

Mission Boardgame



Mars Cards



\$ 30
▲ 50

ROVER

It is about the size of a car and will explore Mars surface conducting science experiments.

1

NCAS



\$ 40
▲ 30

PHOTO CREDIT: Tracy Staedter, IEEE Spectrum

MARS HABITAT

3D printed habitat made from the regolith.

NASA PARTNER: Penn State University

2

NCAS



\$ 20
▲ 10

ORBITER

Explore the red planet's upper atmosphere

3

NCAS



\$ 60
▲ 40

HELICOPTER

This helicopter can lift a mission that has up to 65 mass units

4

NCAS

GIVES YOUR MISSION ELECTRICITY 

\$ 10
▲ 7
10 POWER LIMIT



LOW-POWER SOLAR PANEL

PROS

- Low cost, low mass.
- Lasts a few years.

CONS

- Must have sunlight. Only works during daylight.
- Only works near the equator.

1 Requires on-board battery. (CARD #10)

5

NCAS

GIVES YOUR MISSION ELECTRICITY 

\$ 15
▲ 15
25 POWER LIMIT



MEDIUM-POWER SOLAR PANEL

PROS

- Low cost, medium mass.
- Lasts a few years.

CONS

- Must have sunlight. Only works during daylight.
- Only works near the equator.

1 Requires on-board battery. (CARD #10)

6

NCAS

GIVES YOUR MISSION ELECTRICITY 

\$ 25
▲ 20
40 POWER LIMIT



HIGH-POWER SOLAR PANEL

PROS

- Medium cost, medium mass.
- Lasts a few years.

CONS

- Must have sunlight. Only works during daylight.
- Only works near the equator.

1 Requires on-board battery. (CARD #10)

7

NCAS

1 A BATTERY IS REQUIRED FOR ALL SOLAR-POWERED MISSIONS. 

\$ 5
▲ 5
5



ON-BOARD BATTERY

PROS

- Medium cost, medium mass.
- Lasts a few years.

CONS

- Must have sunlight. Only works during daylight.
- Only works near the equator.

1 Requires on-board battery. (CARD #10)

8

NCAS

GIVES YOUR MISSION ELECTRICITY 

\$ 40
▲ 25
50 POWER LIMIT



FUEL CELL

PROS

- Medium cost, medium mass.
- Lasts a few years.


CONS

- Must have sunlight. Only works during daylight.
- Only works near the equator.

1 Requires on-board battery. (CARD #10)

9

NCAS

GIVES YOUR MISSION ELECTRICITY 

\$ 40
▲ 25
50 POWER LIMIT



RADIOISOTOPE POWER SYSTEM

PROS

- Does not need the sun or a battery.
- Provides the most power of all.
- Works everywhere.
- Lasts over a decade.

CONS

- Costs the most.
- Has the most mass.

10

NCAS

STORES ENOUGH POWER FOR ONE 90 SECOND FLIGHT PER DAY 

\$ 10
▲ 5
20 POWER LIMIT



LITHIUM ION BATTERY

PROS


- Small and lightweight
- Good for years

CONS


- High cost

11

NCAS

GIVES THE MISSION MORE MOBILITY 

\$ 10
▲ 10



PROPELLER BLADES

PROS

- Gives the ability to see more
- Low power cost
- Additional mobility

CONS

- Medium cost, High risk (unproven technology)
- Medium weight

12

NCAS

CHARGES LITHIUM ION BATTERY AND POWERS ELECTRONICS 

\$ 7
▲ 5
15 POWER LIMIT



SOLAR PANEL FOR HELICOPTER

PROS

- Low cost
- Warms equipment
- Low mass

CONS

- Slow charging method
- Fragile

13

NCAS

EITHER WHEELS OR TRACKS ARE REQUIRED FOR ROVER MISSIONS.



\$ 15
▲ 10
⚡ 12

WHEELS

PROS

- Wheels carry rovers to discoveries beyond their landing sites.
- Medium speed and work rocky terrain.

CONS

- Have a little more mass, and use a little more power than tracks.

MASS 14

NCAS

EITHER WHEELS OR TRACKS ARE REQUIRED FOR ROVER MISSIONS.



\$ 15
▲ 8
⚡ 10

TRACKS

PROS

- Have less mass and use less power than wheels.

CONS

- Can make it harder to climb over some obstacles.
- Less precise steering.

MASS 15

NCAS

COLLECTS SAMPLES AND CARRIES A NUMBER OF SCIENCE INSTRUMENTS.



\$ 5
▲ 8
⚡ 1
✦ 1

ROBOTIC ARM

PROS

- Doesn't use much power.
- Low cost.
- Provides an added science point.


