Martian Outpost

The Challenges of Establishing a Human Settlement on Mars

Erik Seedhouse

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The Challenges of Establishing a Human Settlement on Mars

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Contents

Preface xiii
Acknowledgments xv
About the author xvii
List of figures xix
List of tables xxiii
List of abbreviations and acronyms xxv

1 **Why go?** 1
  Benefits of traveling to Mars 5
    Science 5
    Human expansion 7
    International cooperation 8
    Technological advancement 8
    Human performance 8
    Inspiration 9
  The role of NASA 9
  The inevitability of humans on Mars 10
  References 11

2 **Interplanetary plans** 13
  European Space Agency 13
    Aurora missions 14
    European politics 18
  Russia and China 19
  United States 22
    The new vision 22
    American politics 23
  Global exploration strategy 24

3 **Mission architectures** 27
  Interplanetary trajectories 27
    Basic orbital mechanics 27

  Trajectory variables 28
  Trajectory options 28
  Braking into orbit. 30
  In summary 31
Das Marsprojekt 31
  Mission architecture 31
Mars Direct 33
  Mars Direct architecture. 33
  Medical aspects 35
  Surface architecture 35
  Radiation and mission risk 36
  The pros and cons of Mars Direct 36
Reference mission of the Marsdrive Consortium. 37
  Mission architecture 37
  Mission hardware. 39
  Mission analysis 39
Project Troy 41
  Mission architecture 42
  Mission parameters. 44
  Lift mass and launch requirements 44
  Cost and timescale 45
  Mission requirements 46
European Space Agency 48
  Mission architecture 48
Global Aerospace Corporation. 50
  Mars transit base 50
  Cycling orbits 51
  Transit stations. 53
  Testing the plan 54
  Cycler analyzed 54
NASA Design Reference Mission 54
SpaceWorks Engineering Inc. (SEI) 56
  Mission architecture 58
  Mission parameters. 60
  Architecture flight hardware 60
  Entry, descent, landing and Mars ascent. 67
  Architecture surface hardware 67
  Architecture masses 69
  Mars exploration campaign 69
  Mission risk 69
DIRECT 2.0. 70
  Jupiter launch system 71
  Integration and utilization of Shuttle-derived technology 73
  Integration and utilization of existing technology 73
  Mission architecture 73

In summary 76
References 77

4 **Abort modes and the challenges of entry, descent and landing** 79
Abort options 79
  Free return trajectory 80
Challenges of entry, descent and landing 81
  Generic entry, descent and landing sequence 83
  Why landing on Mars won't be easy 84
Resolving the EDL problem 87
  Approach and entry to Mars' atmosphere 87
  The Skycrane option 94
  Space elevator 95
In summary 96
References 97

5 **Propulsion systems** 99
Variable specific impulse magnetoplasma rocket 100
  Overview 100
  Plasma-based propulsion technology 101
  The rocket engine 101
  VASIMR today 103
Nuclear propulsion 104
  History 104
  Nuclear thermal propulsion overview 104
  Nuclear thermal propulsion technology 104
  Nuclear thermal propulsion today 105
  Bimodal nuclear thermal rocket 105
Liquid oxygen augmented nuclear thermal reactor 106
  Technology 106
Magnetoplasmadynamic thrusters 107
  Overview 107
  Magnetoplasmadynamic thruster technology 107
  Magnetoplasmadynamic research today 107
Magnetized target fusion 108
  Overview 108
  Magnetized target fusion technology 108
  Magnetized target fusion today 109
Antimatter 109
  Overview 109
  Antimatter concept of operations 109
  Problems with antimatter 110
  Antimatter spaceships 110
In summary 112
References 113

6 Mars hardware 115
Mars mission architecture review 115
Exploration systems Architecture Study 116
Ares V 116
  Design requirements 116
  Ares V overview 117
  Ares V core stage propulsion 118
Ares I 118
  Design history 118
  Design endorsement 120
  Ares I design 120
  Ares I first stage design 121
  Ares I upper stage design 121
  Ares I avionics 122
  Ares I safety systems 122
  Ares I test flights 122
  Development problems 123
Ares I and V propulsion 124
  J-2 and J-2X history 124
  J-2X concept of operations 124
  J-2X hardware 124
Orion 125
  Concept of operations 125
  Orion module overview 125
  Designing Orion 126
  Orion systems and subsystems 127
  Orion abort modes 135
  Risk assessment 137
Trans-Mars injection stage 138
In-space propulsion stage 138
In-space inflatable transfer habitats (TransHabs) 138
  Role 138
  Construction 140
  Systems 140
  Life support 140
Mars Excursion Vehicle 140
  Role 140
  Heatshield 141
  Descent stage 142
  Ascent stage 142
Mars surface habitat 142
  Life support system 142
  Extravehicular activity support 145
Pressurized rover 145
In summary 145
References 145

7 Crew selection and training 147
Crew selection 147
  Crew composition 148
  Crew selection overview 149
  Selection criteria unique to Mars missions 150
  Genetic screening 150
  Precautionary surgery 151
Crew training 153
  Basic crew training 153
  Pre-Mars mission-related training 154
  Pre-Mars mission 155
  Mars mission training 155
Analog environments as training tools 162
  Antarctica 162
  Haughton Mars Project 162
  Mars Desert Research Station 163
  NASA's Extreme Environments Mission Operations project 165
  Mars500 166
In summary 167
References 168

8 Biomedical and behavioral issues 169
Biomedical risks 169
Radiation 169
  Overview 169
  Radiation environment 170
  Radiation units 173
  Biological risks 173
  Radiation exposure guidelines 178
  Radiation countermeasures 179
  Radioprotective agents 182
  Radiation forecasting 182
Bone loss 183
  Effect of microgravity on the skeletal system 184
  Mechanism of bone loss 185
  Space radiation-induced bone loss 186
  Bone loss 187
  Monitoring bone loss 187
  Countermeasures to bone demineralization 189
  Non-pharmacological intervention 190
  Bone loss: a summary 192
Muscle loss 193
Cardiovascular changes 194
  Orthostatic intolerance 194
  Cardiac dysfunction 194

