14
Multi-Limb Coordination		13						
Response Orientation		8						
Stamina					14			
Far Vision		14						

Ability Analysis

Top 15 Skills/Abilities by Crew Specialty/Role								
	Leader	Pilot/Nav	Physician	Biologist	Geologist	Computer	Electrician	Mechanic
Inductive Reasoning	8		2	1	1	1	1	1
Deductive Reasoning	10		3	3	2	2	4	3
Problem Sensitivity	3		1	7	12	3	2	2
Confidence	2	6	4	2	5	10	3	11
Patience	4		5	5	4		13	5
Teamwork	1	9	7		3			10
Information Ordering			15	4		4	5	12
Originality	15		11	10	7	15	9	7
Speed of Closure		10	6			14	15	
Selective Attention				6	9	12	10	
Written Comprehension			12	11		6		6
Visualization		15			10		12	8
Oral Comprehension	11		8			7		
Time Sharing	14	5		15		8		
Oral Expression	6				8	9		
Manual Dexterity			9	12			8	4
Emotional Control	5	7	14		13			
Speech Clarity	9							
Near Vision		11		13		11	14	
Finger Dexterity			10	9			7	
Flexibility of Closure				14	11			
Fluency of Ideas	13				15			
Mathematical Reasoning						5	11	9
Affability	12		13					
Arm-Hand Steadiness				8				13
Reaction Time		1						
Perceptual Speed		12						
Memorization						13		
Control Precision		2						15
Tolerance	7							
Visual Color Discrimination							6	
Spatial Orientation		3			6			
Rate Control		4						14
Multi-Limb Coordination		13						
Response Orientation		8						
Stamina					14			
Far Vision		14						

