The Path To Mars
Risk Informed Decision Making (RIDM)

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THE PATH TO MARS

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*** Adapted from Affordable Mars presentation by Sam Scimemi**

Historical Log - Robotic Missions To Mars

Launch Date	Name	Country	Result	Reason
1960	Korabl 4	USSR (flyby)	Failure	Didn't reach Earth orbit
1960	Korabl 5	USSR (flyby)	Failure	Didn't reach Earth orbit
1962	Korabl 11	USSR (flyby)	Failure	Earth orbit only; spacecraft broke apart
1962	Mars 1	USSR (flyby)	Failure	Radio Failed
1962	Korabl 13	USSR (flyby)	Failure	Earth orbit only; spacecraft broke apart
1964	Mariner 3	US (flyby)	Failure	Shroud failed to jettison
1964	Mariner 4	US (flyby)	Success	Returned 21 images
1964	Zond 2	USSR (flyby)	Failure	Radio failed
1969	Mars 1969A	USSR	Failure	Launch vehicle failure
1969	Mars 1969B	USSR	Failure	Launch vehicle failure
1969	Mariner 6	US (flyby)	Success	Returned 75 images
1969	Mariner 7	US (flyby)	Success	Returned 126 images
1971	Mariner 8	US	Failure	Launch failure
1971	Kosmos 419	USSR	Failure	Achieved Earth orbit only
1971	Mars 2 Orb/Lander	USSR	Failure	Orbiter arrived, but no useful data and Lander destroyed
1971	Mars 3 Orb/Lander	USSR	Success	Orbiter obtained approximately 8 months of data and lander landed safely, but only 20 seconds of data
1971	Mariner 9	US	Success	Returned 7,329 images
1973	Mars 4	USSR	Failure	Flew past Mars
1973	Mars 5	USSR	Success	Returned 60 images; only lasted 9 days
1973	Mars 6 Orb/Lander	USSR	Success/Failure	Occultation experiment produced data and Lander failure on descent
1973	Mars 7 Lander	USSR	Failure	Missed planet; now in solar orbit.
1975	Viking 1 Orb/Lander	US	Success	Located landing site for Lander and first successful landing on Mars
1975	Viking 2 Orb/Lander	US	Success	Returned 16,000 images and extensive atmospheric data and soil experiments
1988	Phobos 1 Orbiter	USSR	Failure	Lost en route to Mars
1988	Phobos 2 Orb/Lander	USSR	Failure	Lost near Phobos
1992	Mars Observer	US	Failure	Lost prior to Mars arrival
1996	Mars Global Surveyor	US	Success	More images than all Mars Missions
1996	Mars 96	Russia	Failure	Launch vehicle failure
1996	Mars Pathfinder	US	Success	Technology experiment lasting 5 times longer than warranty
1998	Nozomi	Japan	Failure	No orbit insertion; fuel problems
1998	Mars Climate Orbiter	US	Failure	Lost on arrival
1999	Mars Polar Lander	US	Failure	Lost on arrival
1999	Deep Space 2 Probes	US	Failure	Lost on arrival (carried on Mars Polar Lander)
2001	Mars Odyssey	US	Success	High resolution images of Mars
2003	Mars Express Orbiter/Beagle 2	ESA	Success/Failure	Orbiter imaging Mars in detail and lander lost on arrival
2003	Mars Rover - Spirit	US	Success	Operating lifetime of more than 15 times original warranty
2003	Mars Rover - Opportunity	US	Success	Operating lifetime of more than 15 times original warranty
2005	Mars Reconnaissance Orbiter	US	Success	Returned more than 26 terabits of data (more than all other Mars missions combined)
2007	Phoenix Mars Lander	US	Success	Returned more than 25 gigabits of data
2011	Mars Science Laboratory	US	Success	Exploring Mars' habitability
2011	Phobos-Grunt/Yinghuo-1	Russia/China	Failure	Stranded in Earth orbit
2013	Mangalyaan	India	En route	On way to Mars
2013	MAVEN	US	En route	On way to Mars

