RACE FOR GLORY:
The Essential High Frontier

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VIOLET TEXT = Indicates changes since **Nov 25, 2019**. BURN YELLOW: since Dec 30.

GRAY TEXT = Indicates changes since **Jan, 2020,** sent to China March 31?

MAGENTA TEXT = Indicates changes since **Mar 31, 2020,** sent to China March 31

RED TEXT = Indicates changes since **Apr 16, 2020,** sent to China Apr 29

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iiA. Race for Glory Introduction

In *High Frontier*, you'll play one of several major spacefaring Factions with unique capabilities, racing to claim and develop the resources of the solar system over the course of the next few decades. You'll be competing with, but also potentially cooperating with, the other players as you lead humanity's expansion beyond the confines of our small planet. Winning is achieved by earning victory points from staking Claims, building Factories, establishing Colonies, and capturing glories. <<<TIP: *Race for Glory* scenarios also have specific victory point opportunities. Read the scenarios carefully.

Race for Glory (RfG) is the "essentials only" form of *High Frontier 4 All* Core – it excludes events, supports and Radiation Hazards. You can play *High Frontier* using the *RfG* selection of rules and the *RfG* cards as your main *High Frontier* experience, or use it merely as a stepping stone to the full *High Frontier* Core game. It is intended as a teaching system to make the step to the full game easier. Importantly, you will not need to unlearn any rules to transition to the full *High Frontier* experience. Everything you learn here is consistent with *High Frontier* Core. If you plan to introduce others to *High Frontier* using the *RfG* book, then you should take time to review this book and the tutorial ahead of time.

Important: RfG is not a rulebook. The Core Rulebook remains the definitive rule document used in *High Frontier*. *RfG* incorporates:

- **RfG reference document** (you are reading it now), including a tutorial consisting of a recorded game (using Scenario 1: Race to Mars) that you can walk through to learn all the essential *High Frontier* rules needed to play the included scenarios.
- **RfG card deck.**

iiA1. How does RfG differ from the Core Rules?

As the "essentials only" version of *High Frontier*, RfG does not include *supports* (Section **J**), *events* (Section **K**), and any associated subrules. It also excludes one type of Hazard: Radiation Belts. When reading the Core Rulebook, note the diamond icons. A filled diamond (♦) indicates a core rule that is modified for the RfG game. Empty diamond (♢) indicates a rule that is not used in the RfG game.

The box below provides information on those elements of the Core rules that are modified (♦) in or excluded completely (♢) from RfG. If the section from the Core Rulebook is not listed in the box below (that is, sections

A, **E**, **F**, **L** and **M**), then all the material in that section is used as written. Finally, the Core Rulebook's *golden rule* (**A2c**) applies to the RfG rules too: any text on a card or in a scenario takes precedence over general text presented in the Core Rulebook or RfG game.

Example: *In the "essentials only" RfG rules, there is no change to Core rule* ***C1*** *(it isn't listed in the changes in the text box below). However, several scenarios use fewer Seniority Disks than the 4 stipulated in* ***C1****. These are scenario-specific changes, and so are covered by the golden rule (****A2c****) and do not constitute a rule modification requiring a filled diamond.*

B. Component & Anatomies

♦ **B2**. RfG uses its own cards and so the illustrations in **B2** may not apply. A full description of the RfG cards is provided in the tutorial (**tB**).

♦ **B7h**. Ignore the border colors visible on certain Sites (the Synodic Comets), such as the kreutz sungrazer. Treat these as any other Site for the purposes of landing, takeoff and prospecting.

C. Core Setup

♦ **C4**. RfG uses a separate set of patent decks consisting of three types of patents (thruster, robonaut and refinery) rather than the six described in the Core Rulebook.

♦ **C5**. Give players 6 Aquas each at the start of a game unless specified otherwise in the particular scenario being played.

D. Yearly Play Sequence

◇ **D2a**. Use the RfG side of the sunspot placard.

G. Free Actions

◇ **G1h**. Glitch rules are not used in RfG.

◇ **G7**. Glitches are not relevant to RfG.

H. Movement

◇ **H4c.** Bonus Pivots are not used in RfG.

♦ **H8c.** The Venus flyby is always available in RfG.

◇ **H8g.** Glitch rules are not used in RfG.

◇ **H10**. Radiation Belts and radiation rolls are not used in RfG. Ignore them when moving your Rocket.

I. Operations

♦ **I5**. Ignore references to Glitches.

♦ **I6**. Ignore references to Glitches.

♦ **I7**. Ignore references to Glitches.

◇ **I7a,g**. Supports, including radiators and cooling, are not used in RfG. Ignore any support requirements for operations.

♦ **I9**. Ignore references to Glitches.

J. Supports

◇ **J**. Supports are not used in RfG. Ignore any reference to supports.

K. Sunspot Cycle & Events

◇ **K**. Colored seasons and events are not used in RfG.

N. Negotiation

◇ **N8**. Glitch repair and Glitches are not used in RfG, so can't be negotiated for.

The following rules are not explicitly demonstrated in this tutorial, but they are all valid in RfG and we encourage you to use them.

a. **Fuel Grades & Mixing Fuel (F4).** Thrusters with a gray thrust triangle use dirt as Fuel instead of water. You are not allowed to use thrusters with a blue (water) thrust triangle if you are using dirt fuel. But you could use water to fuel a gray (dirt) thruster. If you mix dirt and water, treat all the Fuel as dirt **(F4d)**.

b. **Dirt Refueling (G1c).** Dirt Fuel is produced at any Site provided you have a card with an ISRU value. Dirt is easy to come by, so you can refuel as much dirt as you want as a free action if your activated thruster is a non-crew dirt thruster.
c. **Jettison Fuel (G1f).** This *free action* lets you vent Fuel to space by jettisoning it. Just move your Wet Mass Chit as many steps as you'd like to the left along the black line.
d. **Fuel to FT (G2b).** This is generally used to create Fuel as FT cargo for transferring to another Stack.
e. **Phileas Fogg (G2c).** You can create Fuel from stuff Jules-Verne style! For each point of Mass Decommissioned back to your Hand, gain one FT of dirt fuel.
f. **Voluntary Discard of Cards & Tokens (G6).** If you have too many cards in your hand or tokens you no longer need, you can discard them as a free action.
g. **Factory-assist Landing/Takeoff (H6c).** If a Site has a Factory, a Spacecraft with an activated operational thruster may enter or exit that Site without needing a thrust greater than the Site Size, but you need to make a Hazard Roll to do it. You can't use this for Sites big enough to have a lander burn, except for Atmospheric Sites you can use *acetylene rocketplanes* **(H6c)** to takeoff.
h. **Air-Eater Op (I5c).** A Spacecraft Stack containing an operational "pac-man" card may refuel on an Aerobrake Hazard Space. This produces tanks of Fuel equal to 4 minus the Stack's *fuel consumption.*
i. **Raygun Prospecting (I6a).** You can prospect multiple Adjacent Sites provided your card's ISRU rating meets the Hydration requirement of each Site being prospected and the Sites involved don't have an atmosphere.
j. **Negotiated Factory-Assist and Factory-Refuel (N5-6).** Making deals with opponents to use their Factories for refueling or takeoff or landing.

