Mars missionen

Hvem kan udvikle den mest effektive ubemandede mission til Mars?

I dette spil skal dine elever designe en mission til Mars. De skal indkredse et formål med missionen. De skal vælge de rigtige fartøjer. Og de skal vælge det rigtige udstyr. Alle valg træffes ud fra spillekort med informationer, som eleverne skal udforske. Når de har designet deres mission, skal de "launche" den. Og til sidst skal de evaluere, hvad de fik ud af missionen. Spillet er udviklet af NASA (https://www.jpl.nasa.gov/edu/teach/activity/marsbound/).

Intro

Spillet er en form for brætspil, med spilleplade og 47 kort, som handler om at designe en mission til Mars. *OBS: Der er en del printarbejde i opgaven, så den kræver en del forarbejde.*

Der er fokus på spørgsmålet: Hvordan løser ingeniører problemer? Og undervisningsmaterialet adresserer følgende spørgsmål:

- Hvad skal et design bruges til?
- Hvad er kriterierne for og begrænsningerne ved at finde en god løsning?
- Hvad er processen, når man udvikler potentielle designløsninger?
- Hvordan kan de forskellige foreslåede designløsninger sammenlignes og forbedres?
- Eleverne skal lære at skabe og sammenligne en analog model af en ingeniørmæssig mission begrænset af specifikke kriterier og grænser og vælge passende instrumenter til at søge efter liv på Mars.

SELVE SPILLET

Opgaven er – ud fra nogle afgrænsede valgmuligheder – at designe en mission, der både har:

- et balanceret budget under hensyntagen til masse, energi og udgifter
- ideer til videnskabelige resultater
- et mål om, at missionen kan lykkes sikkert

Metoden følger – "De 5 E'er":

- Engage
- Explore
- Explain
- Elaborate
- Evaluate

STEP 1: ENGAGE / MOTIVÉR

Som lærer kan du motivere eleverne – bl.a. med videoer fra dette link:
http://mars.jpl.nasa.gov/participate/marsforeducators/soi/

Du kan også bruger film, som er lagt op på Vild med Rummet:

1. Mars/Missioner til Mars.
    a. Kunsten at ramme Mars
    b. Sikker landing
2. Mars/Geologien på Mars
    a. Rødt støv overalt
3. Animationerne om, hvordan Marsroverne Curiosity og Perseverance leder efter liv:
    a. Robot har gjort spændende fund
    b. Mars 2020 Missionen

STEP 2: EXPLORE / UDFORSK

A: Aktivitet 1: Udform et videnskabeligt spørgsmål, som kræver et teknologisk design

Formålet med aktiviteten er at gøre eleverne fortrolige med målene for udforskningen af Mars. Her er udgangspunktet de nationale amerikanske mål, da opgaven er udviklet af NASA. Målet er yderligere at sætte eleverne i stand til at kategorisere videnskabelige spørgsmål i forhold til disse mål.

Eleverne skal vælge et af NASAs 4 fokusområder for missioner til Mars:

- Determine if life ever arose on Mars.
- Characterize the climate of Mars.
- Characterize the geology of Mars.
- Prepare for human exploration

B. Aktivitet 2: Vælg et videnskabeligt mål og et/en teknologisk design/løsning

Eleverne skal i grupper diskutere mulige videnskabelige mål. De skal at beslutte, om de vil flyve et landingsfartøj, kredsløbsfartøj eller en fly-by mission til Mars.

C. Aktivitet 3: Design en teknologisk løsning

Eleverne skal i grupper prøve at designe et konkret rumfartøj, som de vil bruge til deres mission. Her får eleverne hjælp fra spillekortene, som du finder sidst i pdf'en her, hvor der er en præsentation af typiske systemer og typer af udstyr/hardware, som kan være om bord på et rumfartøj. Eleverne skal læse hvert kort omhyggeligt, da teksten giver ledetråde om, hvad de forskellige typer udstyr kan anvendes til, og hvilke begrænsninger der kan være forbundet med dem.

OBS: Vent med at bruge de (grønne) specialhændelseskort, indtil spillet er færdigt.
OBS: Det er læreren, der skal definere budgettet. Jo lavere beløbet er, jo mere udfordrende er spillet. Man kan starte med $ 250 millioner – det giver en god "gennemsnitlig" sværhedsgrad.

Spillets gang:

1: Man starter med at vælge et (rødt) raketkort og raket-næse-kegle.
Raketkortet bestemmer massegrænsen for mission og vil have indflydelse på omkostningerne regnet i millioner af dollars.

Næsekeglen betyder ekstra vægt og udgifter, så eleverne bliver nødt til at registrere disse oplysninger i deres (G) rumfartøjsdesignlog, som de skal skrive i undervejs.

2: Herefter vælger eleverne et (orange) energisystem/forsyningskort. Dette kort vil fastlægge den tilgængelige energi under missionen.

3: Herfra vælger eleverne deres (lilla) computersystemer, (turkis) kommunikationssystemer og (blå) videnskabsinstrumentkort for at nå deres videnskabsmål angivet i aktivitet 2. Det øger muligheden for at opnå videnskabelige resultater.

4: Hvis eleverne har valgt en rover eller lander til deres mission, skal rovere have et (pink) mobilitetssystem. Og både rovere og landere vil kræve det (hvide) indgangs-, afstamnings- og landingssystemer.

5: Den sidste beslutning er valgfri (gule) mekaniske systemer. Disse kan øge det videnskabelige udbytte, men de skal besluttes til sidst, fordi de kan give budgetmæssige begrænsninger.

6: Mind eleverne om, at de skal bevare overblikket i deres (G) rumfartøjsdesignlog så de holder sig inden for budget, energi og masse.

7: Når eleverne har designet en mission der overholder budget, energi og masse, kan de nu vælge et (grønt) specielle event-kort. Halvdelen af disse kort er spin-offs eller fremskridt inden for teknologi, der kan kommercialiseres. Derfor kan disse øge budgettet. Den anden halvdel af kortene er fiaskoer eller nedskæringer i budgettet. Disse fjerner penge fra budgettet. Eleverne skal have tid til at tilpasse deres mission til de forskellige scenarier på de grønne kort.

8: Sidste trin er ”launch-dag”. For hver mission beregnes forholdet mellem økonomien i missionen og det videnskabelige udbytte. Det gøres ved at dele det beløb, der er brugt på missionen med antallet af optjente videnskabelige stjerner. (Se spillekortene) Herefter kan klassens missioner rangordnes.