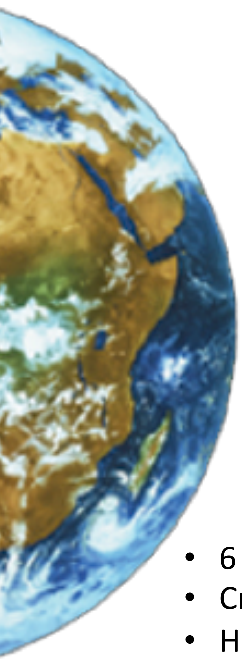
http://mars.nasa.gov/programmissions/missions/log/

Some Challenges

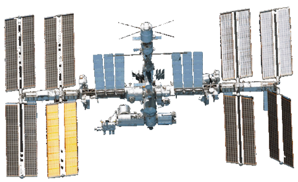
- The path to Mars involves closing knowledge and performance gaps in a systematic manner:
  - The health threat from exposure to high-energy cosmic rays and other ionizing radiation and negative effects of a prolonged low-gravity environment on human health, including eyesight loss.
  - Human performance considerations related to a long-duration isolated mission in a confined habitable space.
  - The inaccessibility of terrestrial medical facilities.
  - Critical systems, including propulsion, habitation, and life support that are reliable, require little to no maintenance, and have a small mass/volume.
  - Long duration navigation, and operations in deep space environment.
  - Ability for crew to operate autonomously including onboard analysis of crew and environmental samples.

Understanding the Gap

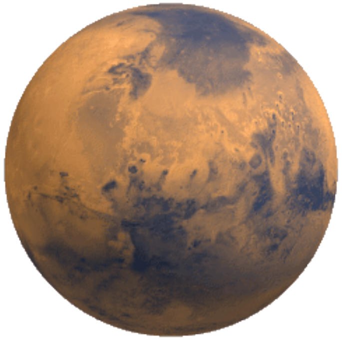
Today — 2020's — 2030's



ISS
400 kilometers



Mars
228,000,000 kilometers



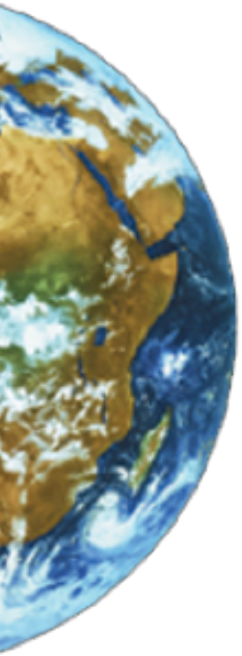
- 6 month crew duration
- Crew health and performance research in-work
- Habitation and life support and other critical systems are large and require regular maintenance and consumable resupply
- Prepositioned spares and regular resupply
- Ground analysis of crew/environmental samples and system failures
- Near real-time communications
- Any time crew return
- Heavy lift capability in development

- 1.5 year + crew duration
- Crew health and performance vital to a mission
- Habitation and life support and other critical systems mass/size limited and must have high reliability with limited consumable resupply
- Limited spares, systems must be reliable
- No opportunity for ground validation of crew/ environmental samples or system failure
- Communication delay of up to 42 minutes
- No emergency crew return
- Heavy lift available to support Mars transit

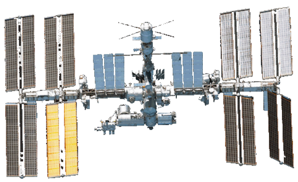
Closing the Gap
Following A Structured Approach

Today — 2020's — 2030's

(1) Establish An Objective Hierarchy

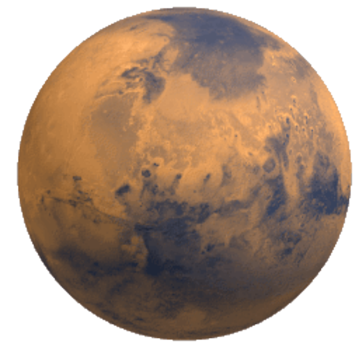


ISS
400 kilometers



Cis/trans lunar space
443,400 kilometers

Mars
228,000,000 kilometers



(2) ISS to 2024 and Cis-lunar are Essential to Turn Unknown Risk to Known Risk

- Crew Health
- Human Performance
- System Reliability

(3) Make Risk Informed Decisions

Identify Alternates – Analyze Risk – Make Informed Decisions

Mission Formulation - System Design – Technical Management – Mission Operations


Risk Informed Decision Making
as part of ISS demonstration
and cis-lunar missions
is critical in taking the
next steps on the path to Mars