CONS

- Medium mass.

MASS 22

NCAS

COLLECTS SAMPLES BY DRILLING INTO ROCKS.



\$ 5
▲ 3
⚡ 5
✦ 1

ROCK DRILL

PROS

- Low cost, low mass.
- Provides an added science point.

CONS

- Medium power.

MASS 23

NCAS

PROVIDES FLEXIBLE STRUCTURE FOR MULTIPLE SCIENCE INSTRUMENTS.



\$ 5
▲ 3
⚡ 1
✦ 1

ROTATING INSTRUMENT MOUNT

PROS

- Holds science instruments so they can collect data in a circle without moving the spacecraft.

CONS

- Adds minor costs, mass and power usage to your mission.

MASS 24

NCAS

EITHER AIRBAGS OR RETRO ROCKETS ARE REQUIRED FOR MARS LANDERS AND ROVERS



\$ 40
▲ 15
⚡ 0

AIRBAGS

PROS

- Protect spacecraft from impacts on rocks and slopes

CONS

- Higher cost and mass than rockets.
- Precise landings are difficult because the airbags bounce.

MASS 19

NCAS

PROBES CAN BE ADDED TO ENHANCE DISCOVERIES.



\$ 10
▲ 5
⚡ 0
✦ 1

IMPACT PROBE

PROS

- Penetrates the Martian surface at high speeds to collect data from below the surface.
- Does not use power.


CONS

- Adds cost and mass to your mission.

MASS 20

NCAS

USED FOR LANDING AND PHYSICAL ORIENTATION (REQUIRED FOR HELICOPTER)



\$ 5
▲ 6
⚡ 0

LANDING LEGS

PROS

- Lightweight, doesn't use power

CONS

- Fragile, may not survive deployment

MASS 21

NCAS

AT LEAST ONE MICROPROCESSOR IS REQUIRED FOR ALL MARS MISSIONS.



\$ 5
▲ 1
⚡ 1

STANDARD MICROPROCESSOR

PROS

- Provides mission "brainpower".
- Low cost, mass and power usage.

CONS

- Provides only basic functions needed to receive commands and send data.

NCAS **25**

AT LEAST ONE MICROPROCESSOR IS REQUIRED FOR ALL MARS MISSIONS.



\$ 5
▲ 1
⚡ 2
+ 1

ADVANCED MICROPROCESSOR

PROS

- More "brainpower" lets the spacecraft make simple choices without commands from Earth.

CONS

- Costs more and uses more power than the standard microprocessor.

NCAS **26**

CONNECTS SCIENCE TOOLS WITH THE ONBOARD COMPUTER SO THEY WORK. REQUIRED FOR ALL MISSIONS!



\$ 20
▲ 5
⚡ 1

MAIN BUS

PROS


- Low power usage.
- Allows you to make discoveries with your science tools.

CONS

- Medium cost and mass.

NCAS **27**

WITH THE USE OF SENSORS AND COMPUTER PROVIDES A HIGH LEVEL OF AUTONOMY



\$ 8
▲ 4
⚡ 5

AUTONOMOUS CONTROL SYSTEM

PROS


- Add autonomous movement about the planet
- Lightweight, Low cost

CONS

- High risk (unproven), Medium mass

NCAS **28**

AT LEAST ONE MICROPROCESSOR IS REQUIRED FOR ALL MARS MISSIONS.



\$ 5
▲ 1
⚡ 1

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▲ 1
⚡ 2
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▲ 4
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CONS

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NCAS **28**

THIS ROCKET CAN LIFT A MISSION THAT HAS UP TO 45 MASS UNITS.



\$ 50
45
6

PHOTO CREDIT: © REUTERS / Thom Baur

LIGHT-LIFT ROCKET I

PROS

- Low cost.
- Low risk: works 5 times out of 6.

CONS

- Lift small, lightweight missions with few science tools.

NASA PARTNER: SpaceX **29**

THIS ROCKET CAN LIFT A MISSION THAT HAS UP TO 90 MASS UNITS.



\$ 75
90
6

PHOTO CREDIT: SpaceX

LIGHT-LIFT ROCKET II

PROS

- Lifts medium-size missions due to add-on thrusters.

CONS

- Costs more than Light-Lift Rocket I due to additional thrusters.
- Medium risk: works 4 times out of 6.

NASA PARTNER: SpaceX **30**

THIS ROCKET CAN LIFT A MISSION THAT HAS UP TO 125 MASS UNITS.