Neurovestibular . . . 195
  Space Adaptation Syndrome . . . 195
  Sensorimotor and locomotion adaptation . . . 195
Immunological . . . 195
Behavioral issues . . . 196
  Expedition stressors . . . 196
  Behavioral problems . . . 197
  Psychiatric disorders . . . 199
  Positive effects . . . 199
References . . . 201

9 Voyage to Mars . . . 203
Mission risk . . . 204
Pre-launch activities . . . 208
Launch and initial low Earth orbit operations . . . 209
Trans-Mars injection and interplanetary travel . . . 211
  Life and death . . . 211
  Sleeping . . . 213
  Expedition clothes . . . 214
  Hygiene . . . 215
  Running to Mars . . . 215
  Preparing meals . . . 216
  Working en-route . . . 217
  External communication . . . 218
  Getting along . . . 219
  Leadership . . . 220
  Leisure time . . . 222
  Habitability . . . 223
  In-flight medical care . . . 223
Arrival at Mars and orbit capture . . . 224
Mars entry, descent and landing . . . 224
  Approach phase . . . 225
  Entry/atmospheric deceleration phase . . . 225
  Parachute descent phase . . . 225
  Powered descent phase . . . 226
Initial surface operations . . . 229
Long term surface operations . . . 230
Departure preparations and departure . . . 230
Rendezvous, docking and transfer to Earth return vehicle . . . 231
Trans-Earth injection and interplanetary travel . . . 232
Earth entry, descent and landing . . . 233
Post landing recovery . . . 233
  Bone demineralization . . . 233
  Muscle atrophy . . . 234
  Neurovestibular problems . . . 234
References . . . 236

10 Exploration activities and surface systems 237
Surface exploration. 237
Exploration strategy 237
Surface exploration considerations 238
Surface objectives 240
Surface systems 240
Power generation and storage 240
Extravehicular activity 242
Life support systems. 246
Surface habitat 249
In-situ resource utilization 252
Surface mobility 253
Martian communications and navigation capabilities 255
Communications overview 255
Surface-based communications network: concept of operations. 255
Mars to Earth communications: concept of operations 257
Descent and landing navigation capability 257
Surface mobility navigation capability 258
Radiometric time architecture. 258
Surface communication systems 258
Surface wireless mesh networking. 258
References 259

11 Extreme EXPeditionary Architecture 261
Mobile, adaptable systems for Mars exploration. 261
Revolutionary exploration objectives 262
Extreme EXPeditionary Architecture background. 262
EXP-Arch vehicle design concepts 263
Design principles 263
Initial conceptual designs 263
Final vehicle design: MSR Scorpion 264
Final vehicle design: Mini Rover 267
Radiation and shelter strategy 268
Advanced composite materials 268
Thermo-sets 268
Three-dimensional braided fabrics 270
Bioinspired engineering of exploration systems 270
Gecko-tech 271
Entomopters. 271
Biomorphic explorers 273
Yabbies 274
References 275

Epilogue 277
Glossary 279
Index 285

Preface

> "I am convinced that the future development of the possibilities of your own people, as well as those of mankind, will depend on some of you young people striking boldly out along new tracks."
>
> *Legendary explorer, Fridtjof Nansen.*
> *Rectorial address at St. Andrews University, 1926.*

Fridtjof Nansen (1861–1930) was perhaps the greatest explorer of all time, a man who led the way in surmounting obstacles and ignoring regular conventions, as exemplified by his 1888 expedition to cross the Greenland ice-cap from east to west, without dogs or sledges.

Like all of Nansen's expeditions, the Greenland project was simple and bold but required thorough preparation and planning. At the outset, the body of expert opinion condemned Nansen's plan as madness, arguing that without dogs and sledges it would be impossible to traverse the inland ice. Nevertheless, Nansen embarked upon his expedition and, after facing delays due to ice and weather, his expedition came ashore on the east coast of Greenland in August 1888. The journey across the ice cap was hazardous and exhausting in the extreme. Nansen's party had to climb nearly three thousand meters above sea-level, navigate through huge fissures in the ice and suffer temperatures that regularly plummeted below minus forty degrees Celsius. Despite the adversities, Nansen's team completed the descent to the west coast and through their expedition, made a decisive contribution to the scientific knowledge of the interior of Greenland, which many experts had mistakenly believed to be free of ice.

Nansen's Greenland crossing, however, was completely overshadowed by his next expedition to the polar region. Once again, following a simple, elegant yet unorthodox plan, Nansen's idea was to sail a ship as far east as possible along the Siberian coast, and then allow the vessel to be frozen in the ice, in the hope it would be carried across the North Pole or a point close to it. Once again, experts dismissed Nansen's plan as folly but, choosing to ignore the opinion of the naysayers, Nansen set out in the summer of 1893 in the *Fram*, a ship specifically designed to withstand the pressure of the polar ice. In September, the *Fram* was trapped in the ice and began drifting in a north-westerly direction, once again confirming Nansen's theory.

After a year trapped in the ice, Nansen had to accept the *Fram* would not be carried as far north as he had hoped. Instead, bold as ever, Nansen decided to leave the ship with companion, Hjalmar Johansen, and continue northwards across the pack ice, using skis and sledges drawn by dogs. Taking supplies sufficient for only one hundred days, Nansen and Johansen set out in March 1895 as *Fram* continued on her course. Struggling across frozen seas and almost impassable masses of ice towards an unknown fate, the intrepid explorers endured a journey of incredible privation and danger, eventually reaching a point that was the closest a human had ever been to the North Pole before being forced to turn back due to lack of food. After 132 days, Nansen and Johansen sought refuge on Franz Josef Land, a bleak and desolate island, where they spent the winter in a primitive shelter built of rocks and ice. The following year, the two explorers continued their trek south, eventually encountering British explorer, Frederick Jackson, who took them back to Norway on his ship. The *Fram* returned to Norway at almost the same time, having drifted for three years, as predicted by Nansen.