Den type raket, eleverne valgte fra start har stor betydning for om man lykkes. For eksempel er der stor risiko ved Heavy-Lift-raketten, som kun løfter succesfuldt 3 ud af 6 gange.

STEP 3: EXPLAIN / FORKLAR

Analysér begrænsninger i teknologisk design

Eleverne præsenterer deres arbejde for hinanden.

STEP 4: ELABORATE / UDVIKLING

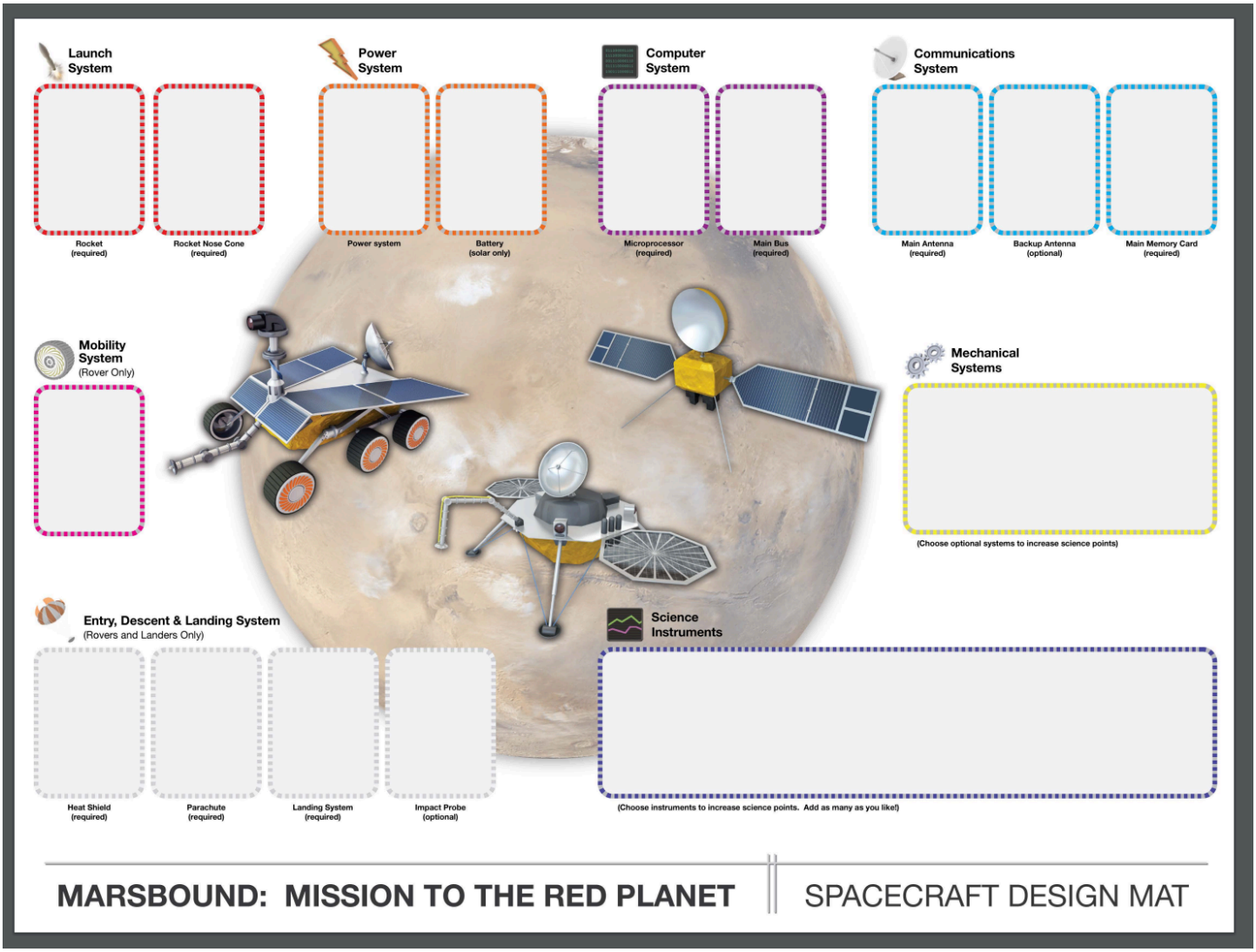
Eleverne udveksler/bytter spil/løsninger og udvikler videre på hinandens opgaver.

STEP 5: EVALUATE / EVALUERING

Diskutér fx hvor stor økonomisk risiko man løber med den slags missioner – ikke mindst fordi mange missioner går galt i den afsluttende fase.

SPILLEPLADE

Print spillepladen i stort format:



På de næste sider finder du spillekortene, som skal printes og klippes ud. Kortene har følgende funktions- og farvekoder:

Design mat system	Farvekode på spillekort	Numre på spillekort
Launch system	Rød	1-6
Power system	Orange	7-12
Videnskabelige instrumenter	Blå	13-25
Mobilitetssystem	Pink	26-27
Mekanisk system	Gul	28-30
Mødet med atmosfæren på Mars (Entry), nedstigning og landingssystem	Hvid	31-35
Computer system	Lilla	36-38
Kommunikationssystem	Turkis	39-41
Særlige muligheder	Grøn	42-47

Light-Lift Rocket I

This rocket can lift a mission that has up to 45 mass units.

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

✘ **CONS:**
- Lifts small, lightweight missions with few science tools.

1

Light-Lift Rocket II

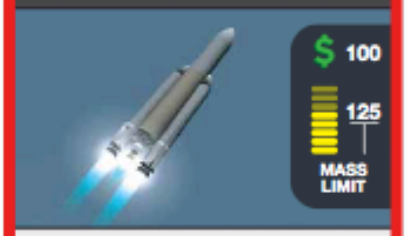
This rocket can lift a mission that has up to 90 mass units.

✔ **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.

2

Medium-Lift Rocket A



This rocket can lift a mission that has up to 125 mass units.

✔ **PROS:**
- Lifts large missions with more science tools.

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

3

Medium-Lift Rocket B

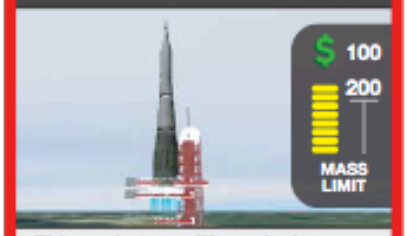
This rocket can lift a mission that has up to 125 mass units.

