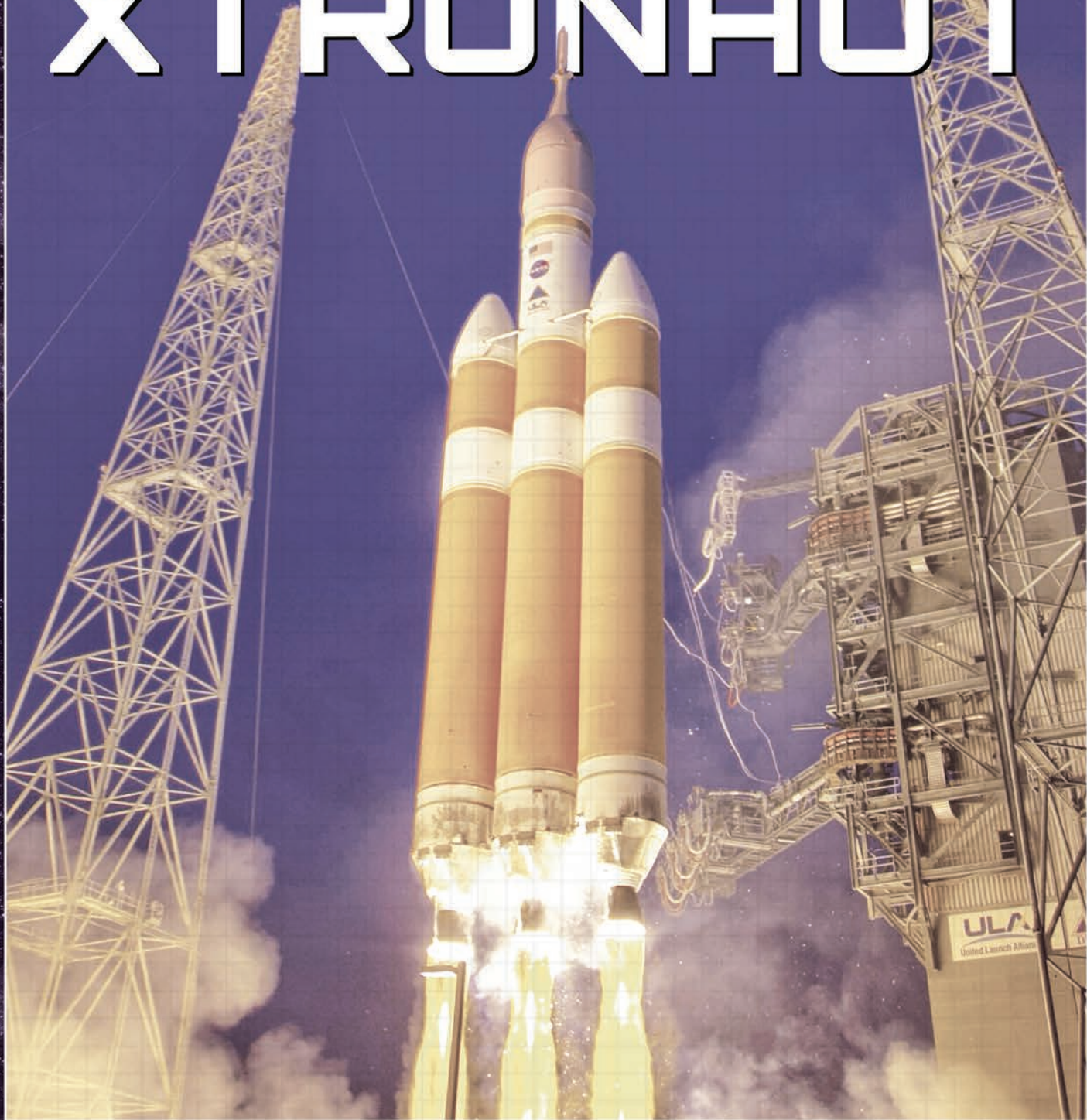# THE GAME OF SOLAR SYSTEM EXPLORATION
XTRONAUT

RULEBOOK

Greetings Xtronauts!

My name is Dante Lauretta and I am a Professor of Planetary Science at the University of Arizona. As part of my job, I am serving as the Principal Investigator for the OSIRIS-REx™ Asteroid Sample Return Mission[1]. OSIRIS-REx™ is a mission that is launching a spacecraft to rendezvous with near-Earth asteroid Bennu, study it in great detail, select a specific location on the asteroid surface, collect a sample, and return it to Earth for study in terrestrial laboratories. I created Xtronaut™ to capture the thrills and challenges that we face in designing and implementing real space missions.