The adventures of the *Fram* and her crew attracted worldwide attention and established Nansen's reputation as one of the great pioneers of polar exploration. The scientific results realized by the expedition were no less impressive than the courage of the explorers, since the data collected proved of great value in the disciplines of arctic meteorology, oceanography and zoology.

When Nansen set out on his first great expedition over Greenland, there were still large blank areas on the maps of the world. By the time he died in 1930, there were hardly any left, a fact that saddened the great Norwegian who was driven by exploring the unknown. More than one hundred years after Nansen's epic expeditions, uncharted lands still await discovery, but this time we must venture a little further than the eminent Norwegian explorer. Traveling to Mars will provide a challenge on the same scale as Nansen's expeditions to Greenland and the high arctic. Such an expedition will be one fraught with danger and risk, but pioneering such a venture will be no less noble a challenge than the expeditions embarked upon by Nansen and his fellow explorers more than a century ago.

Civilizations thrive on challenge and decay without it and the time is long past for humans to once again face outward and embrace the bold endeavor of travelling to Mars. In so doing, we will make a profound statement testifying to the enduring human spirit. We must not shrink back from this task but attack it with the same enthusiasm and intelligence that Nansen brought to the challenges of his time.

The heroes of one generation are too easily forgotten by the next and the world is in dire need of rediscovering the bold example of Fridtjof Nansen. A manned mission to Mars is the key to reviving the spirit of exploration and once again expanding the limits of the possible. This book describes how we will embark on such a bold endeavor.

Acknowledgments

In writing this book, I have been fortunate to have had my wife, Doina Nugent as my proof-reader. Once again, she has applied her considerable skills to make the text as smooth and coherent as possible.

I would like to thank Bob of John Frassanito and Associates for giving me permission to use some of the outstanding images that appear in this book. I am also grateful to SpaceWorks Engineering Inc.'s Mark Elwood, Director, Space Media Group, and Brad St. Germain, Director of Advanced Concepts for permission to use the images illustrating SEI's Mars mission architecture. Thanks also to space artist, Adrian Mann, who created the wonderful concept art of the Skylon spaceplane and provided permission to use his images and to Guillermo Trotti of Trotti and Associates for permission to use their art illustrating extreme expeditionary architecture. Many thanks also to António H.F. Maia of the DIRECT team for permission to use the wonderful images illustrating the Jupiter launch system.

I am also grateful to the five reviewers who made such positive comments concerning the content of this volume and to the Publisher, Clive Horwood, and his team at Praxis for guiding this book through the publication process. The author also gratefully acknowledges the Chief Subject Advisory Editor for Praxis, Dr John Mason, whose attention to detail and patience greatly facilitated the publication of this book.

Finally, this book is dedicated to the countless individuals who have worked on the designs of future interplanetary spacecraft, many of which will never be developed, and to those engineers and scientists working on developing the Orion and Ares family of launch vehicles that will one day transport astronauts millions of kilometers to the Red Planet.

To
Rose-Marie, Richard and Tracy

About the author

Erik Seedhouse is an aerospace scientist and manned spaceflight consultant with ambitions to become an astronaut. After experiencing his first taste of microgravity during the European Space Agency's 22nd Parabolic Flight Campaign in 1995 he gained his Ph.D. while working at the German Space Agency's Institute for Space Medicine in Cologne. Recently, Erik worked as an astronaut training consultant for Bigelow Aerospace in Las Vegas and wrote 'Tourists in Space', the training manual for spaceflight participants. His company – Spaceflight Solutions – provides training programs and advice to the private spaceflight sector. He is a Fellow of the British Interplanetary Society and a member of the Aerospace Medical Association. An avid pilot and scuba diver, Erik also races Ultraman triathlons, climbs mountains and spends as much time as possible in Kona on the Big Island of Hawaii and at home in Sandefjord, Norway. Erik lives with his wife and two cats on the Niagara Escarpment in Canada.

Figures

1.1* A whole disk image of the planet Mars. 6

2.1 The European Space Agency's Mars Sample Return ascent module.. . . . 17
2.2 The Russian cosmonaut, Dr Valery Polyakov. 19
2.3 Launch of Shenzhou 6, the second Chinese manned space mission. 21
2.4* Orion is NASA's replacement for the Space Shuttle. 24

3.1 The Hohmann transfer orbit. 29
3.2* NASA's Ares V is a two-stage, vertically stacked launch vehicle. 34
3.3 The Mars for Less stack departing for Mars. 39
3.4 The European Space Agency's Ariane V launch vehicle.. 40
3.5* The Skylon Single-Stage-to-Orbit spaceplane. 42
3.6 An orbiting operations base station in low Earth orbit. 43
3.7 Former astronaut, Buzz Aldrin, has his own proposal for mankind's next giant leap. 52
3.8 An AstroTel will perform cyclic orbits between Earth and Mars. 53
3.9 NASA's Mars Design Reference Mission is a split mission concept. 55
3.10 SpaceWorks Engineering Inc. Mars mission architecture. 57
3.11 SpaceWorks Engineering Inc. Bullseye trajectory planning software. 60
3.12 Ares I launch vehicle.. 61
3.13 SpaceWorks Engineering Inc. Earth Return Vehicle. 61
3.14 SpaceWorks Engineering Inc. launch vehicles. 62
3.15 SpaceWorks Engineering Inc. trans-Mars injection stage. 63
3.16 SpaceWorks Engineering Inc. in-space propulsion stage.. 64
3.17 SpaceWorks Engineering Inc. TransHab. 65
3.18 SpaceWorks Engineering Inc. Mars Excursion Vehicle.. 66
3.19 SpaceWorks Engineering Inc. rover. 68
3.20 DIRECT 2.0 Jupiter 120 and 232 launch vehicles. 71
3.21 DIRECT 2.0 Mars mission architecture.. 74