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

✘ **CONS:**
- Costs more than Light-Lift I & II and Medium-Lift Rocket A

4

Heavy-Lift Rocket



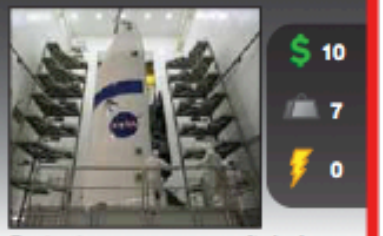
This rocket can lift a mission that has up to 200 mass units.

✔ **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.

5

Rocket Nose Cone



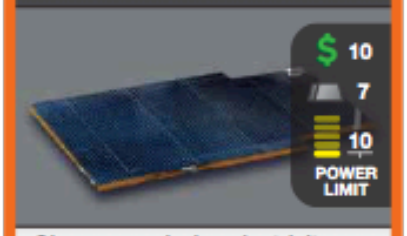
Protects your spacecraft during launch. Required for all missions!

✔ **PROS:**
- Low cost.
- No power needed.

✘ **CONS:**
- Medium mass.

6

Low-Power Solar Panel



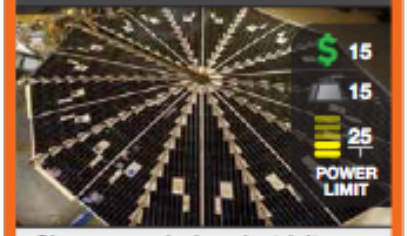
Gives your mission electricity.

✔ **PROS:**
- Low cost, low mass.
- Lasts a few years.

✘ **CONS:**
- Must have sunlight. Only works during daylight.
- Only works near the equator.
- Requires on-board battery (card #10)

7

Medium-Power Solar Panel



Gives your mission electricity.

✔ **PROS:**
- Low cost, medium mass.
- Lasts a few years.

✘ **CONS:**
- Must have sunlight. Only works during daylight.
- Only works near the equator.
- Requires on-board battery (card #10)

8

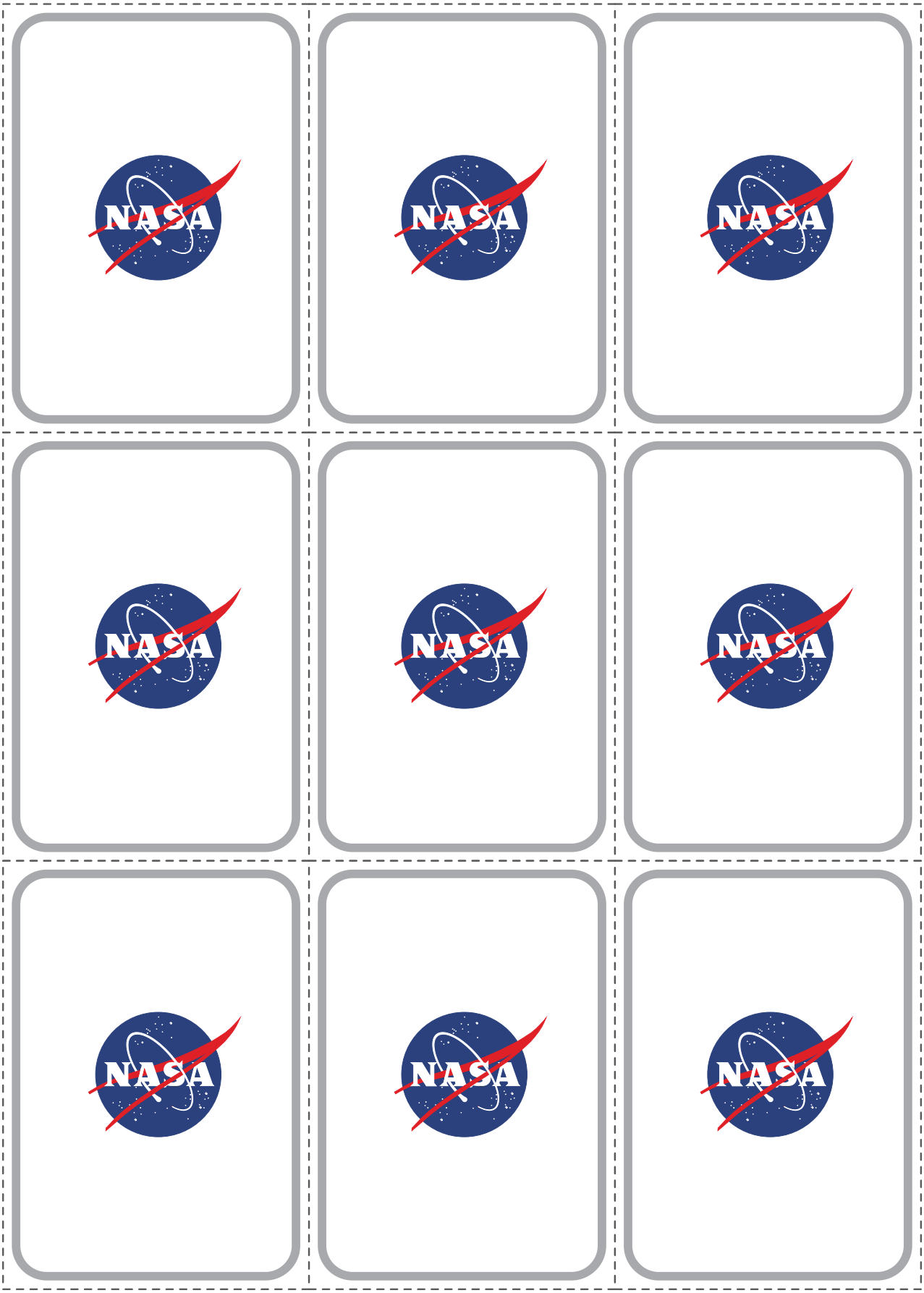
High-Power Solar Panel

Gives your mission electricity.

✔ **PROS:**
- Medium cost, medium mass.
- Lasts a few years.

✘ **CONS:**
- Must have sunlight. Only works during daylight.
- Only works near the equator.
- Requires on-board battery (card #10)

9


NASA
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On-board Battery

$ 5
5
5

A battery is required for all solar-powered missions.