The solar system is filled with many exciting destinations for planetary exploration. This game allows you to explore the gas-giants, ice-giants, terrestrial planets, dwarf planets, satellites, and asteroids using a wide range of different spacecraft. The challenge in this game is to build the right rocket to reach your destination. All the rocket performance values and planetary destinations are accurate and are based on real rocket science – the same calculations we use to plan real planetary missions. The game is filled with strategy, decision making, and a bit of luck. I hope you have as much fun playing Xtronaut™ as I had putting together OSIRIS-REx™.

Onward and Upward!
Professor Dante Lauretta

[1] OSIRIS-REx is a trademark of the Arizona Board of Regents and is licensed for use by Xtronaut Enterprises.

The OSIRIS-REx spacecraft with the Sample Acquisition and Return Assembly (SARA) being installed.

CREDITS:

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Development:
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Producer:
Michael Lyon

Special Thanks:
United Launch Alliance for permission to use the Atlas and Delta rocket product lines

Richard Kruse at http://historicspacecraft.com/ for great images and drawings of rocket components.

Brent Barbee for verifying the delta-V calculations

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Luigi Balarinni, Tory Bruno, Thad Carlson, Elisa Chambers, Julie Cheifetz, Fernando Couto, Andrew Daniels, Michele De Giuli, Terry Dougherty, James T. Fite, Doug Garnett, Melissa Hamende, Richard Hoff, Myles Jakubowski, Griffin Jayne, Darren Johnson, Roger Kaestle, Don Kaltenbach, Luba Kisiel, Joe Lampe, Elliot Lyon, Paula Magno, Yvan Martino, Kathleen Mayer, Russ McNeilly, Nate Mericle, Mike Moreau, Mike Nolan, Christian Nuera, Ian O'Neil, Chuck Pell, Martti Pelttari, Kristin Pilotte, Planetary Resources, Emily Przybyla, Carlos Benito Sanchez, Carrie Sekeres, Scar3crow, Shaun Sensenig, Scarlett Shuck, Edward Smith, Chris Thompson, Corey Michael Wells, Worldwide Helicopter Solutions

INTRODUCTION:

Xtronaut is an exciting game where players race to complete space missions and earn points. Earn **10 Data Points** and you win!

In Xtronaut, you assemble the necessary rocket components and mission enhancements to complete your assigned space mission. The main "currency" of space is Δ**V** (pronounced "delta-v"), which stands for change in velocity. As applied to space missions and this game, it means the change in velocity necessary for a spacecraft to complete an exploration mission in the Solar System.

Two to four player can compete in Xtronaut, each with their own game board and individual missions.

Cape Canaveral Air Force Station Space Launch Complex 41 in Florida.

CONTENTS:
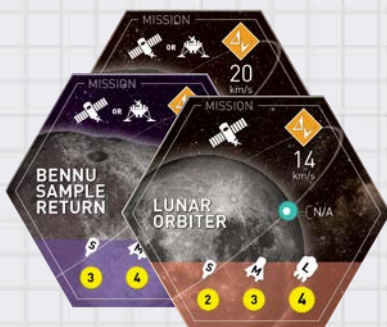
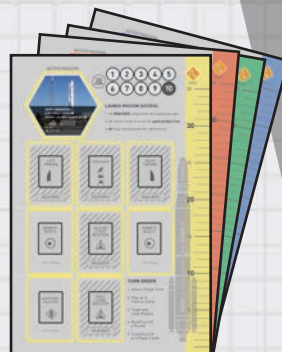**Instruction Book**

108 Playing Cards

17 Atlas Vehicles

15 Delta Vehicles

13 Falcon Vehicles

5 SLS Vehicles

29 Mission Cards

4 Player Boards

8 Gravity Assists

18 Spacecraft

4 ΔV Cubes

4 Score Discs

32 Action Cards

3

SETUP

Discard Pile Area

1. All players choose a color and place their **player boards** in front of them.

2. Shuffle the **Mission Cards** and place the deck in the middle of the table.

3. Deal all players **1 Mission Card**. They are placed face-up on the "Active Mission" hexagons on each playerboard.

4. Assemble the **Player Card Deck***, shuffle it, and place in the middle of the table. Also designate an area next to the deck to be the **Discard Pile**.