4.1 Solving the entry, descent and landing problem. 86
4.2* Aerocapture is a flight maneuver used to insert a spacecraft into orbit. 87
4.3 A rigid aeroshell encases the spacecraft. 89
4.4 An inflatable aeroshell.. 90
4.5 An artist's rendering of a Hypercone.. 91
4.6 An artist's rendering of a space elevator. 96

5.1* US astronaut Franklin Chang-Diaz.. 100
5.2 A simplified diagram of the Variable Specific Impulse Magnetoplasma Rocket. 101
5.3 Components of the Variable Specific Impulse Magnetoplasma Rocket. 102
5.4* Artist's rendering of Bimodal Nuclear Thermal Rocket. 106
5.5 A Magnetized Target Fusion engine. 108
5.6 Penning Trap schematic.. 111
5.7* An antimatter spaceship. 112

6.1 Ares V core stage. 117
6.2 RS-68 rocket engine. 119
6.3* J-2X rocket engine. 120
6.4 Exploded view of Orion. 126
6.5* Orion prototype/manufacturing demonstration unit.. 129
6.6 Orion's drogue chutes. 133
6.7 Orion's primary chutes. 133
6.8 Ares I Launch Abort System.. 134
6.9 SpaceWorks Engineering Inc. in-space propulsion stage.. 139
6.10 SpaceWorks Engineering Inc. Mars Excursion Vehicle.. 141
6.11 SpaceWorks Engineering Inc. Mars Surface Habitat. 143

7.1* The Airbus A300 performing parabolic flight. 154
7.2 California ground squirrel.. 159

8.1 SOHO image of a coronal mass ejection. 172
8.2 Percentage change in bone mineral density of femur for cosmonauts. . . 184
8.3 The AMPDXA equipment in a clinical setting.. 188
8.4 Astronauts must exercise during long duration missions. 191
8.5 An artificial gravity vehicle proposed by NASA. 193

9.1 Astronaut Quarantine Facility in Houston. 209
9.2 Ares I/Orion on the launch pad.. 210
9.3* Ares I launch. 212
9.4 The Anglo-Irish Antarctic explorer, Ernest Shackleton. 221
9.5* Astronauts drilling for samples. 232
9.6 Astronauts conducting exploration using an unpressurized rover. 232

10.1 Spacesuit engineer Dustin Gohmert.......... 243
10.2 The revolutionary Bio-suit.......... 245
10.3 Bigelow Aerospace's Genesis II inflatable module in orbit.......... 250
10.4 Inflatable structure being tested at McMurdo Station, Antarctica..... 252
10.5 NASA's Recon Rover.......... 254
10.6 The All-Terrain Hex-Limbed Extra-Terrestrial Explorer.......... 254
10.7 Astronaut recording surface exploration activities.......... 256

11.1 EXP-Arch Mother Ship Rover/Scorpion.......... 263
11.2* EXP-Arch Mother Ship Rover/Scorpion. Side view.......... 265
11.3 Scorpion interior.......... 266

(* Figures marked with an asterisk also appear in the color section positioned between pages 160 and 161)

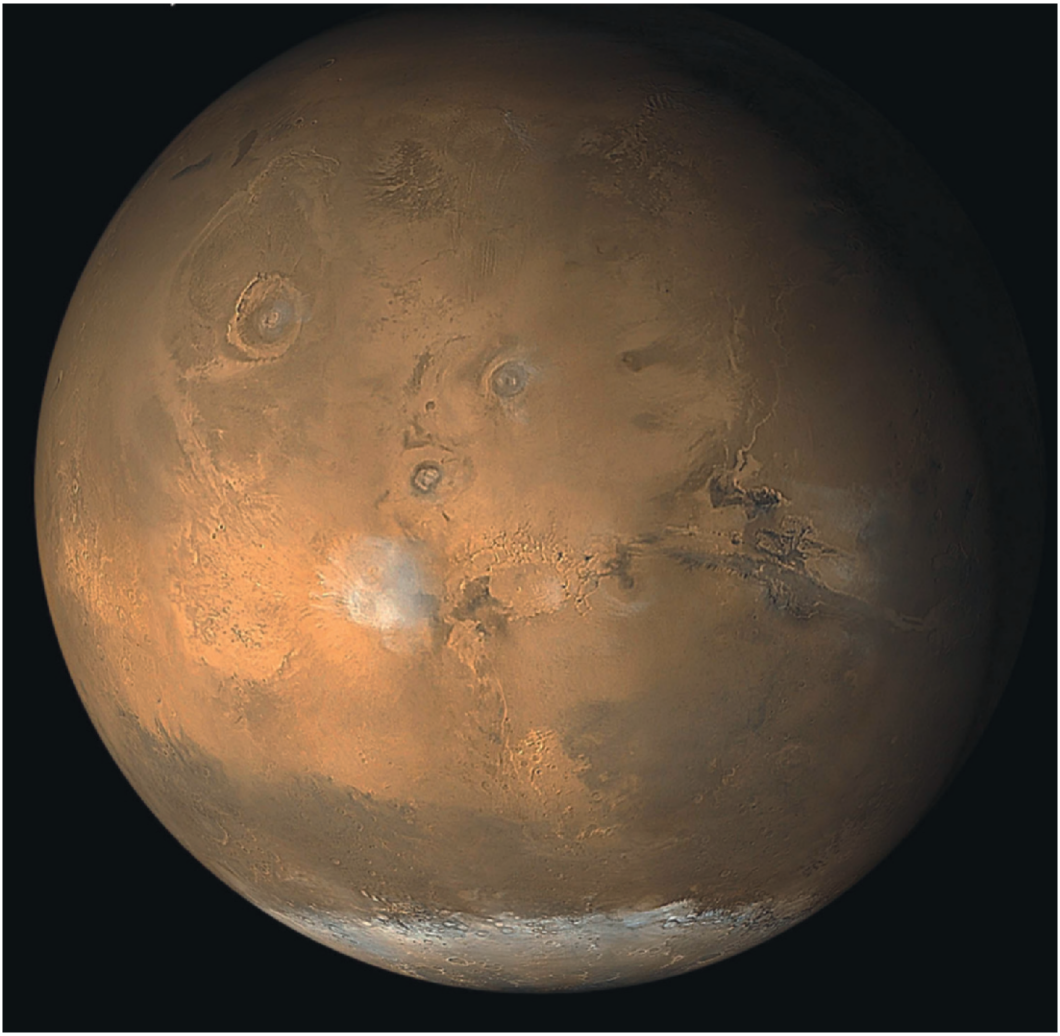

PLATE 1 A whole disk image of the planet Mars taken by the Mars Global Surveyor spacecraft in June 2001. It is winter in the southern hemisphere and there is dust storm activity in the Tharsis volcanic region. (Malin Space Science Systems/NASA.)