✔ **PROS:**
- Stores power collected by solar panels so your mission can survive when the sun is not visible.

✘ **CONS:**
- Increases the cost, mass and power points for your mission.

10

Fuel Cell

$ 40
25
50
POWER LIMIT

Gives your mission electricity.

✔ **PROS:**
- Does not need the sun or a battery.
- Provides more power than solar panels.
- Works everywhere.

✘ **CONS:**
- Lasts a few months.
- Costs more than solar panels.

11

Radioisotope Power System

$ 75
30
75
POWER LIMIT

Gives your mission electricity.

✔ **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.

12

Low-Resolution Camera

$ 10
1
1
1

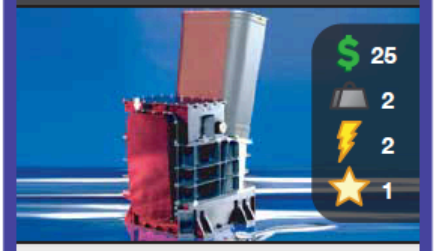
Makes discoveries about the environment on Mars.

✔ **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.

13

Medium-Resolution Camera



$ 25
2
2
1

Makes discoveries about the environment on Mars.

✔ **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.

14

High-Resolution Camera

$ 40
3
4
1

Makes discoveries about the environment on Mars.

✔ **PROS:**
- Sees the most detail of all.

✘ **CONS:**
- See only a tiny area of Mars.
- Costs the most.
- Has more mass and uses more power than other cameras.

15

Infrared Camera

$ 25
2
2
1

Makes discoveries about the environment on Mars.

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

✘ **CONS:**
- Medium cost.

16

Infrared Spectrometer

$ 30
3
2
1

Helps discover if Mars was ever a habitat for microbial life.

✔ **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.

17

High-Energy Spectrometer

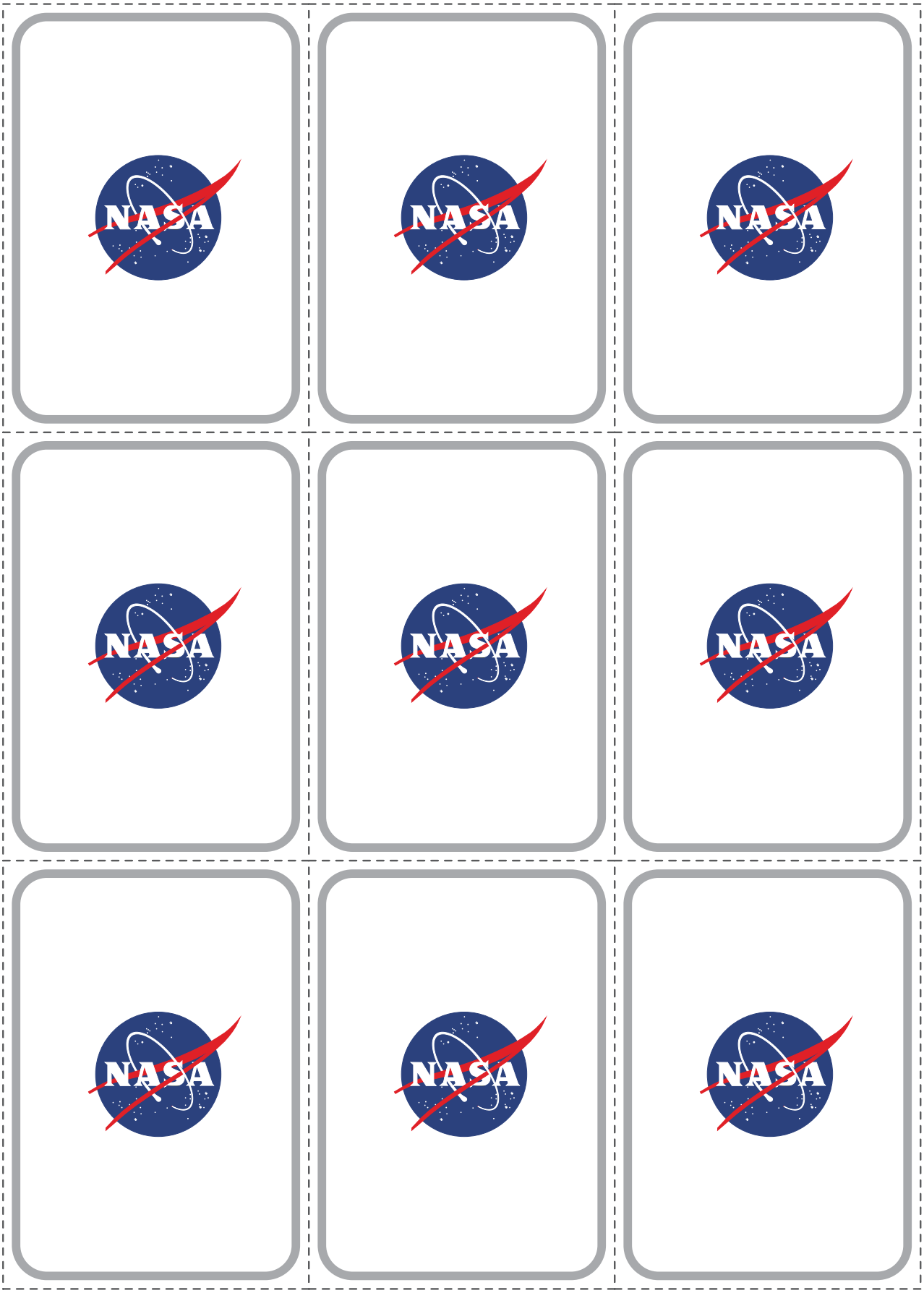
$ 30
4
5
1

Helps discover if Mars was ever a habitat for microbial life.

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

✘ **CONS:**
- High cost.

18


NASA

Radiation Sensor

$ 15
1
3
1

Helps discover if Mars could be a habitat for humans someday.

✔ **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.

19

Life Sciences Laboratory

$ 60
8
25
2

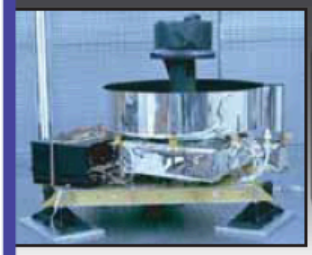
Helps discover signs of past or present microbial life on Mars.