5. Deal all players a hand of **5 Player Cards**. Keep this hand secret.

6. Place the **scoring disk** associated with each player on the "Total Data Points" space on the score track of each player board.

7. Place the **ΔV cubes** associated with each player near the bottom of the ΔV track on each player board.

GAMEPLAY

OBJECTIVE:

The first player to accumulate **10 Data Points** from completed missions wins the game!

PLAYERS' TURN ORDER:

The player who has last looked into a telescope is the **Starting Player** to take the first turn. If there is a tie, choose at random. A player's turn is broken into **five phases taken in order** (may not be taken out of order):

Phase 1 - Draw a Player Card

The current player draws **one card** from the Player Card Deck. If the deck ever runs out of cards, reshuffle the Discard Pile and make that the new Player Card Deck.

Phase 2- Play up to 3 Action Cards

A player may play up to **three "action" cards** from their hand on their turn. If a player does not want to play, or has no action cards, they will skip this phase.

Phase 3 - Trade with other Players

Each player may negotiate trades with other players. Any trades **MUST** involve the current player. There is no limit to the number of trades that may occur on one turn. Trades may involve cards in a player's hand or on their game board. There **MUST** always be cards traded, players are not permitted to just "give" cards. Trades may also involve future deals and alliances, such as boycotting trade with another player or for future trades. Future deals are not binding, but immediate trades are.

Phase 4 - Build/Launch a Rocket

The current player may place, replace, or remove any number of vehicles, gravity assists, or spacecraft cards on their player board in the appropriate areas . Cards may be moved from the player's hand and onto the board, and vice versa (*See Building a Rocket, page 8*). If the player's rocket is complete, they may declare if they are able to have a **mission success**! (*See Completing a Mission , page 10*)

Phase 5 - Discard/Draw to 5 Player Cards

If the current player has more than five cards, they discard cards of their choice to the **Discard Pile** until they have five cards. If the player has fewer than five cards, they draw cards until they have five cards in hand. *Cards on the player board do not count towards the number in their hand.*

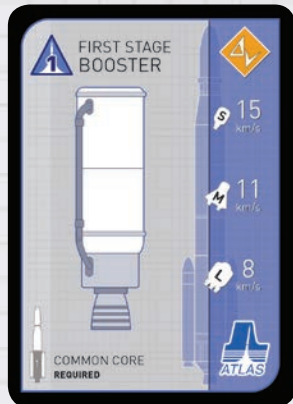Play continues clockwise around the table until someone wins the game.

PLAYER CARDS

Players can place any number of playing cards from their hand on the player board during their turn. Cards must go on the player board (*one per space*) in their proper location depending on their type:
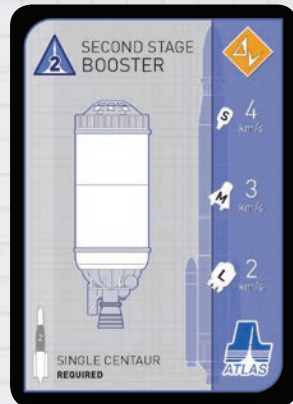
VEHICLE CARDS:

There are four different types, and four **different product lines**, of launch vehicle components:
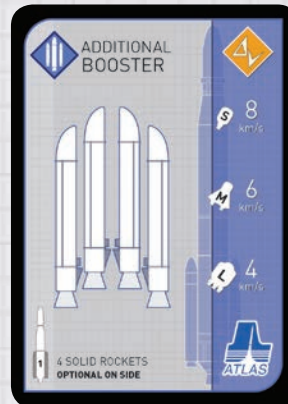
1 FIRST STAGE BOOSTER

The primary booster for a rocket. This stage is the first to achieve ignition and begin the lift off of a spacecraft from the surface of the Earth. The first Stage provides ΔV that varies depending on the size of the spacecraft.

2 SECOND STAGE BOOSTER

The second stage ignites after the first stage has spent all of its fuel and dropped back to the Earth. For interplanetary spacecraft, the second stage often provides enough thrust for both it and the spacecraft to achieve escape velocity from the Earth.

ADDITIONAL BOOSTER

Added to the first stage, these boosters achieve more thrust during lift off. They can be either Solid Rocket Boosters or additional first-stage booster cards. Boosters are optional and are **not required** for a rocket to be considered complete.