← Cognitive

← Social

← Physical

Ability Analysis

Skill/Ability Rank by Crew Specialty/Role Ranks 1 - 29									
	Leader	Pilot	Physician	Biologist	Geologist	Computer	Electrician	Mechanic	Combined
1	Teamwork	Reaction Time	Problem Sensitivity	Inductive Reasoning	Inductive Reasoning	Inductive Reasoning	Inductive Reasoning	Inductive Reasoning	Inductive Reasoning
2	Confidence	Control Precision	Inductive Reasoning	Confidence	Deductive Reasoning	Deductive Reasoning	Problem Sensitivity	Problem Sensitivity	Deductive Reasoning
3	Problem Sensitivity	Spatial Orientation	Deductive Reasoning	Deductive Reasoning	Teamwork	Problem Sensitivity	Confidence	Deductive Reasoning	Problem Sensitivity
4	Patience	Rate Control	Confidence	Information Ordering	Patience	Information Ordering	Deductive Reasoning	Manual Dexterity	Confidence
5	Emotional Control	Time Sharing	Patience	Patience	Confidence	Mathematical Reasoning	Information Ordering	Patience	Patience
6	Oral Expression	Confidence	Speed of Closure	Selective Attention	Spatial Orientation	Written Comprehension	Visual Color Discrimination	Written Comprehension	Teamwork
7	Tolerance	Emotional Control	Teamwork	Problem Sensitivity	Originality	Oral Comprehension	Finger Dexterity	Originality	Information Ordering
8	Inductive Reasoning	Response Orientation	Oral Comprehension	Arm-Hand Steadiness	Oral Expression	Time Sharing	Manual Dexterity	Visualization	Originality
9	Speech Clarity	Teamwork	Manual Dexterity	Finger Dexterity	Selective Attention	Oral Expression	Originality	Mathematical Reasoning	Speed of Closure
10	Deductive Reasoning	Speed of Closure	Finger Dexterity	Originality	Visualization	Confidence	Selective Attention	Teamwork	Selective Attention
11	Oral Comprehension	Near Vision	Originality	Written Comprehension	Flexibility of Closure	Near Vision	Mathematical Reasoning	Confidence	Written Comprehension
12	Affability	Perceptual Speed	Written Comprehension	Manual Dexterity	Problem Sensitivity	Selective Attention	Visualization	Information Ordering	Visualization
13	Fluency of Ideas	Multi-Limb Coordination	Affability	Near Vision	Emotional Control	Memorization	Patience	Arm-Hand Steadiness	Oral Comprehension
14	Time Sharing	Far Vision	Emotional Control	Flexibility of Closure	Stamina	Speed of Closure	Near Vision	Rate Control	Time Sharing
15	Originality	Visualization	Information Ordering	Time Sharing	Fluency of Ideas	Originality	Speed of Closure	Control Precision	Oral Expression
16	Information Ordering	Information Ordering	Fluency of Ideas	Speed of Closure	Written Comprehension	Speech Clarity	Teamwork	Auditory Attention	Manual Dexterity
17	Speech Hearing	Manual Dexterity	Selective Attention	Fluency of Ideas	Affability	Patience	Arm-Hand Steadiness	Finger Dexterity	Emotional Control
18	Written Comprehension	Deductive Reasoning	Oral Expression	Written Expression	Far Vision	Teamwork	Night Vision	Reaction Time	Speech Clarity
19	Written Expression	Arm-Hand Steadiness	Arm-Hand Steadiness	Visual Color Discrimination	Visual Color Discrimination	Finger Dexterity	Oral Expression	Speed of Closure	Near Vision
20	Speed of Closure	Depth Perception	Tolerance	Mathematical Reasoning	Speech Clarity	Visualization	Time Sharing	Flexibility of Closure	Finger Dexterity
21	Category Flexibility	Selective Attention	Visualization	Wrist-Finger Speed	Tolerance	Fluency of Ideas	Written Comprehension	Static Strength	Flexibility of Closure
22	Visualization	Problem Sensitivity	Time Sharing	Teamwork	Speed of Closure	Perceptual Speed	Number Facility	Multi-Limb Coordination	Fluency of Ideas
23	Auditory Attention	Night Vision	Speech Clarity	Oral Expression	Near Vision	Flexibility of Closure	Memorization	Dynamic Strength	Mathematical Reasoning
24	Selective Attention	Speech Hearing	Flexibility of Closure	Category Flexibility	Oral Comprehension	Manual Dexterity	Flexibility of Closure	Oral Comprehension	Affability
25	Memorization	Patience	Speech Hearing	Number Facility	Manual Dexterity	Emotional Control	Perceptual Speed	General Hearing	Arm-Hand Steadiness
26	Perceptual Speed	Oral Comprehension	Perceptual Speed	Oral Comprehension	Written Expression	Control Precision	Oral Comprehension	Gross Body Coordination	Reaction Time
27	Reaction Time	Inductive Reasoning	Spatial Orientation	Control Precision	Information Ordering	Number Facility	General Hearing	Tolerance	Perceptual Speed
28	Flexibility of Closure	Glare Sensitivity	Reaction Time	Memorization	Gross Body Coordination	Gross Body Coordination	Wrist-Finger Speed	Reaction Time	Fluency of Ideas
29	General Hearing	Peripheral Vision	Depth Perception	Visualization	Gross Body Equilibrium	Reaction Time	Speech Clarity	Sound Localization	Control Precision
	Key: Cognitive Abilities=				Social Skills=			Physical Abilities=	