iiB. RfG Components

a. **RfG Patent Decks** containing 12 thrusters, 12 robonauts and 12 refineries. These have the R prefix on the card number and the *Race for Glory* wedge in the top right corner.
b. **Glory Chits** (**B3**) won for achieving certain objectives in the game.
c. **Playmats** (**B4**) where you will track Fuel and the cards in your Stacks.
d. **Sol Solar Cycle Placard** (**B5**), using the RfG side.
e. **Crew Cards** (**B6**).
f. **Solar System Map** (**B7**).
g. **Reserves Components** (**C3**). 2 rockets, 7 domes, 7 cubes, & 9 disks per player.
h. **Blue Beads** to track resource exploitation and Aqua.
i. **Red Translucent Disks** to mark Busted Sites and Seniority.
j. **Wet Mass Chits** (to track Fuel on-board Rockets). One per player.
k. **Dry Mass Chits** to track Rocket Dry Mass (the Mass without Fuel). One per player.
l. **Outpost Chits.** 2 per player.
m. **RfG Player Aid Placard.** (reverse side of assembly diagram placard).
n. **A 6-sided Dice** (1d6).

iiC. What Next?

<<stop sign>> If recommended by the Progressive Learning Chart (found in the *Read Me First* book), do the tutorial found further back in this rulebook that you are reading. After you've worked your way through the tutorial, head back here. If you don't need to do the tutorial, read on.

iiD. RfG Scenarios

The following scenarios have all been designed to play using the “essentials only” RfG ruleset. The third scenario **(iiD3)** is actually just a standard *High Frontier* game using only those rules relevant to RfG. The other four scenarios include cooperative and competitive options. If you are playing *High Frontier* for the first time, perhaps after just having read the tutorial, the tutorial scenario *Race to Mars* **(iiD1)** or the second scenario *In Pursuit of Happiness* **(iiD2)** are good places to start. *Race to the Top* **(iiD3)** is a full RfG game with a normal game length (48 turns) and normal victory conditions. *Race for Patriotic Glory* **(iiD4)** is equivalent to the standard scenario, but with a narrower set of victory conditions and variable game length. Finally, *Race to the Rescue* **(iiD5)** is a second cooperative scenario.

iiD1. Race to Mars

> In this scenario, you and your fellow players will compete to get to, exploit and return from Mars as quickly as possible. This scenario is used as the subject for the tutorial contained in RfG.

Number of Players: 2 to 5 competitive.

Play Area: Mercury to Mars Heliocentric Zones inclusive. Any Stack that ends its move outside this designated area is considered “lost in space”. All cards in the “lost” Stack are *Decommissioned* as per Core Rulebook Section **E7**.

Setup: As per Core Rulebook Section **C**, with the following changes:

- **C1**. Place 2 Seniority Disks in the center of the Sunspot Cycle.
- **C5**. Players start with 4 Aquas each.

Special Rules: None.

Game End: The game ends one of 2 ways: *variable* (25 to 30 years) or *endgame trigger*.

- **Variable**. After the second Seniority Disk is removed from the Sunspot Cycle, roll 1 dice (1d6) each time the Sunspot Cube subsequently advances. If the roll is a 1, the game immediately ends. The game ends immediately at the end of Year 30 (i.e. half a Sunspot Cycle after the last Seniority Disk is removed).
- **Endgame Trigger.** The game ends immediately if the Sunspot Cube advances and all achievements (see below) and the Mars Zone *glory chit* **(L)** have been claimed.

Victory Conditions: Normal scoring as per Core Rulebook Section **M**. In addition, the following achievements earn 1 VP:

- First Faction to land a Rocket on Mars.
- First Faction to build a Factory on Mars.
- First Faction to sell an ET product (from any Site) on the free market.

iiD2. In Pursuit of Happiness

Humanity has come together to work collectively for the betterment of each. Ideological differences have been put aside and you are all pursuing the exploration and exploitation of space for the sake of the human condition. In this scenario, you win by cooperating and the lowest individual score determines how well you did as a team.

Number of Players: 2 to 5 cooperative.

Play Area: Out to and including the Jupiter Heliocentric Zone.

Setup: As per Core Rulebook Section **C**, with the following changes:

- **C1**. Place 3 Seniority Disks in the center of the Sunspot Cycle.

Game End: The end of the game is *variable* (37 to 42 years). After the third Seniority Disk is removed from the Sunspot Cycle, roll 1 dice (1d6) each time the Sunspot Cube subsequently advances. If the roll is a 1, the game immediately ends. The game also ends immediately at the end of Year 42 (i.e. half a Sunspot Cycle after the last Seniority Disk is removed).

Special Rules: None.

Victory Conditions: Victory in this game is determined as outlined in the text box. Normal scoring as per Core Rulebook Section **M**, except as follows:

- Victory points are not scored for Claims
- Sum the VP value of all *glories* and Factories achieved by each player. Compare the player who has the LOWEST score to the following table to see how you succeeded as a team:

VP Score	Outcome
Less than 7	Dystopia
7 to 16	Struggles
17 to 26	Prosperity
Greater than 26	Utopia

Strategy Notes: Victory is determined not by doing better than your fellows, but by beating the clock with the best 'low score'. To this end, never bid against each other on *research auctions* and make liberal use of *negotiation* as outlined in Core Rulebook (**N**).

iiD3. Race to the Top

A full 48 turn game using the RfG-applicable rules from the Core Rulebook. Essentially, this is the *High Frontier* Core game without events, supports, and Radiation Belts.

Number of Players: 1 to 5 competitive.

Play Area: The full map.

Setup: As per Core Rulebook Section **C**, with the RfG rules components.

Special Rules: None.

Game End: As per **M1**.

Victory Conditions: As per **M2**.

iiD4. Race for Patriotic Glory

Nation against nation, Faction against Faction as you try to assert your dominance over space the way we once sought supremacy at sea. *Glories* are all that matter when it comes to game end scoring.

Number of Players: 2 to 5 competitive.

Play Area: The full map.

Setup: As per Core Rulebook **Section C**, with the following changes:

- **C1**. Place 3 Seniority Disks in the center of the Sunspot Cycle.

Special Rules: None.

Game End: The end of the game is *variable* (37 to 42 years). After the third Seniority Disk is removed from the Sunspot Cycle, roll 1 dice (1d6) each time the Sunspot Cube subsequently advances. If the roll is a 1, the game immediately ends. The game also ends immediately when the Sunspot Cube enters Year 42 (i.e. half a Sunspot Cycle after the last Seniority Disk is removed).