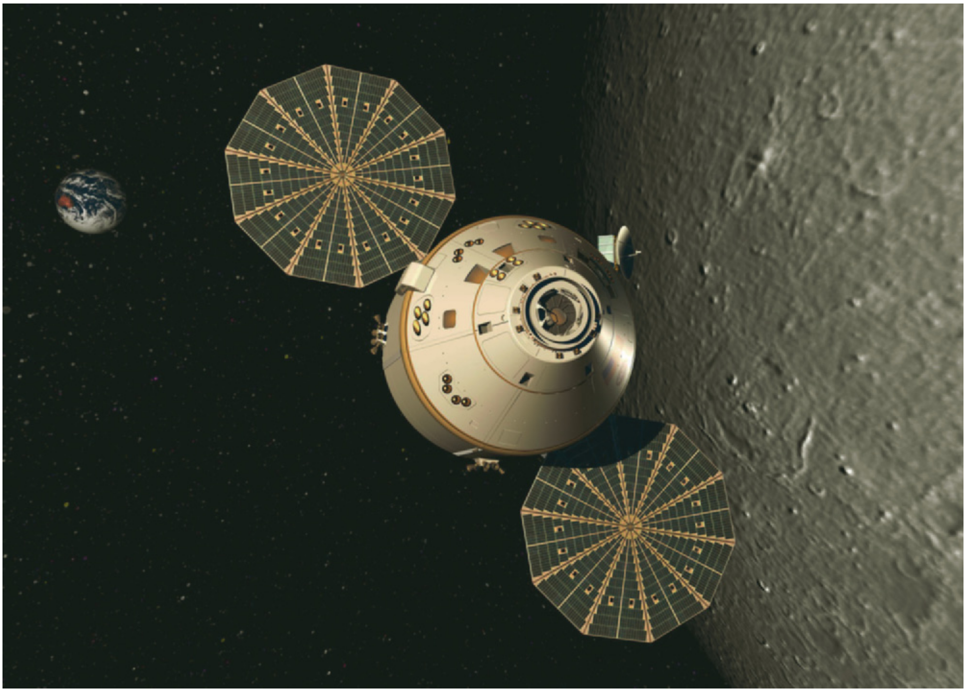

PLATE 2 Orion is NASA's replacement for the Space Shuttle and is due to enter service in 2015. It will also be the vehicle carrying Mars crews to low Earth orbit. (NASA.)

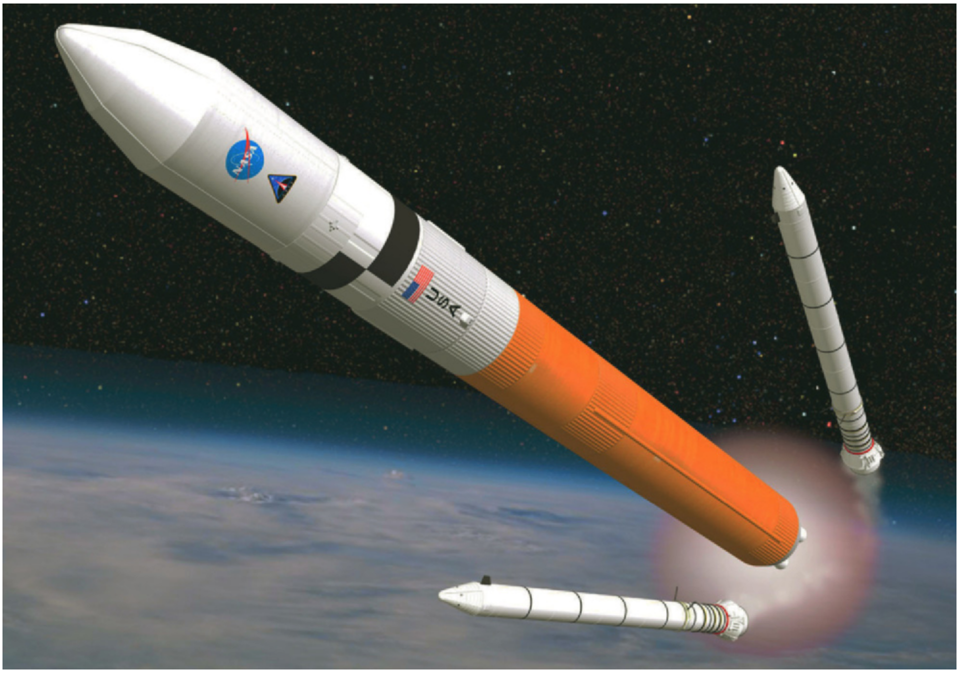

PLATE 3 NASA's Ares V is a two-stage, vertically stacked launch vehicle capable of carrying 188 metric tonnes to low-Earth orbit. For the initial insertion into Earth orbit, the Ares V first stage utilizes two five and a half segment reusable solid rocket boosters derived from the Space Shuttle's solid rocket boosters. In the Mars Direct architecture, the Ares V would deploy a forty-tonne cargo payload into a direct trans-Mars trajectory. (NASA.)

PLATE 4 The Skylon Single-Stage-to-Orbit (SSTO) spaceplane in orbit. (Adrian Mann, Reaction Engines Limited.)