✔ **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).**

20

Laser Topography Mapper



$ 30
3
2
1

Makes discoveries about the environment on Mars.

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

✘ **CONS:**
- High cost.

21

Color Stereo Camera

$ 20
3
2
1

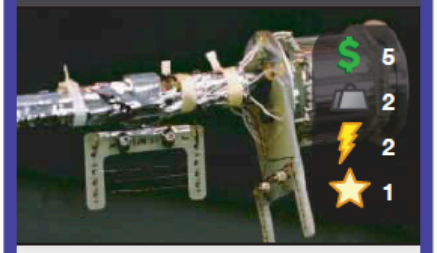
Makes discoveries about the environment on Mars.

✔ **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.

22

Atmosphere/Wind Sensors



$ 5
2
2
1

Makes discoveries about the environment on Mars.

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

23

Magnetometer

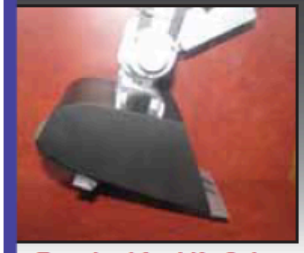
$ 5
2
2
1

Helps discover areas that might protect microbial or human life.

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

24

Sample Collection Device



$ 5
3
1
1

Required for Life Sciences Laboratory.

✔ **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.

25

Wheels

$ 15
10
12

Either wheels or tracks are required for rover missions.

✔ **PROS:**
- Wheels carry rovers to discoveries beyond their landing sites.
- Medium speed and work on rocky terrain.

✘ **CONS:**
- Have a little more mass, and use a little more power than tracks.

26

Tracks

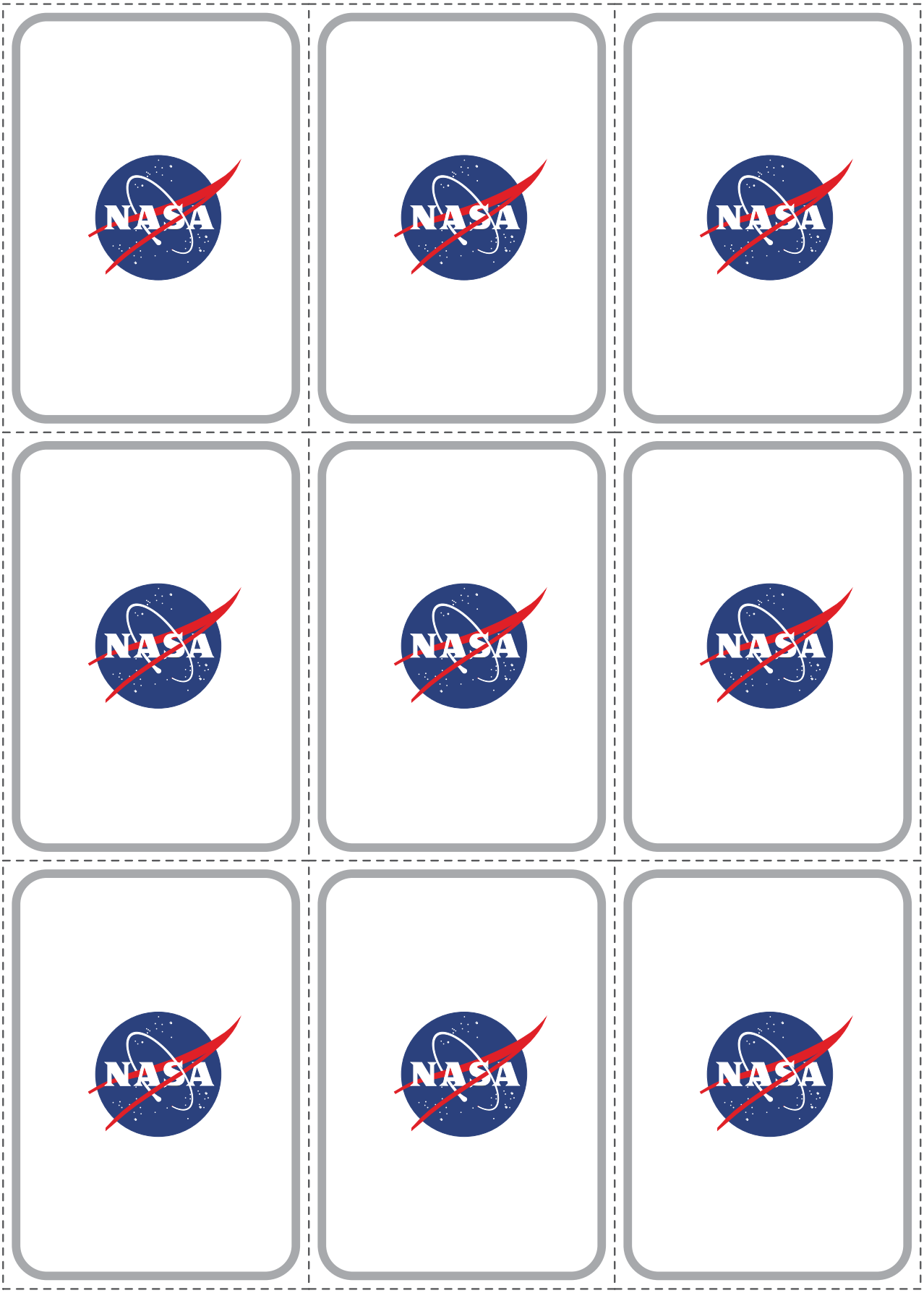
$ 15
8
10

Either wheels or tracks are required for rover missions.

✔ **PROS:**
- Have less mass and use less power than wheels.

✘ **CONS:**
- Can make it harder to climb over some obstacles.
- Less precise steering.

27


NASA

Robotic Arm

$ 5
8
1
1

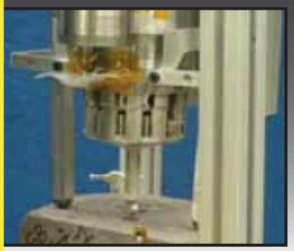
Collects samples and carries a number of science instruments.

✔ **PROS:**
- Doesn't use much power.
- Low cost.
- Provides an added science point.

✘ **CONS:**
- Medium mass.