Victory Conditions: Normal scoring as per Core Rulebook Section **M2**, with the following exceptions:

- Victory points are not scored for Claims, Factories, Colonies or factory stock prices.

Strategy Notes: This game is about winning *glories*. Claims and Factories are merely means to getting a Crew to a glory location and returning the Crew to LEO. Focus on building the infrastructure to capture glories, but don't lose sight of the fact that being able to ET produce may be an important step to building the technology you need to get your hands on those rewards.

iiD5. Race to the Rescue

A "colony city" in the deepest regions of the solar system is catastrophically failing. Work together to rescue the Colonists before complete collapse occurs. But be quick! Time is running out and every year that passes risks the lives of hundreds.

Number of Players: 1 to 5 cooperative.

Play Area: The full map.

Setup: You begin this game having already achieved a degree of Exoglobalization - ignore the setup rules in Section C of the Core Rulebook. Normal rules for allowable Stacks apply (that is, no Faction may have more than 2 Outpost Stacks).

- Randomly select Factions and the 1st Player.
- Place 2 Seniority Disks in the center of the Sunspot Cycle.
- Place 8 red translucent disks on a Site selected as follows to represent the stranded Colonists. This is a collective choice.
    - For a 2 player game, choose any Size 6 or greater Site in the Jupiter Heliocentric Zone.
    - For a 3 or 4 player game, choose any Size 6 or greater Site in the Saturn Heliocentric Zone.
    - For a 5 player game, choose any Size 6 or greater Site in the Uranus or Neptune Heliocentric Zones.
    - If you prefer to leave it to chance, randomize this selection.
- Each player starts with 6 Aquas.
- Shuffle the patent decks.
- In player Turn order, each player selects a patent card from the top of any one of the patent decks until every player has 3 patent cards.
- In Turn order, each player places a Claim on any eligible Site **not** in the Heliocentric Zone containing the Colonists, until every player has placed two Claims or 8 total Claims have been placed. An eligible Site is one with a Hydration level equal to or greater than the lowest ISRU rating on a patent in a player's Hand. <<<The highest possible ISRU rating is that of your Faction's Crew.
- Each player places a single Factory cube on one Claim.
- In Turn order, each player does one of the following, with no duplication allowed, until all options have been selected:
    - Selects a 4th patent.
    - Selects an additional 2 Aquas.
    - Places a third Claim as per above.
    - Places a second Factory.
    - Places 4 FTs on one Factory Site.
- From here on in, players may trade cards in their Hands and trade Aqua in LEO at no cost while completing the following setup actions:
    - One player may assemble and place an unfueled Rocket on any Site with a Claim disk.
    - One player may place a card Black Side up on a Site containing a Factory, establishing an outpost.
    - Finally, one player may place any number of White-Side Cards from their Hand onto an outpost at least 2 Heliocentric Zones away from the zone containing the Colonists.
- Divide 8 *Space Diamonds* discovery chits as evenly as possible amongst the players. Players may place their discovery chits on any Stack(s) of their choice on their playmat.
- Do not use the Exploitation Tracks.
- Normal play begins.

Special Rules: The following special rules apply:

- Red translucent disks represent Colonists. Each Colonist disk has Mass 1. Colonist disks may be traded as Cargo (**G1**) but otherwise have no function beyond needing to be returned to LEO.

Colonist disks may not undergo voluntary *Decommission* **(E7)** except in LEO, where they are then placed onto the LEO Stack to record their return.

- Discovery chits represent “temporary regenerative life support facilities” (and the all important Hibernation Vat Manager[1]). Each discovery chit has a Mass of 1. Discovery chits may be traded as Cargo (**G1**) but otherwise have no function beyond saving Colonists.
- To save the Colonists, you need to:
    - Deliver 1 discovery chit to the Colony Site for each Colonist disk remaining there.
    - Return the Colonists and their matching discovery chits to LEO.
- At the end of each year after Year 16, one Colonist disk without a Colocated matching discovery chit must be removed from the game. This represents the death of 1/8th of the original Colonist population.
- Colonists on any Rocket involuntarily *Decommissioned* before reaching LEO are permanently lost.
- Colonists can be placed onto any Claim as a new outpost en-route to LEO, but must still be returned to LEO to satisfy the victory conditions.

Game End: The game ends when the last Colonist dies or the remaining Colonists are returned to Earth.

Victory Conditions: You win if you beat the clock by returning all the Colonists to LEO in the allotted time. Your final score is determined by how many Colonists you get back to Earth. Failing to return any Colonists is considered a humanitarian tragedy. Anything less than 8 is a partial victory, but a victory nonetheless.

Strategy Notes: Victory is determined not by doing better than your fellows, but by again beating the clock. Placement of your Claims, Factories and Colonies is essential to getting to the stranded Colony in time and getting the Colonists home, but initial setup reflects the fact that you didn’t plan to have to do this rescue mission. When making placements, think about routes you need to use to reach the stranded Colonists, where you need to refuel, and the type of ET production you need to get the right technologies into place. During the game, never bid against each other in *research auctions* and make liberal use of *negotiation* as outlined in Core Rulebook Section **N**. With more Factions, you might split the load. Not all Colonists have to be on the same Rocket.

[1] THE HIBERNATION VAT MANAGER is an essential but modest helper that keeps all the hard-working colonists alive. He knows who he is.

TUTORIAL

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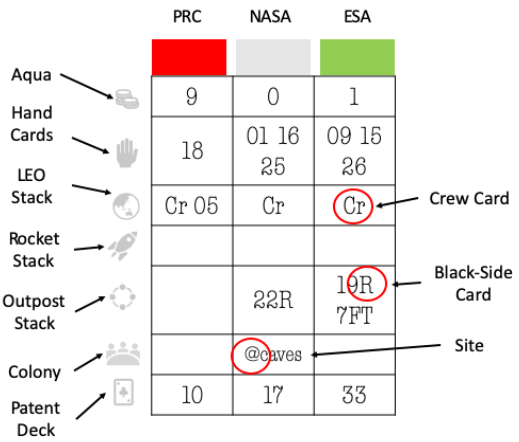
tA. Introduction

This tutorial will help you to learn the rules for the "essentials only" version of *High Frontier* by leading you through a detailed example of game play using Scenario 1 from *Race for Glory* (RfG). All the rules for *High Frontier* are contained in the Core Rulebook, and the tutorial will reference it extensively, so you might want the Core Rulebook handy. You will use the special set of cards that work with RfG. A playthrough of the introductory game, *Space Diamonds*, is useful for learning the basics of movement but is not necessary, with movement covered in full here.