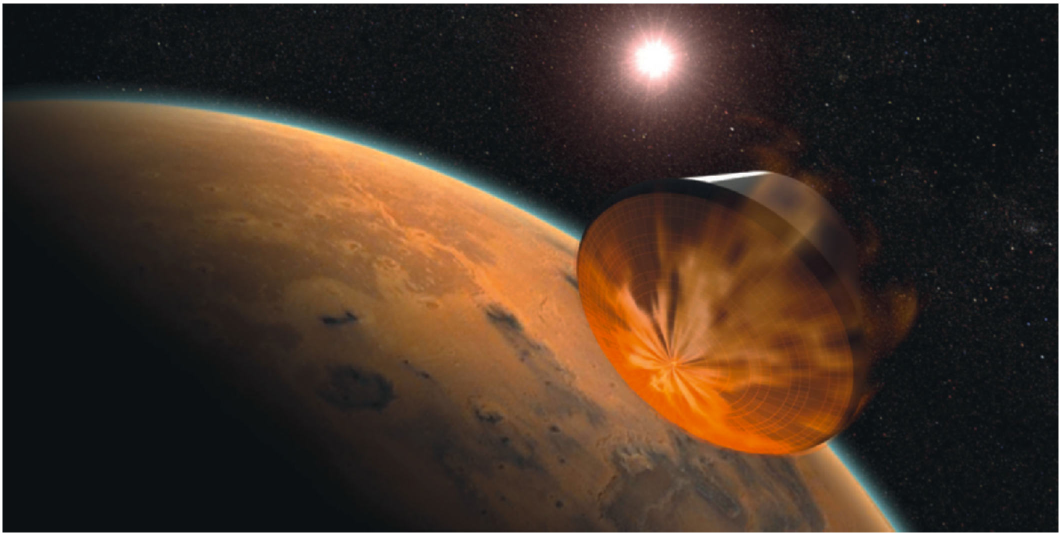

PLATE 5 Aerocapture is a flight maneuver used to insert a spacecraft into orbit using the atmosphere as a brake. The atmosphere creates friction, used to slow the vehicle, transferring the energy generated by the vehicle's high speed into heat. The maneuver enables quick orbital capture without the requirement for heavy loads of propellant. (NASA.)

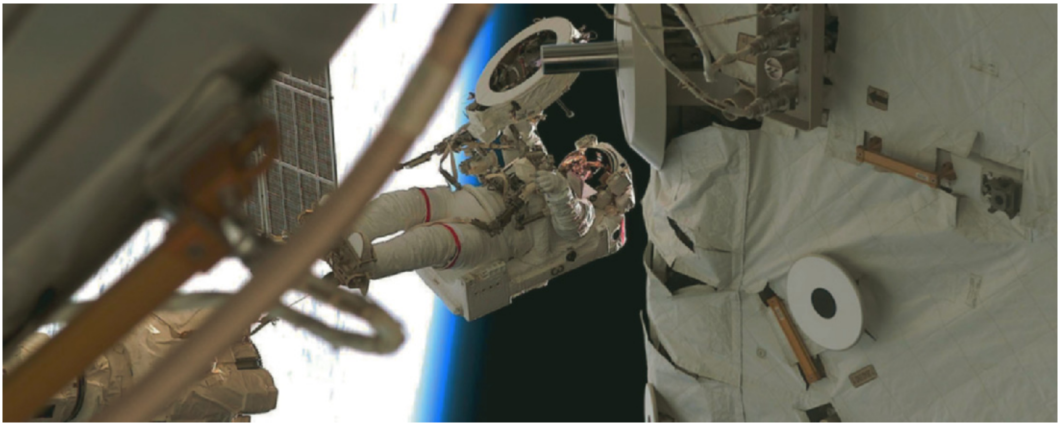

PLATE 6 US astronaut Franklin Chang-Diaz working on the International Space Station during Space Shuttle mission STS-111. (NASA.)

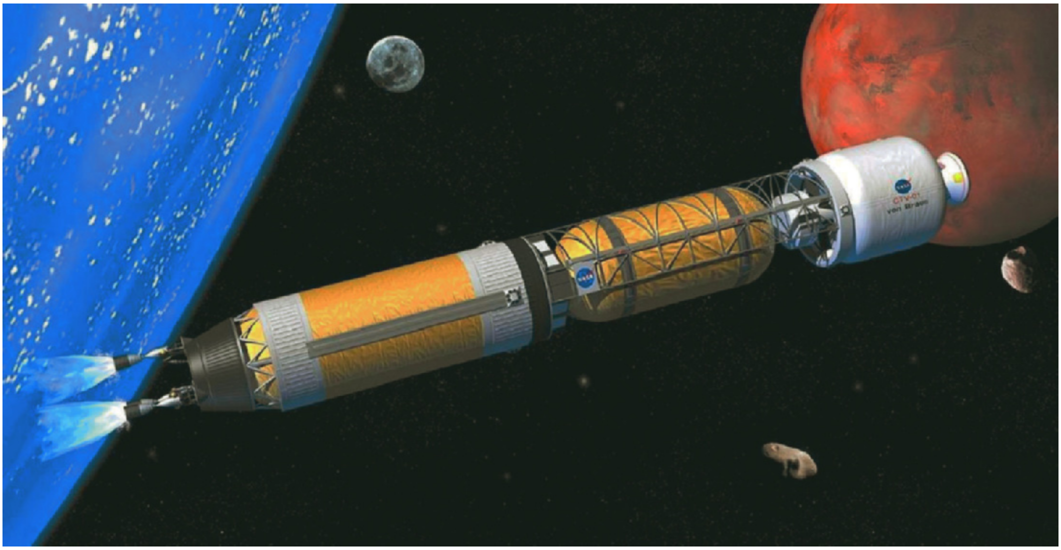

PLATE 7 Artist's rendering of Bimodal Nuclear Thermal Rocket. (John Frassanito and Associates/NASA.)