28

Rock Drill



$ 5
3
5
1

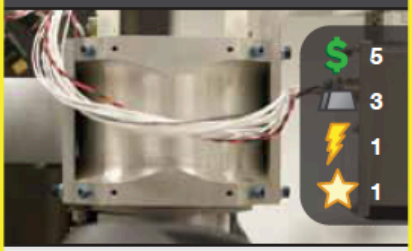
Collects samples by drilling into rocks.

✔ **PROS:**
- Low cost, low mass.
- Provides an added science point.

✘ **CONS:**
- Medium power.

29

Rotating Instrument Mount



$ 5
3
1
1

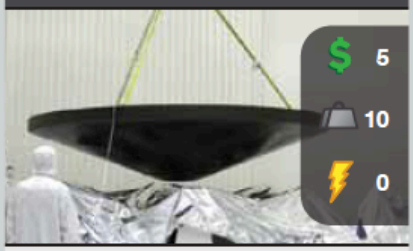
Provides flexible structure for multiple science instruments.

✔ **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.

30

Heat Shield



$ 5
10
0

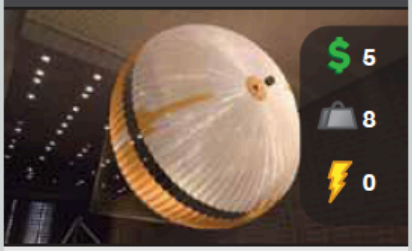
Required to protects all landers and rovers traveling through the atmosphere to the surface.

✔ **PROS:**
- Very low cost.
- Does not use power.

✘ **CONS:**
- Medium mass.

31

Hypersonic Parachute



$ 5
8
0

Required for all Mars landers and rovers.

✔ **PROS:**
- Slows the spacecraft down prior to using airbags or retro rockets.
- Low cost.
- Does not use power.

✘ **CONS:**
- Medium mass.

32

Retro Rockets

$ 10
8
0

Either airbags or retro rockets are required for Mars landers and rovers.

✔ **PROS:**
- Slows the spacecraft down for a controlled landing.
- Lower cost and mass than airbags.

✘ **CONS:**
- Spacecraft can be damaged by landing in rocky terrain.

33

Airbags

$ 40
15
0

Either airbags or retro rockets are required for Mars landers and rovers.

✔ **PROS:**
- Protects spacecraft from impacts on rocks and slopes.

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

34

Impact Probe

$ 10
5
0
1

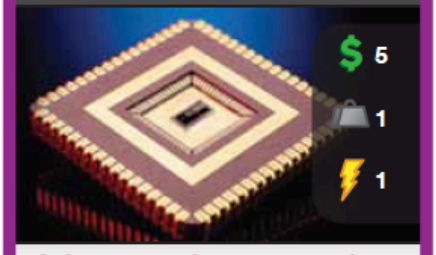
Probes can be added to enhance discoveries.

✔ **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.

35

Standard Microprocessor



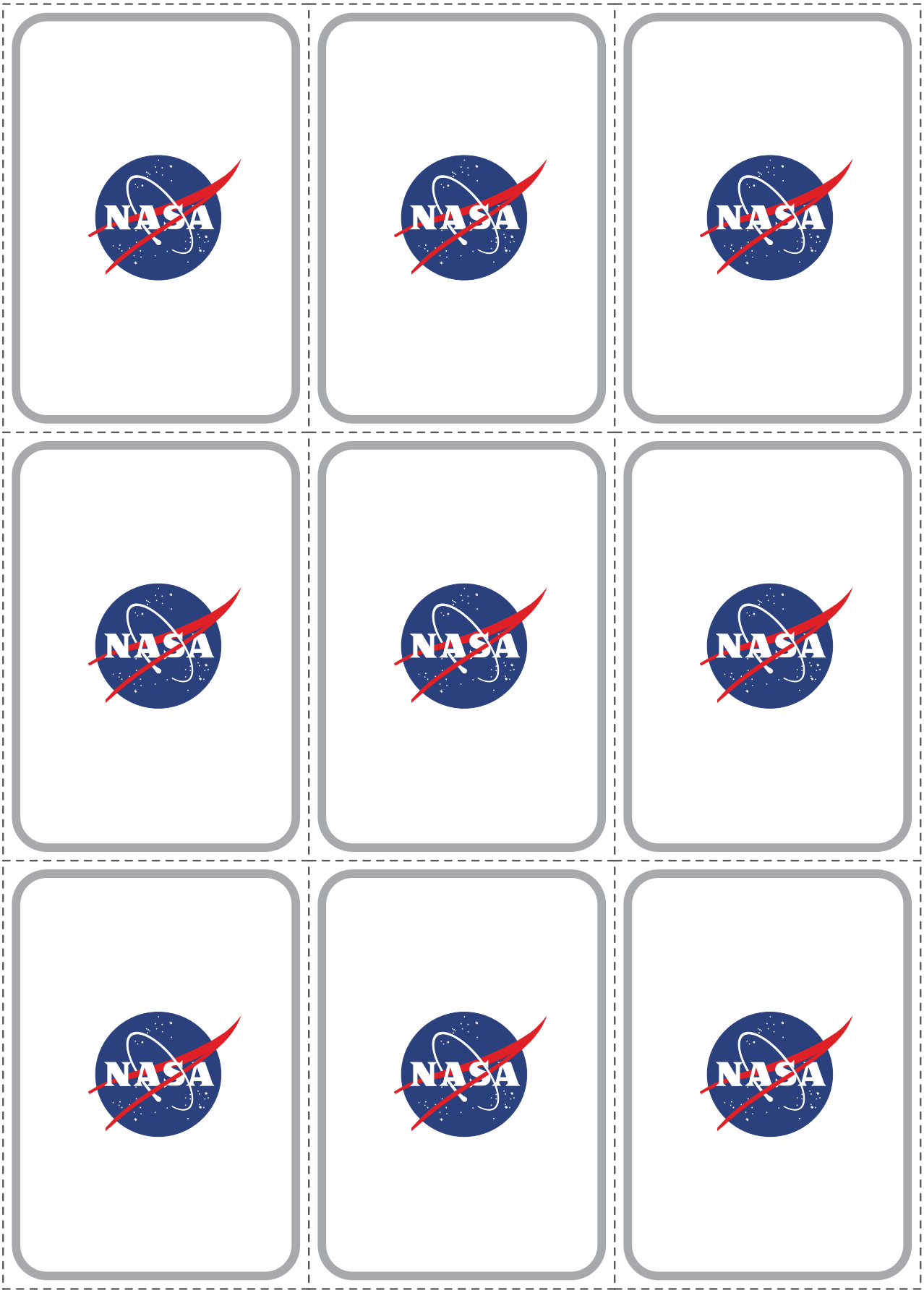
$ 5
1
1

At least one microprocessor is required for all Mars missions.