\$ 100
125
6

PHOTO CREDIT: Northrop Grumman

MEDIUM-LIFT ROCKET A

PROS

- Lifts large missions with more science tools.

CONS

- Costs more than Light-Lift Rockets.
- Medium risk: works 4 times out of 6.

NASA PARTNER: Northrop Grumman **31**

THIS ROCKET CAN LIFT A MISSION THAT HAS UP TO 125 MASS UNITS.



\$120
125

MEDIUM-LIFT ROCKET B

PROS

- Able to lift large missions with more science tools.
- Low risk: works 5 times out of 6.

CONS

- Costs more than a Light-Lift I & II and Medium-Lift Rocket A.

NASA PARTNER: Roscosmos

NCAS

MARS 32

THIS ROCKET CAN LIFT A MISSION THAT HAS UP TO 90 MASS UNITS.



\$100
200

HEAVY-LIFT ROCKET

PROS

- The most powerful on Earth! Able to lift very large missions with the most science tools.

CONS

- High risk: works 3 times out of 6.

NCAS

MARS 33

PROTECTS YOUR SPACECRAFT DURING LAUNCH. REQUIRED FOR ALL MISSIONS!



\$100
7
0

ROCKET NOSE CONE

PROS

- Low cost.
- No power needed.

CONS

- Medium mass.

NCAS

MARS 34

MAKES DISCOVERIES ABOUT THE ENVIRONMENT ON MARS



\$10
1
1
1

LOW-RESOLUTION CAMERA

PROS

- Sees a very wide area of Mars.
- Low cost, low mass.
- Does not use much power.

CONS

- Can't see small details on Mars.

NCAS

MARS 35

MAKES DISCOVERIES ABOUT THE ENVIRONMENT ON MARS



\$25
2
2
1

MEDIUM-RESOLUTION CAMERA

PROS

- Sees twice as much detail as the low-resolution camera.
- Low mass and low power usage.

CONS

- Medium cost.
- sees a smaller area on Mars than the Low-Resolution Camera.

NCAS

MARS 36

MAKES DISCOVERIES ABOUT THE ENVIRONMENT ON MARS



\$40
3
4
1

HIGH-RESOLUTION CAMERA

PROS

- Sees the most detail of all.

CONS

- Sees only a tiny area of Mars.
- Costs the most.
- Has more mass and uses more power than other cameras.

NCAS

MARS 37

MAKES DISCOVERIES ABOUT THE ENVIRONMENT ON MARS

\$ 25

▲ 2

⚡ 2

✦ 1



INFRARED CAMERAS

PROS

- Gives basic information about minerals and grain size of the soil on Mars.
- Low mass and low power usage.

CONS

- Medium cost.

MARS

38

NCAS

HELPS DISCOVER IF MARS WAS EVER A HABITAT FOR MICROBIAL LIFE.

\$ 30

▲ 3

⚡ 2

✦ 1



INFRARED SPECTROMETER

PROS

- Detects minerals in detail, including those that formed in water, which is essential to life.
- Low mass and low power usage.

CONS

- High cost.

MARS

39

NCAS

HELPS DISCOVER IF MARS WAS EVER A HABITAT FOR MICROBIAL LIFE.

\$ 30

▲ 4

⚡ 5

✦ 1



HIGH-ENERGY SPECTROMETER

PROS

- Helps show where on Mars has water, which is essential to life.
- Low mass and low power usage.

CONS

- High cost.

MARS

40

NCAS

HELPS DISCOVER IF MARS COULD BE A HABITAT FOR HUMANS SOMEDAY.

\$ 15

▲ 1

⚡ 3

✦ 1



RADIATION SENSOR

PROS

- Shows healthier places for people where radiation is lower.
- Low cost, mass and power usage.

CONS

- Data may not be used for a long time to support human missions.

MARS

41

NCAS

HELPS DISCOVER IF MARS COULD BE A HABITAT FOR HUMANS SOMEDAY.

\$ 60

▲ 8

⚡ 25

✦ 1



LIFE SCIENCES LABORATORY

PROS

- Helps find out if Earth is the only place that supports life.

CONS

- Highest cost, most mass and uses the most power.
- Requires sample collection device (card #25).

MARS

42

NCAS

MAKES DISCOVERIES ABOUT THE ENVIRONMENT ON MARS.

\$ 30

▲ 3

⚡ 2

✦ 1



LASER TOPOGRAPHY MAPPER

PROS

- Measures the high and low points of the Martian terrain, including mountains and craters.
- Low mass and low power usage.

CONS

- High cost.

MARS

43

NCAS

MAKES DISCOVERIES ABOUT THE ENVIRONMENT ON MARS.