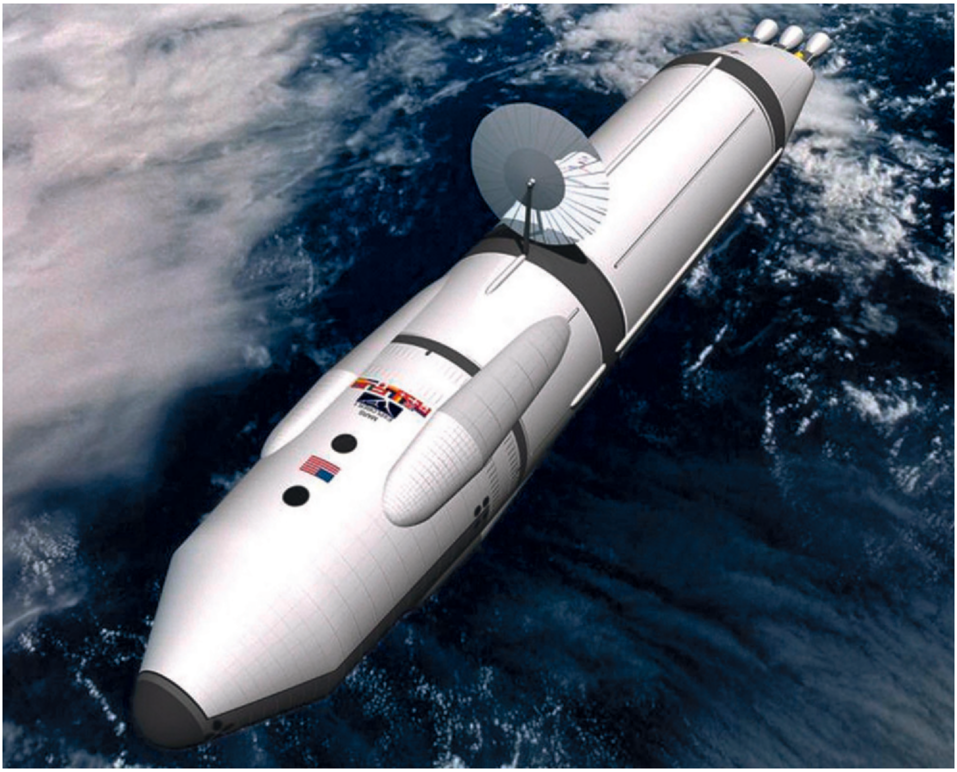

PLATE 8 An antimatter spaceship. (NASA.)

PLATE 9 J-2X rocket engine. (NASA.)

PLATE 10 Orion prototype/manufacturing demonstration unit. (NASA.)

PLATE 11 The Airbus A300 performing parabolic flight. (Novespace.)

PLATE 12 Ares I launch. (NASA.)

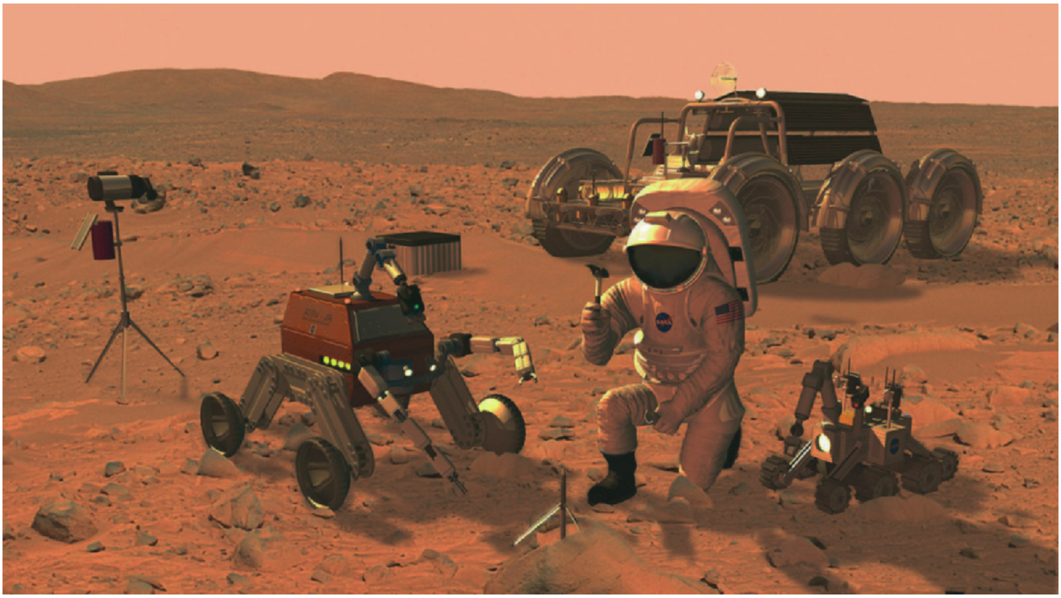

PLATE 13 Astronauts drilling for samples. (John Frassanito and Associates/NASA.)

PLATE 14 EXP-Arch Mother Ship Rover/Scorpion. Side view. Design: Trotti Studio. (Mitchell Joachim.)