LEFT/RIGHT FAIRING

Both halves of the protective nose cone in the rocket's third stage that surrounds a spacecraft during the launch through the Earth's atmosphere. To successfully launch a rocket, the player needs both. The Fairings do not provide any ΔV.

PRODUCT LINES:

To successful launch a rocket, all of the vehicle components **must match** one of the four product lines:

FALCON

Space Exploration Company's (SpaceX) "Falcon 9" rocket has a first stage incorporating 1 or 3 "9-Merlin" engines and its upper-stage powered by a single Merlin vacuum engine. Falcon rockets are designed to use "reusable" boosters.

ATLAS

The United Launch Alliance's Atlas V uses a standard Common Core Booster™, up to 5 strap-on solid rocket boosters, and an upper-stage Centaur Engine configuration.

DELTA

The ULA's Delta IV Launch System is available in multiple configurations: a common booster core with two additional boosters, 2-4 solid rocket boosters, and a cryogenic upper-stage.
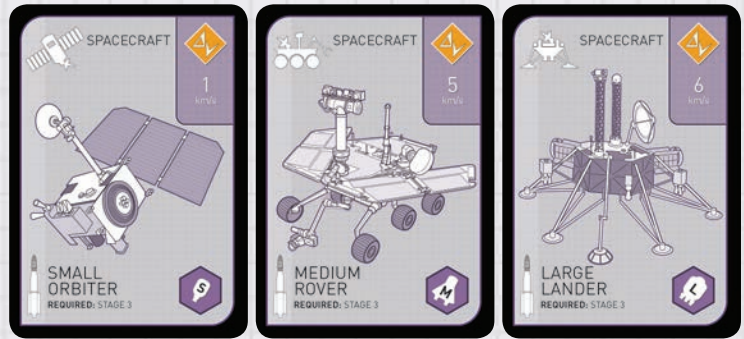
SLS

The Space Launch System (SLS) rocket is under development by NASA as the next-generation launch vehicle for robotic and human missions. The Block 1 SLS configuration consists of four RS-25 engines and 2 five-segment Solid Rocket Boosters, and will use the Interim Cryogenic Propulsion Stage (ICPS) for its upper-stage.

SPACECRAFTS:

The correct spacecraft is required to complete a mission. These vehicles have their own rocket engines and fuel tanks and provide **additional ΔV** for your mission.

SPACECRAFT — SMALL ORBITER — 1 km/s — S — REQUIRED: STAGE 3

SPACECRAFT — MEDIUM ROVER — 5 km/s — M — REQUIRED: STAGE 3

SPACECRAFT — LARGE LANDER — 6 km/s — L — REQUIRED: STAGE 3

TYPES:

There are **three types of spacecraft**, and each mission requires a specific spacecraft type that is listed on the Mission Card:

Orbiters   **Landers**   **Rovers**

SIZES:

There are **three sizes of spacecraft**, whose weight causes different ΔV from the lower-stage boosters when breaking Earth's pull. The larger the spacecraft, the more science and **Data Points** that can be achieved on a mission.
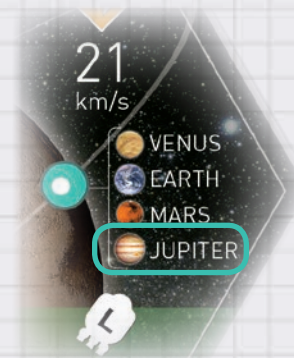
S **Small**   M **Medium**   L **Large**

GRAVITY ASSISTS:

As the craft moves in space, a fly-by Gravity Assist can provide **additional ΔV** to a mission.

Players can only play Gravity Assists that are listed on their Mission Card. The ΔV earned from a Gravity Assist is independent of spacecraft size.

A maximum of two Gravity Assists are allowed per mission.

GRAVITY ASSIST — 6 km/s — JUPITER — MASS: 1.898×10²⁷ KG — OPTIONAL ON SIDE

21 km/s — VENUS — EARTH — MARS — JUPITER

ACTIONS:

Up to **3 Action cards** can be played during **Phase 2** of a player's turn. These represent events in real-life that can either positively or negatively affect a mission. Action cards also can be traded. There are 2 kinds of actions that can be played:

Enhancers: Actions that give a player an immediate benefit, such as drawing more Player Cards or recycling discarded cards.

ACTION — ROCKET SALVAGE

Impeders: Actions that can foil the progress of a mission for your opponents (or yourself if not noted otherwise), such as discarding an Active Mission, stealing Player Cards, or stopping a player from launching a rocket.