\$ 20
 ▲ 3
 ⚡ 2
 ✦ 1

COLOR STEREO CAMERA

PROS

- Provides a 3D experience of Mars by combining images taken by a set of cameras.
- Low mass and low power usage.

CONS

- Medium cost.

NCAS **44**

MAKES DISCOVERIES ABOUT THE ENVIRONMENT ON MARS.



\$ 5
 ▲ 2
 ⚡ 2
 ✦ 1

ATMOSPHERE/WIND SENSORS

PROS

- Collects detailed data about wind speeds and chemicals in the atmosphere.
- Very low cost, low mass and low power usage.

NCAS **45**

HELPS DISCOVER AREAS THAT MIGHT PROTECT MICROBIAL OR HUMAN LIFE.



\$ 5
 ▲ 2
 ⚡ 2
 ✦ 1

MAGNETOMETER

PROS

- Measures where Mars has a magnetic field, which can protect life from radiation.
- Very low cost, low mass and low power usage.

NCAS **46**

REQUIRED FOR LIFE SCIENCES LABORATORY



\$ 5
 ▲ 3
 ⚡ 1
 ✦ 1

SAMPLE COLLECTION DEVICE

PROS

- Collects air, rocks or soil samples for study by the Life Sciences Laboratory.

CONS

- Adds minor costs, mass and power usage to your mission.

NCAS **47**

USED TO DEPLOY HELICOPTER FROM ROVER



\$ 6
 ▲ 2
 ⚡ 3

RELEASE SYSTEM

PROS


- Protects helicopter from damage during rover deployment
- Safely deploys helicopter

CONS

- Adds mass to rover
- Needed to deploy helicopter

NCAS **48**

HELPS IN DETERMINING WHERE THE HELICOPTER IS ON THE PLANET



\$ 11
 ▲ 10
 ⚡ 5
 ✦ 1

NAVIGATION SYSTEM (AVIONICS)

PROS

- Keeps it close to the rover
- Records locations visited

CONS

- Medium cost, high mass
- High power usage

NCAS **49**

THIS TOOL CAN MEASURE AND PRODUCE OXYGEN FROM THE MARTIAN CARBON-DIOXIDE ATMOSPHERE

\$ 5
▲ 0
⚡ 0
✦ 0



CO2 CONVERSION TOOL

PROS

- Energy efficient
- The tool also measures levels of water vapor, oxygen, carbon monoxide, hydrogen, and other noble gases.
- Can be detached from the rover

CONS

- Cannot measure on a large periphery

50

NCAS

TO MEASURE WEATHER AND MONITOR DUST WITH SENSORS FROM THE SURFACE OF MARS

\$ 25
▲ 0
⚡ 0
✦ 0



WEATHER SENSOR

PROS

- Light weight
- Can also be used to measure radiation and wind patterns on Mars

CONS

- Must be attached to the rover to work
- Low data return capacity

51

NCAS

TWO COLOR STEREO NAVIGATION CAMERA

\$ 40
▲ 3



NAVIGATION CAMERAS (NAVCAMS)

PROS

- Help engineers navigate the rover safely
- Can navigate on its own without controllers on earth
- Can see objects as small as a golf ball 82 feet away

52

NCAS

CACHECAM IS A SINGLE CAMERA THAT LOOKS DOWN AT THE TOP OF SAMPLE MATERIALS

\$ 25
▲ 2



CACHECAM

PROS

- Takes photos of sample materials and sample tubes as they are being prepared
- Helps scientists watch over the samples as they are being taken

53

NCAS

AT LEAST ONE ANTENNA IS REQUIRED TO COMMUNICATE WITH EARTH.

\$ 10
▲ 1
⚡ 5
✦ 1



HIGH-GAIN ANTENNA

PROS

- Sends large amounts of data at one time.

CONS


- Costs more and uses more power than the Low-Gain Antenna

54

NCAS

AT LEAST ONE ANTENNA IS REQUIRED TO COMMUNICATE WITH EARTH.

\$ 5
▲ 1
⚡ 3



LOW-GAIN ANTENNA

PROS

- Low cost and power.
- Can be used as a backup for the High-Gain Antenna.

CONS

- Cannot send much information at one time.

55

NCAS

STORES ALL MARS DATA UNTIL IT CAN BE SENT BACK TO EARTH. REQUIRED FOR ALL MISSIONS!

\$ 5
▲ 1
⚡ 3



MAIN MEMORY CARD

PROS

- Low cost, mass and power usage.

CONS

- None! Your mission does not have a continuous link with Earth, so you need a way to store your data.

56

NCAS