This tutorial contains strategy tips, but it is not a strategy guide.<<<"Having a one-page strategy guide in *High Frontier* is like having a page of suggestions included with a jumbo box of Lego blocks." Phirax>>> It is structured to introduce rules in a staged approach and to cover as much rules terrain as possible. You'll see players make mistakes, take too many risks and make questionable strategic choices. The tutorial is structured as follows:

1. **Introduction** – you're reading it.
2. **Components and Setup** – introducing concepts, the playing pieces, the map, and the cards.
3. **Gravity Well** – covering Years 1-9, where you learn how to obtain your Hand of cards, turn them into a Rocket, and gain the propellant you will need to head off into space.
4. **Red Planet or Bust** – covering Years 10-19, where you fuel your Rocket, move it to Mars, land on one of the martian sites, stake Claims and build a Factory.
5. **Pale Blue Dot**[2] – covering Years 20-28, where you exploit your Claim to help you get back home. In this process you will learn about what you can do with a Factory, and how to ship valuable technology back to Earth.
6. **The Final Score** – covering the process of determining the winner.
7. **Other Than This** – rules in RfG scenarios that were not covered in this tutorial.



As you follow along, note that game cards and referenced game terms are written in italics and game terms that are defined in the Core Rulebook glossary are written with the first letter capitalized. **Bold type** indicates a game term that is being defined. The margins contain additional information, including strategy tips, rule explanations, and the *situational*

[2] PALE BLUE DOT. On February 14, 1990, the satellite Voyager I, as it was about to enter interstellar space, was turned to take a now famous series of photos of our solar system. The suggestion to rotate the satellite back toward Earth was made by astrophysicist Carl Sagan, for whom this section of the tutorial was entitled in tribute. The Earth was seen in those photos as a "Pale Blue Dot", as described by Dr. Sagan, providing us with a stark example of how miniscule we are when compared with the enormity of the cosmos.

tables (illustrated and explained in the image) that capture the game state at specific stages of the tutorial. Years are signaled with the header **Y#**. Paragraphs where a specific Faction is taking its Turn in the *player turn phase* of the year are marked with a colored triangle and Faction name (► **CRP**, for example).

References to the Core Rulebook are present throughout, but we'd recommend working through the tutorial first and then reading the Core Rulebook later. If you do open the Core Rulebook as you follow the tutorial, ignore any rule marked by a ♢ icon, and remember that any rule marked by a ♦ indicates it must be adjusted for RfG **(iiA1)**. The *golden rule* (**A2c**) is particularly relevant, which says that any text on a card or scenario supersedes conflicting text in the Core Rulebook.

tB. Components & Anatomies

Let's now take a look at the *High Frontier* components (**B**). See **B1** for the full component list.

Patent Cards represent technologies you will use as you venture across the solar system (**B2**). In your Hand, they are considered patents, but placed onto your playmat, they represent actual physical systems built using those patents. This distinction matters because it will help you understand the relationship between your Hand and the other cards on your Playmat with a map presence indicated by Tokens. RfG scenarios use three unique sets of patent cards: thrusters (used to move Rockets), robonauts (used to prospect, refuel, build Factories and sometimes to move Rockets), and refineries (used to build Factories). Patent cards have a White and a Black Side (**B2a**). The White-Side is always used for patents in your Hand that must be built and boosted from Earth. The Black-Side is only used when you produce technologies on non-Earth Sites.

Information listed on the Patents include card name and number, card patent type, Mass (**B2b**), and Spectral Type (**B2f**). All patent cards have science text and graphics, including an astronaut figure to give a sense of scale. Some patent cards contain one or more pieces of extra information, such as a *thrust triangle* (**B2d**), prospecting information, *Solar-Power* icon (**B2e**), *pushable* icon and card specific rules contained in a red text block. RT005F is the *Re solar moth thruster* card with a Mass of 0, a Spectral Type **D**, and an afterburner fuel consumption of 2 (B2d). <<RB022F image, showing labels for each of the above>>

Glory Chits (**B3**) are placed at specific locations on the map, and can be picked up and returned to Earth along with a Human Crew to earn *glories* worth extra victory points.

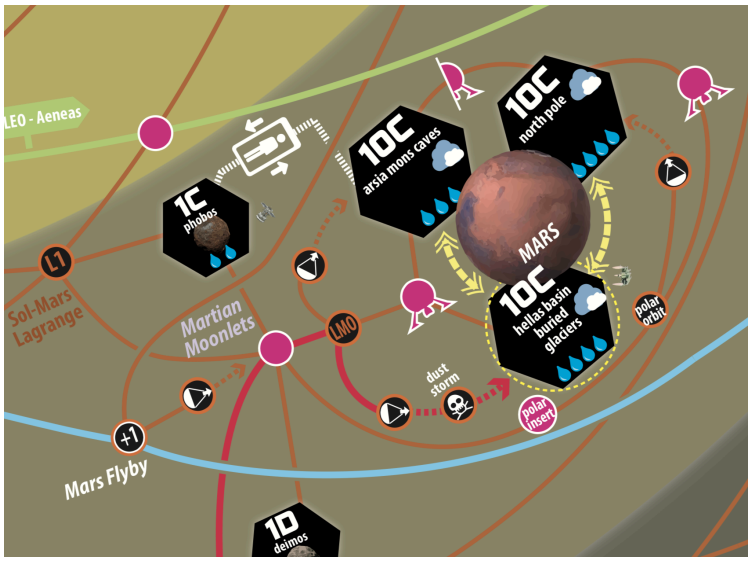
The 5 Playmats (**B4**) are identical. Your playmat serves two key purposes: to help you to track your Rocket's data as you move it around the map (top half of the playmat) and to help you to track all the assets you have in space (lower half of the playmat). <<image of playmat, with labels for top and bottom halves>>

Solar System Charts (**B5**) include: the six Exploitation Tracks (showing Spectral Types **C, S, M, V, D,** and **H)** found on the map; and the Sunspot Cycle found on a separate placard. In RfG, use the side of the placard marked RfG. It does not contain any information related to events or supports but it has other important rules information. <<image of RfG side of the placard>>

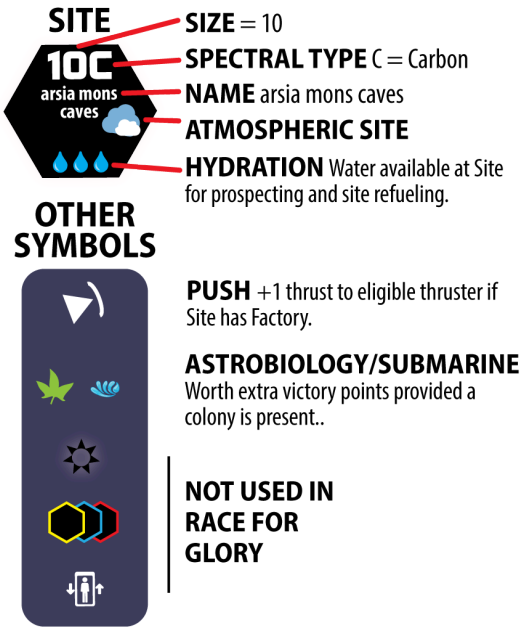
Crew Card[3] indicates your starting Faction (**B6**). Every Crew card contains five core pieces of information: the Crew's identity (in this case NASA), the Faction color (white band across the card), the *thrust triangle*

[3] EACH CREW CARD represents a six-person crew, plus a rocket vehicle with chemical thrusters, a closed-loop life support spun for artificial gravity, and (unrealistically) provisions for an indefinite mission endurance.