ACTION — GOVERNMENT SHUTDOWN
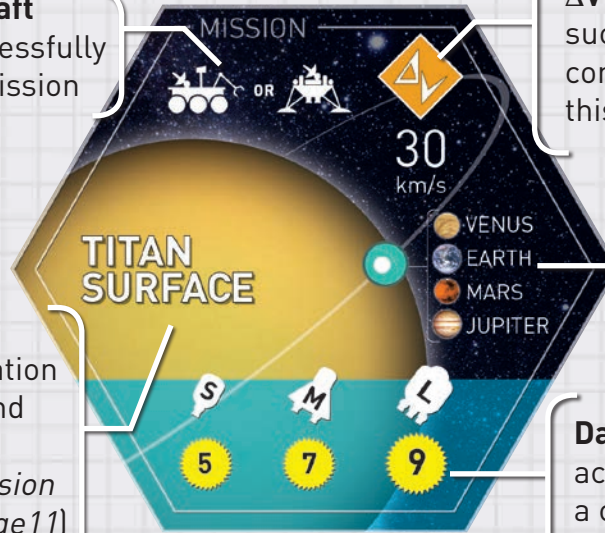
THE ACTIVE MISSION

MISSION BRIEF

MISSION

BRIEF:
Orbit this icy satellite to map the size and composition of a subsurface ocean.

Before a player reveals the Active Mission side of the card, they first must read the **brief on its backside**. For the action of "drawing a new mission," the player draws three and ONLY looks at the briefs before choosing (*see Drawing New Missions, page 10*)

Type of spacecraft required to successfully complete this mission

Mission Title includes the location of the mission and it's purpose (*see Glossary for mission descriptions, page 11*)

MISSION

TITAN SURFACE

30 km/s

VENUS
EARTH
MARS
JUPITER

S 5
M 7
L 9

ΔV required to successfully complete this mission.

Gravity Assists that may be implemented to add ΔV.

Data Points achieved by using a certain size of spacecraft on this mission.

BUILDING A ROCKET

*Until a spacecraft has been played onto the board, the ΔV from the boosters cannot be totalled

In **Phase 4**, the current player may place, replace, or remove any number of vehicle, gravity assist, or spacecraft cards on their player board in the appropriate labeled areas. Cards may be moved from the player's hand and onto the board, and vice versa. Only one card may occupy each space. This simulates early development and research into the different rocket types. Players should strive to play vehicle cards of the same product line, however they may play multiple product lines if they wish.

MOVE CUBE ON ΔV TRACK

Move the cube on the ΔV track to match the current total ΔV*. In this example, after adding the First Stage Booster:

Medium Rover = 5 km/s	
+ Gravity Assist = 2	
+ Second Stage Booster = 3	
	10 km/s
+ First Stage Booster = 11	
	Total ΔV 21 km/s

8

LAUNCHING A ROCKET

To successfully launch a completed rocket, it must meet the requirements of each step under the **LAUNCH MISSION SUCCESS** list on the player board.

1. All component spaces on the player board with the word **"REQUIRED"** must be filled and the correct **type of spacecraft (🛰 / 🛸 / 🔭)** listed on the Mission Card must be used.

2. The left fairing and right fairing, second and first stage boosters, and any additional boosters must all be of the **same product line**. Gravity assists and spacecraft have no product line, and may be added to any rocket in the appropriate position on the player board. *Gravity Assists must match with the Mission requirements next to the 🟢 symbol.*
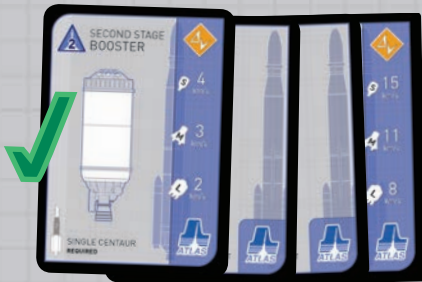
3. The **Mission ΔV** must be met or exceeded.