Ability Analysis

Skill/Ability Rank by Crew Specialty/Role Ranks 30 - 58									
	Leader	Pilot	Physician	Biologist	Geologist	Computer	Electrician	Mechanic	Combined
30	Mathematical Reasoning	Speech Clarity	Auditory Attention	Emotional Control	Time Sharing	Category Flexibility	Auditory Attention	Emotional Control	Tolerance
31	Spatial Orientation	Visual Color Discrimination	Written Comprehension	Perceptual Speed	Category Flexibility	Arm-Hand Steadiness	Sound Localization	Visual Color Discrimination	Visual Color Discrimination
32	Stamina	Finger Dexterity	Written Expression	Speech Clarity	Dynamic Strength	Speech Hearing	Fluency of Ideas	Speech Hearing	Speech Hearing
33	Number Facility	Auditory Attention	Memorization	Tolerance	Memorization	Response Orientation	Dynamic Flexibility	Time Sharing	Spatial Orientation
34	Response Orientation	Gross Body Equilibrium	Multi-Limb Coordination	Affability	Depth Perception	General Hearing	Control Precision	Number Facility	Number Facility
35	Sound Localization	Memorization	Number Facility	Depth Perception	Finger Dexterity	Sound Localization	Extent Flexibility	Oral Expression	Written Expression
36	Near Vision	General Hearing	Control Precision	Reaction Time	Perceptual Speed	Rate Control	Written Expression	Response Orientation	Auditory Attention
37	Depth Perception	Affability	Response Orientation	Rate Control	Mathematical Reasoning	Visual Color Discrimination	Affability	Spatial Orientation	Category Flexibility
38	Rate Control	Oral Expression	Stamina	Speech Hearing	Trunk Strength	Auditory Attention	Category Flexibility	Memorization	Rate Control
39	Control Precision	Tolerance	Mathematical Reasoning	Glare Sensitivity	Arm-Hand Steadiness	Multi-Limb Coordination	Multi-Limb Coordination	Near Vision	Multi-Limb Coordination
40	Manual Dexterity	Stamina	General Hearing	Multi-Limb Coordination	Extent Flexibility	Affability	Emotional Control	Gross Body Equilibrium	Depth Perception
41	Far Vision	Number Facility	Gross Body Coordination	Auditory Attention	Speech Hearing	Gross Body Coordination	Speech Hearing	Selective Attention	General Hearing
42	Gross Body Equilibrium	Wrist-Finger Speed	Wrist-Finger Speed	Spatial Orientation	Static Strength	Tolerance	Wrist-Finger Speed	Speech Clarity	Response Orientation
43	Dynamic Strength	Mathematical Reasoning	Category Flexibility	Response Orientation	Number Facility	Written Expression	Response Orientation	Affability	Stamina
44	Gross Body Coordination	Dynamic Flexibility	Gross Body Equilibrium	General Hearing	Multi-Limb Coordination	Extent Flexibility	Gross Body Equilibrium	Stamina	Gross Body Coordination
45	Peripheral Vision	Gross Body Coordination	Visual Color Discrimination	Gross Body Coordination	Control Precision	Depth Perception	Rate Control	Explosive Strength	Wrist-Finger Speed
46	Multi-Limb Coordination	Written Comprehension	Peripheral Vision	Extent Flexibility	Dynamic Flexibility	Dynamic Flexibility	Gross Body Coordination	Wrist-Finger Speed	Gross Body Equilibrium
47	Visual Color Discrimination	Flexibility of Closure	Dynamic Flexibility	Stamina	Reaction Time	Spatial Orientation	Glare Sensitivity	Perceptual Speed	Sound Localization
48	Finger Dexterity	Originality	Dynamic Strength	Trunk Strength	Rate Control	Night Vision	Depth Perception	Depth Perception	Far Vision
49	Night Vision	Category Flexibility	Rate Control	Dynamic Flexibility	Glare Sensitivity	Glare Sensitivity	Stamina	Trunk Strength	Dynamic Flexibility
50	Static Strength	Extent Flexibility	Far Vision	Gross Body Equilibrium	Explosive Strength	Stamina	Spatial Orientation	Dynamic Flexibility	Dynamic Strength
51	Arm-Hand Steadiness	Dynamic Strength	Sound Localization	Peripheral Vision	General Hearing	Gross Body Equilibrium	Tolerance	Written Expression	Extent Flexibility
52	Trunk Strength	Sound Localization	Extent Flexibility	Sound Localization	Response Orientation	Trunk Strength	Peripheral Vision	Category Flexibility	Night Vision
53	Dynamic Flexibility	Trunk Strength	Static Strength	Dynamic Strength	Wrist-Finger Speed	Peripheral Vision	Dynamic Strength	Extent Flexibility	Glare Sensitivity
54	Extent Flexibility	Speed of Limb Movement	Glare Sensitivity	Night Vision	Auditory Attention	Static Strength	Speed of Limb Movement	Night Vision	Peripheral Vision
55	Speed of Limb Movement	Fluency of Ideas	Trunk Strength	Speed of Limb Movement	Sound Localization	Far Vision	Far Vision	Peripheral Vision	Static Strength
56	Wrist-Finger Speed	Written Expression	Speed of Limb Movement	Static Strength	Speed of Limb Movement	Speed of Limb Movement	Static Strength	Far Vision	Trunk Strength
57	Explosive Strength	Static Strength	Explosive Strength	Far Vision	Peripheral Vision	Dynamic Strength	Trunk Strength	Speed of Limb Movement	Speed of Limb Movement
58	Glare Sensitivity	Explosive Strength	Night Vision	Explosive Strength	Night Vision	Explosive Strength	Explosive Strength	Glare Sensitivity	Explosive Strength
	Key: Cognitive Abilities=				Social Skills=		Physical Abilities=		