✔ **PROS:**
- Provides mission "brainpower."
- Low cost, mass and power usage.

✘ **CONS:**
- Provides only basic functions needed to receive commands and send data.

36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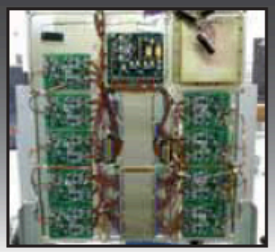
Advanced Microprocessor



$ 10
1
2
1

At least one microprocessor is required for all Mars missions.

✔ **PROS:**
- More "brainpower" lets the spacecraft make simple choices without commands from Earth.

✘ **CONS:**
- Costs more and uses more power than the standard microprocessor.

37

Main Bus

$ 20
5
1

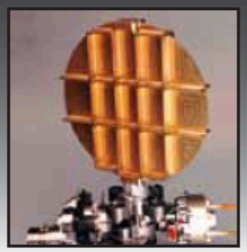
Connects science tools with the onboard computer so they work. Required for all missions!

✔ **PROS:**
- Low power usage.
- Allows you to make discoveries with your science tools.

✘ **CONS:**
- Medium cost and mass.

38

High-Gain Antenna



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1

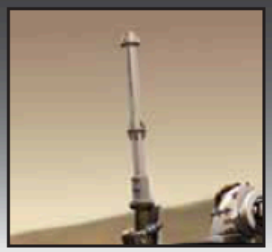
At least one antenna is required to communicate with Earth.

✔ **PROS:**
- Sends large amounts of data at one time.

✘ **CONS:**
- Costs more and uses more power than the Low-Gain Antenna.

39

Low-Gain Antenna



$ 5
1
3

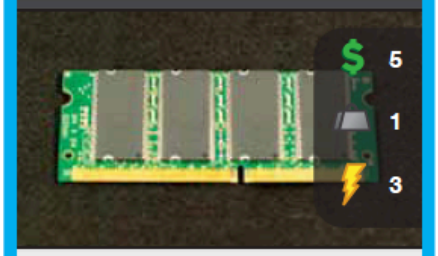
At least one antenna is required to communicate with Earth.

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

✘ **CONS:**
- Cannot send much information at one time.

40

Main Memory Card



$ 5
1
3

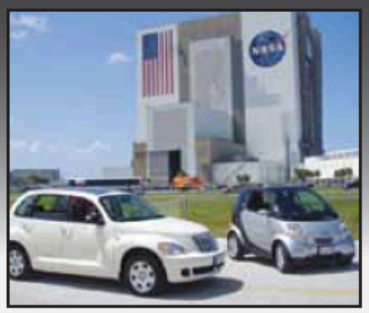
Stores all Mars data until it can be sent back to Earth. Required for all missions!

✔ **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.

41

Spin-Off: Automobile Sensors

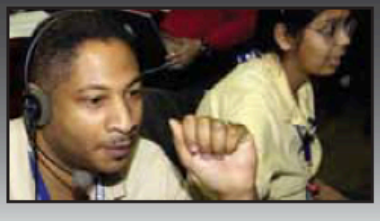


Hooray! Sensors created for your Mars mission help cars become more energy-efficient and easier to maintain!

✔ **EFFECT:**
$25 million for your future research.

42

Spin-Off: Communications

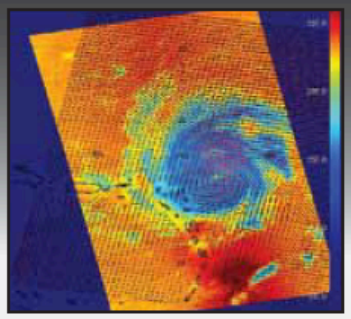


Hooray! People around the world can stay in touch more easily by using new communications technologies created for your Mars mission.

✔ **EFFECT:**
$35 million for your future research.

43

Spin-Off: Weather Prediction



Hooray! Your Mars mission discoveries gave new clues about Earth's atmosphere. Scientists can now predict weather better!

✔ **EFFECT:**
$15 million for your future research.