1: All Required Components Filled

Has both fairings, a spacecraft, and a second and first stage booster
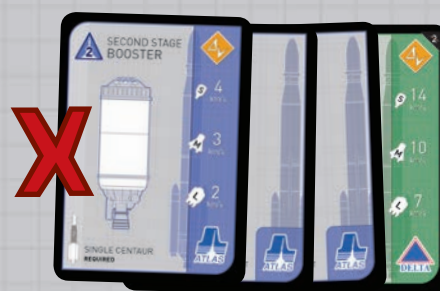
Missing a right fairing and a second stage booster

2: Vehicle Parts are the Same Product Line

All vehicle parts are Atlas

Parts are a mix of Atlas and Delta

3: ΔV must be Met or Exceeded

5
2
+8
15

Because this spacecraft is LARGE, the boosters use the "L" ΔV values. This mission only needs **14 ΔV**.

5
2
+8
15

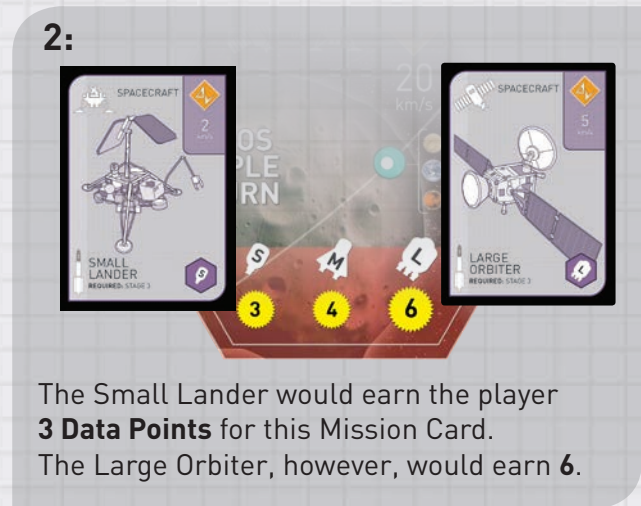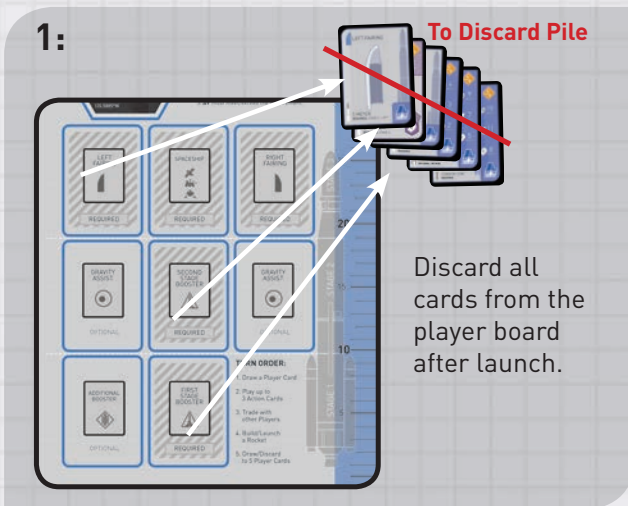This mission fails because it requires **20 ΔV**.

COMPLETING A MISSION

When a rocket is successfully launched, first **discard all cards** from the player board (*except for "reusable" Falcon cards, they may return to player's hand*). Then move the scoring disc up on the player board, adding **Data Points** achieved based on the size of the spacecraft and its matching value on the Mission Card.

1:

To Discard Pile

Discard all cards from the player board after launch.

2:

The Small Lander would earn the player **3 Data Points** for this Mission Card.
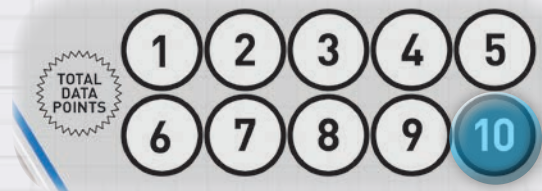The Large Orbiter, however, would earn **6**.

DRAWING NEW MISSIONS:

After completing a mission, the player places the Mission Card to the side of their player board. They then draw **three new Mission Cards** from of the deck, HOWEVER they only look at the **briefs written on the backsides**. From reading those three briefs, the player chooses a new card to reveal and become their new **Active Mission**. Without revealing, they then place the unchosen cards back into the bottom of the deck.

MISSION

BRIEF: Land on this terrestrial planet to study its crushing atmosphere and recent geology.

MISSION

BRIEF: Place a spacecraft on the surface of this planet to study ancient ocean sediments.

MISSION

BRIEF: Journey out to a near-Earth asteroid and retrieve a sample from the surface.

CHECK FOR VICTORY:

If the current player reached **10 Data Points or more**, they immediately win!