Crew Composition / Cross-Training

A: Six-Person Crew

Primary Specialties/Roles

Pilot/Navigator (Robotics & Rovers)
Physician/Astrophysicist
Mechanic/Equipment Operator
Electrician/Computer Specialist
Geologist/Leader
Biologist/Botanist

Backup Responsibilities

Equipment Operator/CMO
Biologist/Geologist
Pilot/Navigator/Astrophysicist
Mechanic/CMO/Botanist
Electrician/Computer Specialist
Leader/CMO

B: Five-Person Crew

Primary Specialty/Roles

Pilot/Navigator (Robotics & Rovers)
Physician/Biologist/Astrophysicist
Mechanic/Equipment Operator
Electrician/Computer Specialist
Geologist/Leader/Botanist

Backup Responsibilities

Geologist/Leader/CMO
Electrician/Computer Specialist
Biologist/CMO/Botanist
Mechanic/Equipment Operator/CMO
Pilot/Navigator/Astrophysicist

C: Five-Person Crew

Primary Specialty/Roles

Pilot/Navigator (Robotics & Rovers)
Physician/Astrophysicist/Botanist
Mechanic/Equipment Operator
Electrician/Computer Specialist
Geologist/Biologist/Leader

Backup Responsibilities

Geologist/Leader/CMO
Pilot/Navigator/Biologist
Electrician/Computer Specialist/CMO
Mechanic/Equipment Operator
Botanist/Astrophysicist/CMO

D: Four-Person Crew

Primary Specialty/Roles

Pilot/Navigator/Leader/Astrophysicist
Physician/Computer Specialist
Mechanic/Electrician/Equipment Operator
Geologist/Biologist/Botanist

Backup Responsibilities

Geologist/Computer Specialist/CMO
Biologist/Mechanic/Electrician/Botanist
Pilot/Navigator/Astrophysicist/CMO
Equipment Operator/Leader/CMO

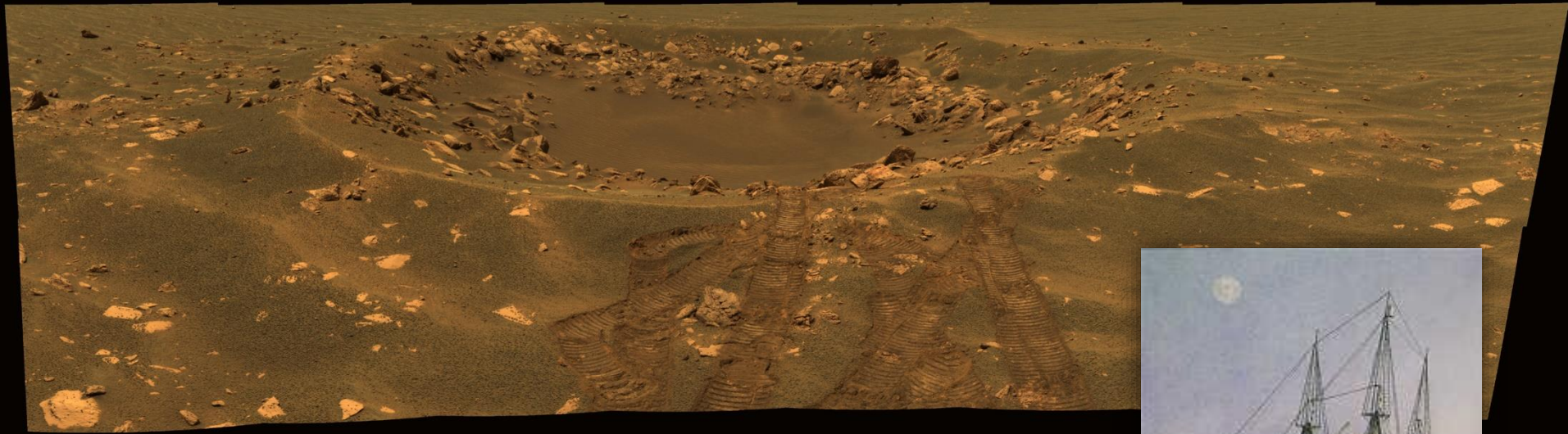
The Pilot/Navigator would have lead responsibility for robotics and rovers during Mars Surface Operations in all four hypothetical crew compositions.