(which you'll learn about later), the Crew's special Ability (Launch Fees), and the Faction's *clout* (**C8**) rating.
<<NASA crew card image, with labels for each of the features>>



The Map is a graphical representation of our solar system (**B7**). It is covered in hexagons referred to as Sites (**B7a**). You can land on and liftoff from Sites, stake Claims on Sites and build on them as well. Sites represent extraterrestrial objects in our solar system such as asteroids, comets, moons and planets. Each Site has a name, a numerical Size, a Spectral Type and a Hydration level (indicated by water droplets) as can be seen in the diagram. Site Size governs the *net thrust* needed to land on and liftoff from the Site, and the ease of prospecting. Spectral Type determines the resource that may be found – (**C**) Carbon, (**S**) Stone, (**M**) Metal, (**V**) Vestoid, (**H**) Helium-3, and (**D**) Dark – and the technology that can be produced there. Hydration shows how much water is available on the Site and how easy it is to extract. The Sites and the map have other symbols on them that will be explained as they are encountered. At the center of the map, you'll see Sol, with a clock face to help locate Sites on the map. Mars, for example, is located at 2 o'clock in the Mars Heliocentric Zone, written II ♂. The other zones are Mercury (☿), Venus (♀), Earth (⊕), Ceres (⚳), Jupiter (♃), Saturn (♄), Uranus (♅), and Neptune (♆).



Mars, the eventual target for the Rockets in Race to Mars, has three Sites – arsia mons caves, north pole and hellas basin buried glaciers – surrounding a picture of the planet. They are identical in Size (10), but arsia mons caves have a lower Hydration (three water droplets), making it harder to produce Fuel and prospect there (more on this later). The large Size of these Sites makes them challenging to land on and liftoff from. The dashed yellow lines are buggy roads. Mars has an atmosphere, as shown by the cloud icon on each Site, that will be a factor when prospecting from remote locations. ~~<<image of a Site with the icons labelled. Suggest using arsia mons caves, and include astrobiology and submarine icons to one side with an indication of what they are>>~~

<<In the center of the three Mars Sites is an image of the famous red planet itself. You do not land on the planet icon.

Routes are the paths that Rockets travel along to get from Site to Site (**B7**). These paths cross at *intersections* (**B7b**) and are marked with a variety of icons. We collectively refer to intersections and other

important points on these paths as **Spaces**. Generally, these points on the map represent stable orbits rather than physical locations. Spaces include **Hohmanns** (where lines intersect or turn sharply but don't have icons), **Lagrange intersections** (marked by circles that aren't magenta-filled), and **Lagrange Burns** (marked by circles that are magenta-filled, but otherwise are treated as Lagranges). You'll learn more about all of this as you play through the tutorial (see the illustrations and descriptions in the table below).[4] Spaces and routes regulate Rocket movement and the Hazards that your Rocket might confront as it moves around the solar system.[5] Some of these routes are colored, but this is merely a visual aid and doesn't change how they function (**B7i**). The text on the map is also mostly for theme rather than gameplay (**B7k**).<<<We've thrown a lot of terms at you in this section. Don't panic, when it matters, we will explain them.

HOHMANN Pass through or 2 Burns to change direction.

BRIDGE Unconnected routes.

AEROBRAKE PATH One way; follow arrow.

LAGRANGE INTERSECTION Exit in any direction for free (LMO=low Mars orbit).

LAGRANGE BURN Expend Fuel to enter. Exit in any direction for free.

RADIATION BELT Treat as Lagrange intersection. Radiation effects do not apply.

LANDER BURN Fuel consumption or half fuel consumption to enter. Do not stop.

AEROBRAKE/CRASH HAZARD Hazard Roll or pay for FINAO. If roll = ⚀, Decommission Rocket Stack.

FLYBY BONUS +X Burns for this Turn. Treat as Lagrange intersection.

BUGGY ROAD With buggy, allows prospecting across two Sites.

tC. Setup

It's now time for setup (**C**). If you haven't already, open the mapboard and hand out three playmats. In this *Race to Mars* walkthrough, we are going to follow along with the play of three Factions: the People's

[4] SPACES, or locations, refer generally to any positions along route lines on the board such as SItes, Hazards, Hohmann's, etc. In *High Frontier*, each Space represents an orbit (that is, a position where a Rocket will stay without expending energy), and each line between two Spaces (such as the line between LEO and the cycler) represents a fixed amount of delta-v, which we will write as Δv (a fixed change in velocity to go from one orbit to the next). The only Spaces that aren't orbits are the *lander burns*, which is why you can't stop on them.

[5] DELTA-V. Let's talk about Δv and its relationship to orbits and to the idea of getting around the solar system. Δv is the change in velocity needed to go from one orbit to another and to blast off from a planet into a stable orbit. For instance, to go from the surface of the Earth to Low Earth Orbit (LEO is around 100-1000 km above the surface of the Earth), a rocket needs to be moving at a specific velocity such that the centripetal force of gravity accelerates the rocket towards the Earth at just the right amount to force it to travel in a circular path about the Earth's center of gravity. In other words, being in orbit involves constantly falling, but moving fast enough that the Earth's surface is curving away from the orbiting object such that it never reaches the surface. To understand the math, the velocity required to overcome the gravitational pull of a body (such as Earth) is given by $v=\sqrt{(G*m_e/R)}$. The top terms are constants, which means the weight of the rocket will not affect the speed of the rocket (or object) in the same stable orbit R. If you are sitting on the Earth's surface and you want to insert yourself into orbit, you need to increase your speed from the rotational speed of the Earth's surface (0.46 km/s at the Equator) to about 7.35 km/s. The needed Δv to get from the Earth's surface to a stable orbit at LEO is 6.89 km/s (neglecting losses due to launching straight up and overcoming air resistance, which actually brings the figure closer to 9.5 km/sec). Compare this value to the Δv required to go from LEO to LMO (Low Mars Orbit): 6.1 km/sec. Purely in terms of energy, it is easier to get from LEO to LMO than from Earth to LEO!

Republic of China (CRP-Purple),[6] the National Aeronautics and Space Administration (NASA-White) and the European Space Agency (ESA-Green). Find these three Crew cards and place one on each playmat in the LEO slot. In an actual game, each player would randomly select a Faction, and then each player would secretly decide which side to use (as per **C2**).