Tables

1.1 Risks of manned mission to Mars 4
1.2 Risks of polar exploration 5

2.1 Manned Mars mission parametric studies. 14
2.2 European Space Agency exploration roadmap 15
2.3 Aurora exploration roadmap mission by mission 15–16
2.4 Constellation spirals. 23
2.5 Members of the Global Exploration Strategy: the Framework for Coordination 25

3.1 Das Marsprojekt mission architecture. 32
3.2 Radiation dose comparison 37
3.3 Earth return vehicle and Mars transfer and surface vehicle launches. . . . 38
3.4 Skylon specifications 42
3.5 Project Troy Hohmann transfer parameters 43
3.6 Precursor and principal mission payloads. 44
3.7 Lift mass and launch requirements. 45–46
3.8 Launch, vehicle and manned costs 45
3.9 Timescale of Skylon development and the Troy Project 46
3.10 Life support requirements. 47
3.11 ESA Mars mission elements 49–50
3.12 Global Aerospace Corporation Mars base mass summary 51
3.13 NASA Mars Design Reference Mission stage by stage 56
3.14 SpaceWorks Engineering Inc. architecture assumptions 58–59
3.15 SpaceWorks Engineering Inc. mission architecture 59
3.16 Entry, descent, landing and Mars ascent. 67
3.17 Life cycle cost estimate for human Mars exploration architecture. 69
3.18 DIRECT Jupiter 120 and 232 launch vehicle concept specifications 72
3.19 DIRECT flight elements. 75

4.1 Generic entry maneuver timeline 81
4.2 Success and failure rate of Mars missions since 1975 82

6.1 CARD cargo launch vehicle description and requirements 117
6.2 CARD crew launch vehicle/Ares I requirements 121
6.3 CARD Orion/CEV description and requirements 126–7
6.4 Orion configurations and mass summary 128
6.5 Orion abort modes 136
6.6 In-space propulsion stage 139
6.7 Mars excursion vehicle. Integrated configuration 141

7.1 Crew selection requirements 150
7.2 Crew training timeline for first flight 153
7.3 Crew training timeline for Mars mission 155
7.4 Effect of hibernation on life support requirements 158
7.5 Bioethical considerations for a manned mission to Mars 161
7.6 MDRS mission options 164
7.7 Mars500 experimental facility 167

8.1 Biomedical risk factors during a mission to Mars 170
8.2 Radiation levels causing excess cancer risk 178
8.3 Chemical composition of candidate shielding materials 181
8.4 Bone loss on Mir (% bone mineral density lost per month) 187
8.5 Behavioral stressors of long duration spaceflight 196
8.6 Positive characteristics of a manned Mars mission 200

9.1 Phases of a manned mission to Mars 203
9.2 Criticality codes 205
9.3 Systems failures travelling to and from Mars 205–208
9.4 Flight rules for landing on Mars 227–228
9.5 Descent and landing failure action rules 228–229
9.6 Scientific and human interest-driven activities 231
9.7 Postflight rehabilitation plan 235

10.1 Mars surface mission time allocation 239
10.2 Surface mission objectives 241
10.3 EVA tasks during Mars surface operations 242
10.4 Life support subsystem description 247–248
10.5 Fundamental life support requirements 249
10.6 Outpost communications traffic model 257

11.1 Mother Ship Rover and Mini-Rover general and specific design criteria 264
11.2 Mother Ship Rover ‘Scorpion‘ specifications 265
11.3 Mini Rover specifications 267
11.4 Radiation shelter deployment 269

Abbreviations and acronyms

AAA	Avionics Air Assembly
ACOS	Attitude and Orbit Control System
ACT	Advanced Concepts Team
AI	Artificial Intelligence
ALARA	As Low As Reasonably Achievable
ALHAT	Autonomous Landing and Hazard Avoidance Technology
ALS	Advanced Life Support
AMPDXA	Advanced Multiple Projection Dual Energy X-ray Absorptiometry
AOD	Automatic Opening Device
AQF	Astronaut Quarantine Facility
ARC	Ames Research Center
ARS	Acute Radiation Syndrome
ASCR	Astronaut Strength Conditioning and Rehabilitation
ASG	Astronaut Spouses Group
ASI	Agenzia Spaziale Italiania
ASRG	Advanced Stirling Radioisotope Generator
ATCO	Ambient Temperature Catalytic Oxidation
ATCS	Active Thermal Control System
ATHLETE	All Terrain Hex-Limbed Extra Terrestrial Explorer
ATSS	Advanced Transportation System Studies
ATV	All Terrain Vehicle
BEES	Bioinspired Engineering of Exploration Systems
BMD	Bone Mineral Density
BMI	Bismaleimide
BNL	Brookhaven National Laboratory
BNSC	British National Space Centre
BNTR	Bimodal Nuclear Thermal Rocket
BPC	Boost Protective Cover
BPS	Biomass Production System
CaLV	Cargo Launch Vehicle
CAPCOM	Capsule Communicator
CARD	Constellation Architecture System Requirements

C&C	Command and Control
C&N	Communications and Navigation
CCAA	Common Cabin Air Assembly
CCB	Common Core Booster
CCDH	Command and Control Data Handling
CEV	Crew Exploration Vehicle
CFD	Computational Fluid Dynamics
CGI	Computer Generated Image
CLV	Cargo Launch Vehicle
CM	Crew Module
CME	Coronal Mass Ejection
CMO	Crew Medical Officer
CMRS	Carbon Moisture Removal System
CNES	Centre Nationale d'Etudes Spatiales
CNM	Computational Network Modeling
CNS	Central Nervous System
CNSA	Chinese National Space Administration
CONUS	Continental United States
COSPAR	Committee on Space Research
CPT	Constant Power Throttling
CRV	Crew Return Vehicle
CSA	Canadian Space Agency
CSAV	Crew Surface Ascent Vehicle
CSIRO	Commonwealth, Scientific Industrial Research Organization
CT	Computer Tomography
DAEZ	Downrange Abort Exclusion Zone
DARPA	Defense Advanced Research Projects Agency
DDOR	Delta Differential One-way Ranging
DDT&E	Design, Development, Test and Evaluation
DEXA	Dual Energy X-ray Absorptiometry
DLR	Deutsche Zentrum für Luft und Raumfahrt
DRM	Design Reference Mission
DS	Descent Stage
DSENDS	Dynamic Simulator for Entry, Descent and Landing
DTE	Direct to Earth
EAC	European Astronaut Centre
EAGLE	Evolved Acceleration Guidance Logic for Entry
ECLSS	Environmental Control Life Support System
EDL	Entry, Descent and Landing
EDS	Earth Departure Stage
EELV	Evolved Expendable Launch Vehicle
EI	Entry Interface
EMS	Electronic Monitoring System
EMU	Extravehicular Mobility Unit
EPS	Electrical Power System