Sightseeing on Mars

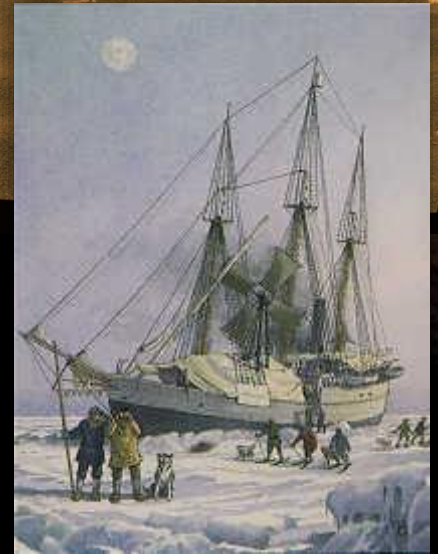


First photo taken on Mars; Viking 1, 20 July 1976.

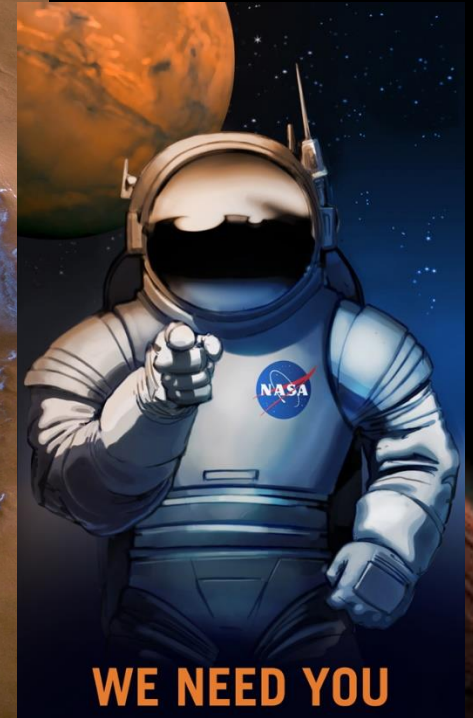
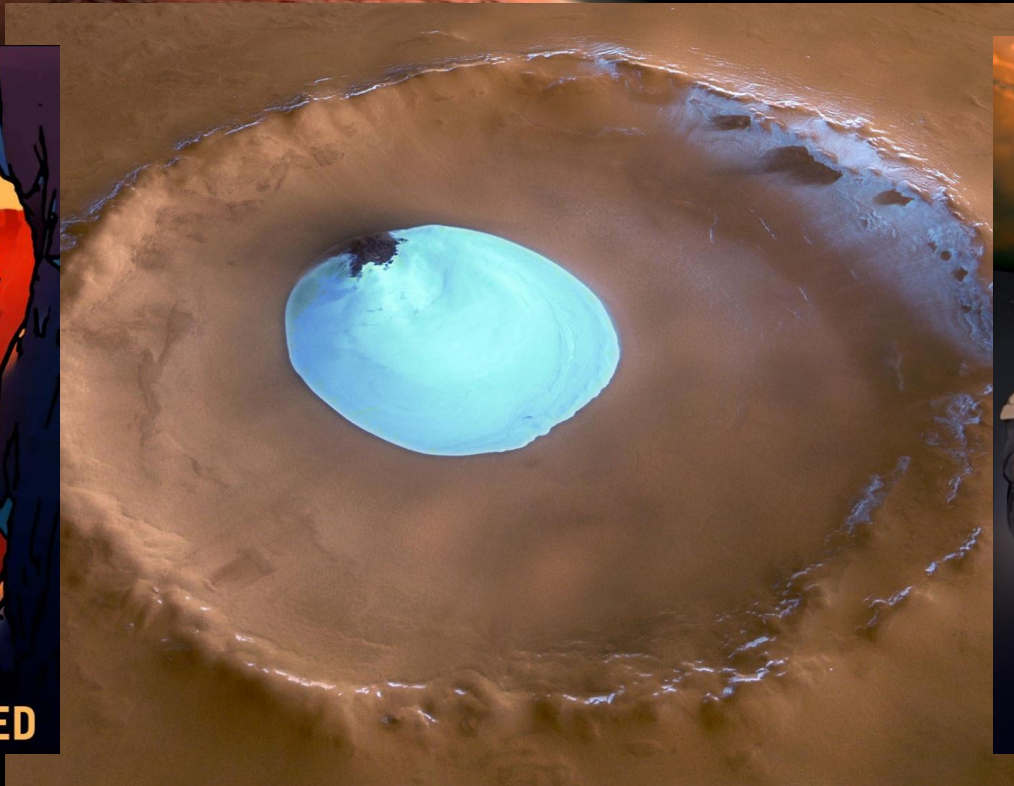
Sightseeing on Mars