Set up the game for the tutorial as follows:

a. **Place 2 red Seniority Disks** (not four as per **C1**) on the Sol graphic at the center of the Sol Sunspot Cycle placard, as per Scenario 1, *Race to Mars*.
b. **Set up your Reserves** as per **C3**.
c. **Locate the RfG patent cards** (they are the cards with the R prefix in their numbering and a yellow wedge in the upper right corner), but do not shuffle them as per **C4**. We need to set these up to support this tutorial. Make sure the cards are placed in their individual*patent* decks in numerical order (this is so you know which cards come up next as they are referenced in the tutorial).
d. **Four Aquas** (water) are given to each player (not 6 as per **C5**). Place them as four blue beads in the Aqua box of each playmat.
e. **Put a Blue Bead** on the starting position of each Exploitation Track as per **C6**.
f. **Place a *glory chit*** (**C7**) on the circle labeled "GLORY" (**B7j**) in the Mars Heliocentric Zone (see map). No other glories are used in the Race to Mars scenario, so you don't need to put them onto the map. The Heroism chits are not used either in this tutorial, so you can leave them aside too.
g. **The 1st Player (C8)** is the CRP, since it has the highest clout rating of the three Factions. The player controlling CRP takes one of his small purple cubes and places it on the start position of the Sunspot Cycle (**C8**), becoming the designated 1st Player.<<< In the core game, events can change the player who will begin each year, thus changing who will put his cube at the start position of the Sunspot Cycle. But in RfG, the Turn order will not change.

<<image of set up all completed showing all the elements labelled. Done on a double page spread if possible.>>

Let's play

tD. 'Gravity Well'

We are now about to start the early game section of this tutorial. Here you will learn how to assemble a Hand of patents and then build a Rocket, while at the same time gathering the Fuel necessary to put that Rocket into space.

High Frontier proceeds as a series of years (**D**), which we'll refer to as Years when talking about a specific year number (such as **Year 22**). Each year is divided into two phases: the *player turn phase* (**D1**) and the *sunspot cycle phase* (**D2**). In the player turn phase, starting with the 1st Player and proceeding clockwise, each player undertakes a Turn, during which she may:

- Perform one Operation and move her Rocket, in the order of her choosing.

[6] In the printed rules, this is written as CRP, what the heck is that? The Chinese Republic of Peoples is a mythical country having nothing to do with a very real socialist nation steeped in oppressive censorship. A country with a long history of serfdom, and an identity card system designed to keep its serfs enslaved in the countryside. But let me share a story about the quest for freedom, a quest I give many details about in my game *Pax Emancipation*. A couple of decades ago these serfs defied their *hukou* identity cards, and overwhelmed the guards assigned to keep them out of the cities. It was very much like the bloodless fall of the Berlin Wall, but their numbers swelled to hundreds of millions. These impoverished ex-serfs now work in factories, and their wages, although low on the global scale, are enough for a greatly improved urban life, including luxuries like cell phones. The cheap products they produce include *High Frontier.* Unfortunately the political censors of this tyranny have decreed that any reference in *High Frontier* to the name or politics of this country will resort in confiscation, and my use of the abbreviation CRP is my little blow for freedom. —Phil Eklund

- Undertake any number of *free actions* at any time except during a move.

Once this phase is complete (every player has had a chance to do the above), the game enters the *sunspot cycle phase*. The 1st Player moves the Sunspot Cube to the next space on the Sunspot Cycle, marking a year of game time. When the *seniority threshold* is crossed, the 1st Player removes a Seniority Disk to mark the passing of a full twelve year solar cycle (**D2b**). Depending upon the specifics of the scenario you are playing, when the last Seniority Disk is removed, the game may end.

In the early game, you don't have to worry about movement because you need to build a Rocket first. You do this by collecting the "pieces" that you need. To this end, we are going to focus on a subset of the Earth-based Operations that will gain cards for your Hand.

But before we do that, let's talk about H_2O. Water is a central concept in *High Frontier*. It is used for currency, resource refining, life support and most importantly as a storable form of hydrogen that can be used to fuel Rockets. Water exists in *High Frontier* in the form of Fuel Tanks (FTs).[7] FTs are the key to unlocking the solar system. FTs stored in LEO are called **Aquas**. They serve not only as Fuel stored in LEO but also as the game's currency. Aquas are placed on a specific area on the playmat, as you learned earlier, and are represented by blue beads. When selling patents using a *free market operation*, undertaking an *income operation*, or participating in a *research auction operation*, you will use *Aquas* as currency (**F1c**). You also use Aquas to fuel your Rocket when it is in LEO. If you fuel your Rocket elsewhere, you must use FTs but if you fuel your Rocket in LEO, you use Aquas. Finally, you can load Aquas onto your Rocket as FTs carried as cargo (**F1b**), which could be useful later in the game, but is not something that is important right now.

tD1. Years 1-4 Income, Free Market & Research Auction Operations

In the first few Turns of *High Frontier* you'll focus on two things: getting patent cards into your Hand, and building up a stock of Aquas.

Y1

The 1st year has begun, and so we start the *player turn phase*. As the 1st Player, CRP takes his Turn first.

► **CRP** studies the three patent decks. There's a *metastable helium thruster* (Mass 5), a *neutral beam robonaut* (also Mass 5) and an *atomic layer deposition refinery* (Mass 3).<<image of the patent decks with the three cards on top>> Mass makes it harder to get parts into orbit and to move them around the solar system, so he decides to build up Aquas in preparation for future auctions for some lighter equipment.[8] He takes an *income operation* (**I1**), collecting 1 Aqua from the pool and adding it to his Aquas in the LEO slot on the playmat. An income operation is the simplest way to get funds. If all you need is 1 Aqua, just take income. <<<Think about the Spectral Type of a card when bidding. It could become useful if it matches the Spectral Type of a Site you might later build a Factory on. All the Mars Sites are Spectral Type C, so those cards are more important than any of the other Spectral Types in this scenario.

[7] EACH FUEL TANK (abbreviated FT) equates to forty tonnes of water. A tonne is equivalent to a metric ton or 1000 kg. This is different from a U.S. ton, or "short ton", which is equivalent to 907 kg and a British ton, or "long ton", which is equivalent to 1016 kg.

[8] MASS VS. WEIGHT. Referring to "lighter" equipment implies that weight and mass are the same, yet they are not. If you walk on Luna, your weight (measured in Newtons) is only ⅙ of that on Earth, yet your mass (measured in kilograms) is unchanged. Weight is an object's mass times the local acceleration of gravity (9.8 m/s^2 on Earth). Therefore a 1000 kg object weighs 9800 $kg \cdot m/s^2$ (Newtons) on Earth, and that same object would weigh 3700 Newtons on Mars, where g is approximately 3.7 m/s^2.