TOTAL DATA POINTS: 1 2 3 4 5 6 7 8 9 10

10

GLOSSARY

ΔV - The "change in velocity" (km/s) equal to the amount of energy needed to reach an object in the solar system. ΔV comes from rocket components, the spacecraft, and gravity assists.

Booster - The primary way rockets achieve ΔV. The **first stage** is the first to achieve ignition and begin the lift off of a spacecraft from the surface of the Earth. The **second stage** ignites after the first stage has spent all of its fuel and dropped back to the Earth. For interplanetary spacecraft, the second stage often provides enough thrust for both it and the spacecraft to achieve escape velocity from the Earth and enter orbit around the Sun. **Additional boosters**, such as solid rocket boosters or additional liquid-fuel boosters can be added to a rocket as well. ΔV will vary depending on the size of the spacecraft.

Fairing - The two-part nose cone of a rocket that protects a spacecraft during passage through the atmosphere like a shell. Once in space, the left and right sides of the fairing are separated and fall back into the atmosphere.

Gravity Assist - Using the gravity from a flyby of a planet or other body to gain additional ΔV.

Lander - A spacecraft that lands on the surface of a body but stays in one place for missions.

Orbiter- A spacecraft that stays in orbit around a planet or small body (moon, asteroid, comet) to perform scientific observations. An **orbiter mission** is to place a spacecraft in orbit around a solar-system object with the intent of performing observations of its interior, surface, and atmosphere.

Reusable - "Falcon" rockets are being designed to use recoverable first-stages, meaning that after launch on the fall back to Earth the boosters land back onto the launching area.

Rover- A spacecraft that lands on the surface of body and can drive around to different places.

Sample Return Mission – A mission to acquire a sample of material from a solar-system object and return it to Earth for analysis in terrestrial laboratories. Sample return missions can be completed by orbiter, lander, or rover spacecraft, depending on the target object.

Spacecraft - Spacecrafts are required to complete a mission. These vehicles have their own rocket engines and fuel tanks and provide additional ΔV for missions. There are **three types and three sizes of spacecraft**. The larger the spacecraft, the more the mass and therefore more ΔV needed. However, more science can be achieved on a mission with bigger crafts!

Surface Mission– A mission to land a spacecraft on the surface of a solar system object to perform observations of its near surface environment. Surface missions can be completed using lander or rover spacecraft, depending on the target.
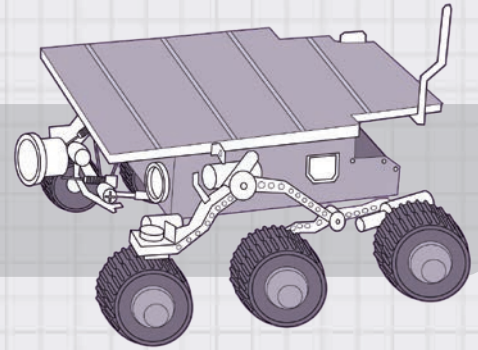
ADVANCED PLAY

EXCESS ΔV PENALTY:

If the players feel up to the challenge, this rule variant can be added.

Players will now **lose Data Points** for exceeding the required Mission ΔV.

For every 5km/s ΔV a player is over, the Mission's Data Point Value is reduced by 1. Always round down.

Over by:

0-4 km/s = **-0 points**   5-9 km/s = **-1 point**
10-14 km/s = **-2 points**   15-19 km/s = **-3 points**

Example:

Dante needs a ΔV of 14km/s to launch a Lunar Orbiter. The total ΔV of his rocket is 23km/s. Because he was over by 9km/s, he would subtract 1 from his Mission Card's Data Value before adding it to his score.

QUICK REFERENCE

PLAYER TURN

1. Draw a Player Card
2. Play up to 3 Action Cards
3. Trade with other Players
4. Build/Launch a Rocket
5. Draw/Discard to 5 Player Cards

LAUNCHING A ROCKET

1. All **REQUIRED** components and spacecraft type.
2. All vehicle cards must be the same product line.
3. ΔV must meet/exceed the requirement.

COMPLETING A MISSION

1. Discard **all cards** from player board.
2. Collect **Data Points** equal to the spacecraft's size on the Mission Card.
3. Look at the **Mission Briefs only** on backside of the 3 new Mission Cards. Choose one to be new Action Mission, place the unchosen back on the bottom of the deck.

GAME OBJECTIVE

The first player to achieve **10 Data Points or more** wins the game!