Fram Crater



Sightseeing on Mars



Louth Crater

Sightseeing on Mars

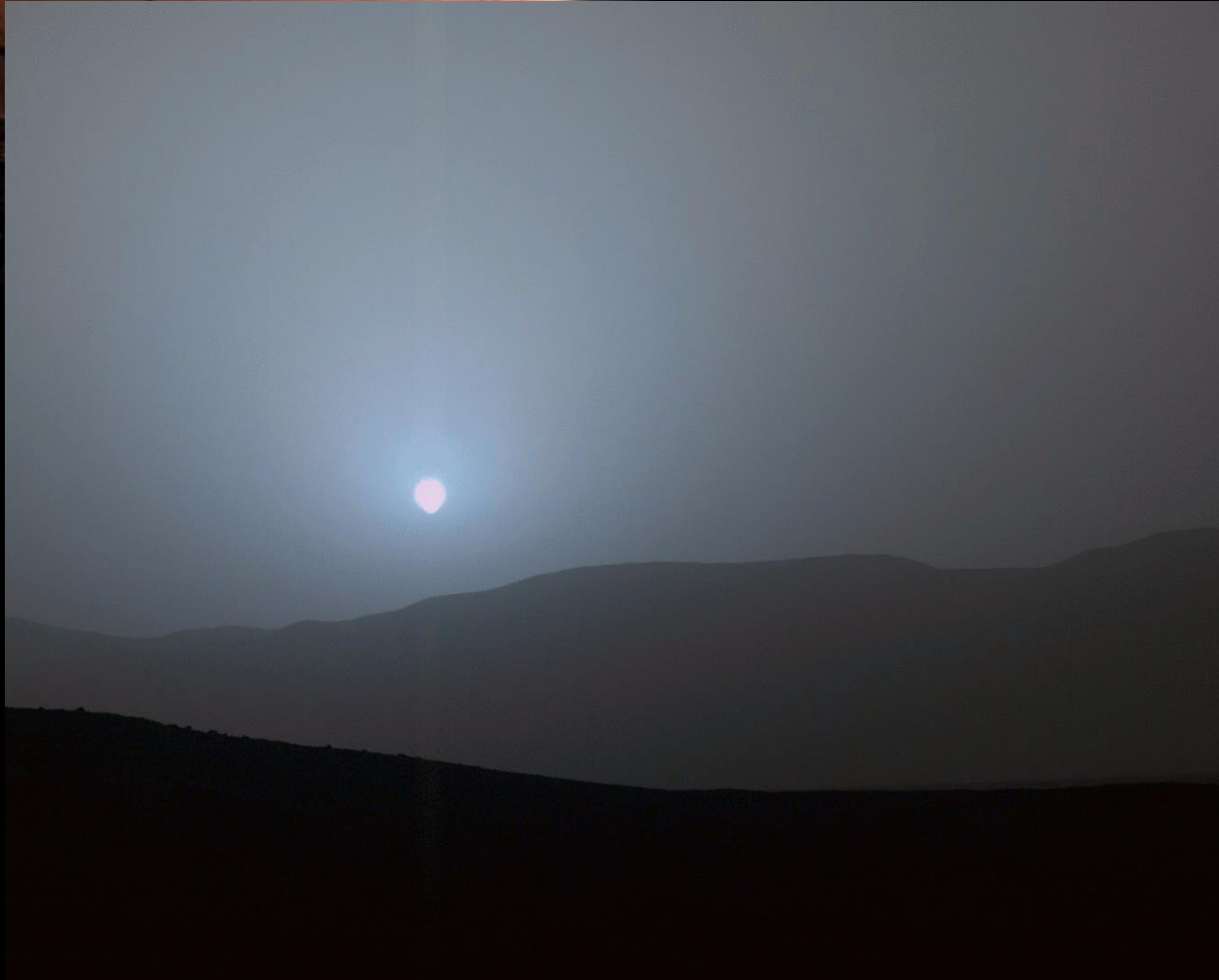


Happy Face Galle Crater



Graben

Sunset on Mars



Earth From Mars



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Special Thanks to
Mihriban Whitmore, PhD, & Tom Williams, PhD
And to all who have contributed to the task and ability analyses.