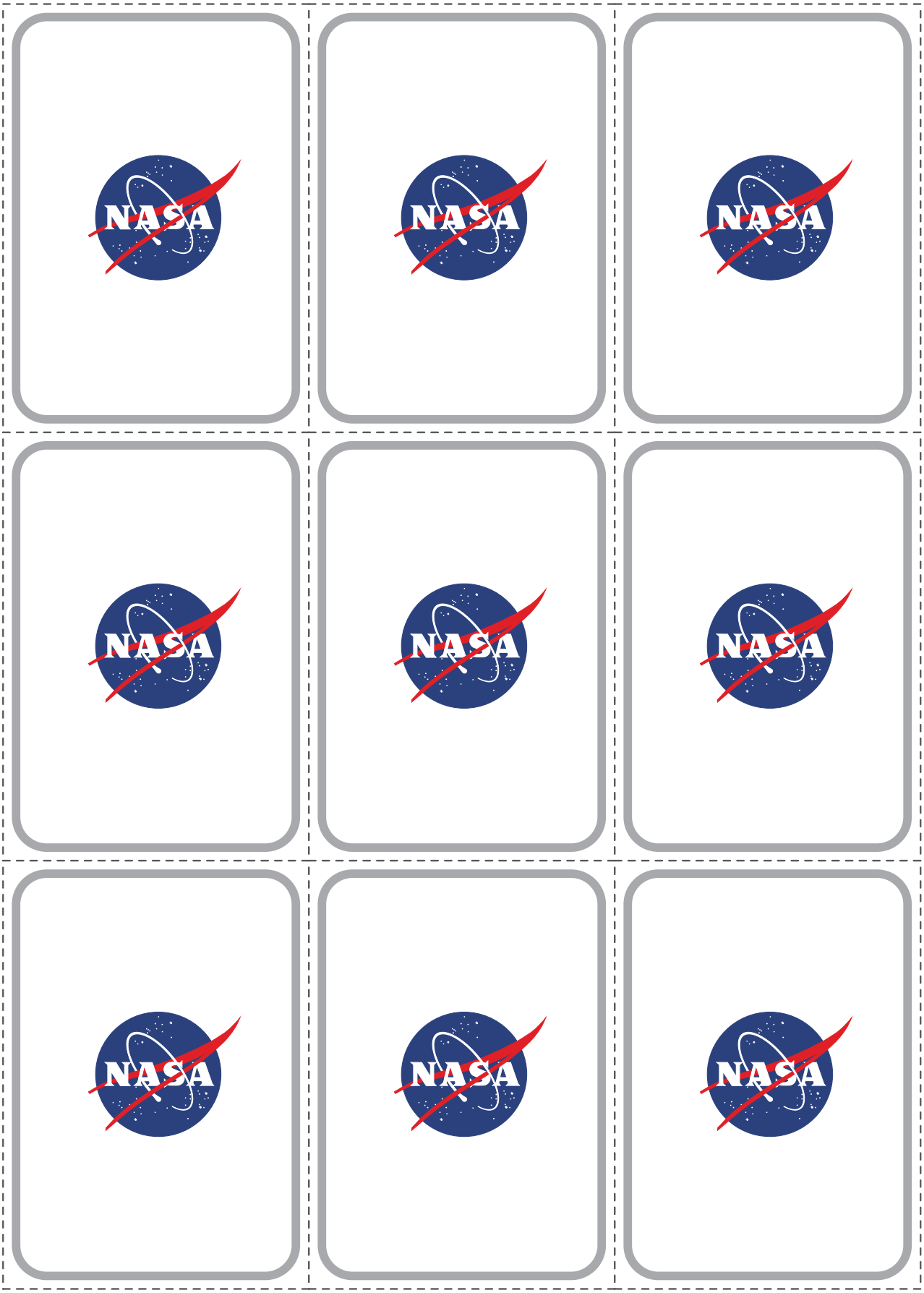
44

Budget Cut!

Sorry! Congress reduced NASA's budget.

✘ **EFFECT:**
Your mission loses one science tool.

45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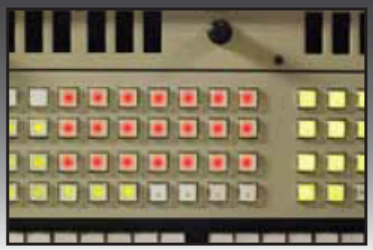
Rocket Failure!

Sorry! Your rocket failed during testing. You had to buy another one.

EFFECT:
You cut out two science tools to help pay for the new rocket.

46

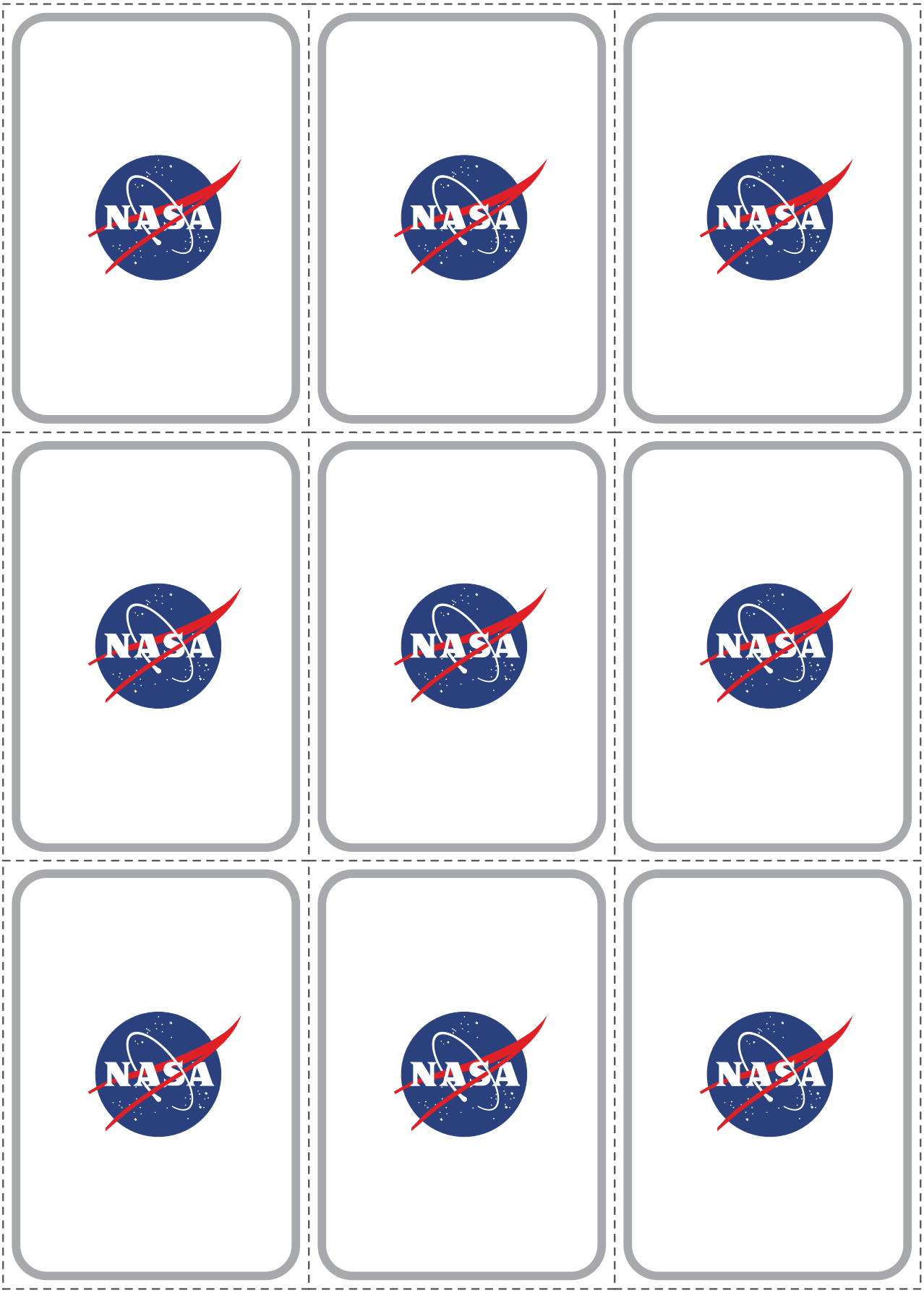
System Failure!



Sorry! During system testing, one science tool failed to work.

EFFECT:
Your mission loses one science tool.

47


NASA