▶ **NASA** has the same patent cards from which to choose. She opts for a *research auction operation* (**I2**) despite the high Mass cards, picking the *metastable helium thruster* and playing it face up for the auction. To initiate or take part in a research auction, a player must have fewer than four cards in his or her Hand (**I2a**). Research auctions are loosely structured; the player conducting the research auction must start the bidding (usually 0 Aquas), and all players, including the initiator of the auction, are able to bid, (or refrain from bidding), in no specific order (**I2b**). When the players stop bidding, the highest bidder wins. Bidding is done using Aquas (**I2c**) and the winner pays the bid to the pool if they initiated the auction or to the initiating player otherwise (**I2d**). Ties are automatically won by the initiator of the auction, in this case NASA (**I2e**). <<<You could use this opportunity to play out the auction yourself to get a feel for how it works, but remember that for the tutorial you need to accept the auction outcome written in the text.

NASA leads with a bid of 0 Aquas, not needing to commit to a value up front, and the auction commences. ESA bids 1 Aqua and CRP passes. Realizing that there is no reason to bid higher with the power to automatically win ties as the initiator, NASA only matches ESA's bid. ESA does not raise the bid and CRP stays out of it. NASA wins the tie, pays 1 Aqua to the pool, and places the *metastable helium thruster* into her Hand, which is stored just to the right of the playmat. <<<Start an auction with a bid of 0 Aqua. You can always bid more later.

▶ **ESA** now takes her Turn, starting a *research auction* for the *neutral beam robonaut* by placing it in the auction area. This robonaut has an *in-situ resource utilization* (ISRU) rating of 2 and a Mass of 5. This good ISRU rating makes the card tempting despite its high Mass because a player with this technology in a Rocket would have the versatility to undertake *site refuel operations* and *prospecting operations* (you'll learn about both later) on any Sites with two or more water droplets, and that includes all three Mars Sites. Bidding proceeds again, ESA leading with 0 Aquas. In the end, NASA bids 2 Aquas because getting this card will put her ahead in the race to reach and exploit Mars. She wins the auction, outbidding CRP's bid of 1 Aqua. ESA is aware that NASA is well on her way to getting her Rocket into space, but she is profiting by NASA's haste. NASA pays ESA 2 Aquas (**I2d**) and both are happy. NASA now has two patent cards in her Hand. <<<When looking at values on the patent cards, note that Mass values range from 0 (light) to 5 (heavy), and prospecting ratings (ISRU) range from 0 (excellent) to 4 (poor), thrust values range from 0 (low) to 14 (high), and *fuel consumption* values range from 0 (efficient) to 14 (thirsty).

It's worth stopping here to look a bit more at the economics of the game. There are essentially three ways to make money in *High Frontier*, and you've seen two of them already. The first is the *income operation*, where a player takes 1 Aqua from the supply. The income operation is simple, but is not very lucrative. However if you take this Operation, it ensures that only you profit without helping any of the other players.

The second is the *research auction operation*, the income from which is variable, as you saw in the first Turn. When deciding to take this Operation, you are really deciding on whether you want the card you are auctioning or whether you think someone else wants it, allowing you to profit as a result. If you let someone else win an auction, you want to make sure that the auction is bid up to at least 2 Aquas, otherwise you should merely have taken an income operation--1 Aqua for you via an income operation is a better result than 1 Aqua for you AND someone else gaining an inexpensive patent from a research auction that you spent your Turn to initiate.

The third way to earn Aquas is to sell a technology patent using a *free market operation*. This earns you a flat 3 Aquas (although you'll see that it can earn a lot more later). The best situation is if you acquire a patent for 1 Aqua in a *research auction* on another player's Turn and then sell it using a free market

operation for 3 Aquas on your Turn. Here, you earn a net 2 Aquas using only one Turn. If you simply intend to free market a card, then you should never pay 2 Aquas for it at auction unless you really don't want someone else to have that card. After paying 2 Aquas and then selling the card on your next Turn for 3 Aquas, you only really achieved the same outcome as taking an income operation and you've made someone else 2 Aquas richer.

As 1st Player, CRP should complete the *sunspot cycle phase* by advancing the Sunspot Cube one space clockwise to show a year has passed. A year is now complete. On to Year 2.

But before we start the next year, let's focus on your Hand for a moment. Your Hand (**E1**) is stored to the right of your playmat. You can have as many cards in your Hand as you'd like (**E1a**). Cards in your Hand must always be White-Side face up and your Hand is open to other players to inspect at any time (**E1b**), as indeed are all cards on your playmat.

Y2

► **CRP** decides that he wants the *cat fusion Z-pinch torch robonaut,* the next card on the top of the robonaut deck, and places it up for auction. Bidding is competitive on this one, and in the end CRP wins by matching ESA's 2 Aquas bid, and pays 2 Aquas to the supply.

► **NASA** suspects that someone else might want the next card in the robonaut deck, the *nuclear drill robonaut*, which has a good thrust (5), a reasonable ISRU value (3) and a low Mass (2). <<image of nuclear drill robonaut>> She auctions this robonaut and is proven correct as ESA outbids CRP, wins the auction and pays 2 Aquas to NASA. Now all players have a robonaut in their Hands. <<<It is possible to launch a Rocket without a robonaut or a refinery, simply by using the Crew card. But without these technologies, any Rocket will be limited in its utility as you'll soon learn.

► **ESA** believes that a refinery may be the next technology that players will want. The top card on the refinery deck is the *atomic layer deposition refinery*, which has a reasonable Mass (3). ESA puts it up for auction. NASA and CRP are both interested and willing to pay big, and ESA intends to sit back, let someone else win, and collect the proceeds. NASA wins the bidding at 3 Aquas. This is a big injection of funds for ESA, who now has a substantial pool of Aquas.

You've finished Year 2, so remember to advance the Sunspot Cube again (from now on, you are on your own to remember this!).<<image of the Sunspot Cube on the Sunspot Cycle, showing the advance direction from the old position at Year 2 to the new position at Year 3>> The Factions have all made progress in terms of building Hands, but only ESA has more Aquas than at the start. Now, each Faction needs to collect enough patents to build a Rocket, gain enough Aquas to boost all the Rocket components (cards) into LEO, and then fuel the Rocket for its journey. NASA is in a good position with an efficient thruster, a good robonaut and a good refinery, which is enough to actually start thinking about getting off the planet, but she has to collect funds to do so. ESA and CRP still must build their Hands.

Y3

► **CRP** again goes first (once begun, the Turn sequence does not change in RfG). CRP thinks a better thruster is needed than what he has with his Crew so he auctions the *hall effect thruster*. NASA already has a good thruster and no funds so she does not get involved. ESA is interested, but she already has propulsion from the *nuclear drill robonaut*. ESA makes a small bid of 1 Aqua just to keep CRP honest but CRP matches it, wins the auction, and pays 1 Aqua to the pool, ending his Turn.

► **NASA** decides to undertake another auction, putting the *de laval nozzle thruster* up with a starting bid of 0 Aquas, which is all that she has. She figures to get the card for nothing or gain some Aquas from the winning bidder. With three cards in Hand, NASA can still participate in this *research auction*, but if she wins she won't be able to participate in auctions due to the *academia hand limit* mentioned earlier (**I2a**). CRP already has a thruster and ESA is still comfortable with the thruster in her Hand so both Factions pass, giving the auction to NASA for free. <<<Participating in an auction can be driven by a desire to obtain a specific card (maybe it has a Spectral Type you need, for example), to inexpensively obtain a card for later resale, or to stop someone else from getting a card. Sometimes, letting someone win an auction is useful because it fills their Hand, as was the case for NASA, locking her out of future auctions until she reduces her Hand size.

► **ESA** decides to auction the *ponderomotive VASIMR thruster* and only bids 0 Aquas, knowing full well that NASA has no funds and no room in her Hand, and CRP already has a good thruster. This should be a free grab … and it is. A good move for ESA! <<< It is important in *High Frontier* to be aware of the next card in the patent deck when a *research auction operation* is initiated. The next card in the deck could profoundly affect what you and the other players will do for the current auction and on future Turns.

Y4

► **CRP** auctions the *carbochlorination refinery*. He takes the bidding to 1 Aqua but won't match the 2 Aquas that ESA is willing to pay for it. NASA still can't participate. In all, not a bad outcome for CRP, as he collects 2 Aquas from ESA.

► **NASA** is next, and needs to clear a card from her Hand. At this stage, she's too broke to boost anything into orbit (we'll learn about *boost operations* shortly), so she takes a *free market operation* (**I3a**) selling the *de laval nozzle thruster* for 3 Aquas, and placing the card at the bottom of the thruster deck. The free market operation is one way of simultaneously earning funds and removing cards from your Hand.

► **ESA** recognizes that CRP could still use a refinery and decides to auction the *CVD molding refinery*. With NASA already holding a refinery, ESA feels if she wins the auction cheaply she can just sell it on the free market, but she hopes that CRP will bid this item up. CRP recognizes what ESA is doing but he likes the lower Mass refinery (refineries range from Mass 2 to 5) and is willing to pay 2 Aquas for it. The ESA player knows that once this auction exceeds 1 Aqua, it becomes more prudent to let CRP win it. She gladly pockets the 2 Aquas from CRP.

	2	3	7
	02 14 27	01 13 25	04 15 26
	Cr	Cr	Cr
	05	16	28

You've now finished this first sequence of Turns. Each player has moved toward obtaining the needed patents. There isn't that much "cash" around, but the Factions have plenty of time to build up Aquas. ESA appears to be in the strongest position, with the most funds and a good set of patents. The situation stands as shown in the *situational table* to the right. <<image of table similar to above (above just provided to supply data>> Use this to check that you've done everything correctly to this point.

tD2. Years 5-6 Boost Operations

Now that you are familiar with the basic components of the game and the *income*, *research auction* and *free market operations*, the tutorial will no longer describe them in detail. Next, we'll cover the rules governing how to get the patents in your Hand onto your playmat. The *boost operation* (**I4**) moves patents from your Hand to the Low Earth Orbit (LEO) slot on the playmat. You need to boost components for your Rocket into

your LEO Stack before you can actually assemble them into a Rocket.[9] Boosting requires funds; you need 1 Aqua for each unit of Mass you boost into LEO. Earlier, we mentioned (and you've probably noticed) that cards also have Black-Sides, but they can only be boosted on their White-Sides (**I4a**) – you'll learn about the Black-Sides later.

Y5

All three players have what they need to not only build a Rocket but to also take the technologies along with them to Mars. The only difference is that the ESA player has managed to accumulate more Aquas than anyone else.

► **CRP** auctions the next card on top of the thruster deck, the *Re solar moth thruster*, and wins it at a cost of 1 Aqua. This thruster has Mass 0, which is very attractive.

► **NASA** needs funds and grabs the *flywheel tractor robonaut* in an auction for nothing since nobody else bids.

► **ESA** is feeling pretty good about her Hand and she's ready to send a mission to Mars, but without the Crew. <<<Crews are useful when it comes to establishing Colonies, committing *Felonies* and winning *glories*, but they can also protect you against Felonies committed by others. They have powerful but inefficient thrusters and basic ISRU capabilities. In the full Core game, they also protect against events. However, you will learn as you get more experienced with the game that it doesn't always make sense to take a Crew on every trip. She boosts the *carbochlorination refinery* and *nuclear drill robonaut* from her Hand into LEO, leaving the *ponderomotive VASIMR thruster* behind. Adding up the Mass of the cards, she gets a total of 5. ESA has 7 Aquas, which is more than enough funds to boost, so she spends 5 Aquas (one for each point of Mass being boosted) to move the two cards from her Hand to the LEO space on the playmat. NASA's *faction privilege* (**B6a**) allows NASA to earn 1 Aqua from the pool every time a *boost operation* is conducted, and so she takes 1 Aqua from the pool for ESA's boost operation.[10] <<image showing the two cards, boosted from Hand to LEO with an arrow. Indicate the masses and the 5 Aquas paid to the pool plus the one Aqua from the pool to NASA>>

Y6

► **CRP** needs to reduce his Hand size below four if he wants to take part in auctions. He has the *Re solar moth thruster* with Mass 0, so he boosts it into LEO (placing it on the CRP playmat in the LEO spot) for nothing since it has no Mass.[11] Once again, NASA earns 1 Aqua from the pool due to CRP's *boost operation*. <<<Boosting cards into LEO is a way to get around the Hand limit for *research auction operations* if you want to keep the card rather than selling it or discarding it.

	1	1	2
	02 14 27	01 13	04 17
	Cr 05	Cr 16 25	Cr 15 26
	06	18	28

[9] BOOSTING. If you aren't familiar with current approaches to space flight, you might wonder why you need to boost technologies to LEO to construct a Rocket. Why not just launch a fully fueled and assembled rocket from Earth? For missions beyond Earth's immediate environment (beyond Luna, for example), space assembly allows for larger systems to be constructed, systems that are simply too big to be launched by a single rocket from Earth. NASA's space launch system (SLS), the largest system being developed today, can lift about 45 tonnes to Luna, about the mass of a single *High Frontier* fuel tank. Interplanetary rockets are much more massive, and will require multiple launches assembled in LEO.

[10] BOOST SERVICE. This is NASA's special Ability. It represents the fact that NASA operates the Space Launch System, and all the Factions, including NASA, make payments to use this service, paying in Aquas. It also highlights the dual nature of Aquas as both Fuel and funds (see **F1c**).

[11] MASS REPRESENTATION. This doesn't mean Re solar moth thruster has literally zero mass. It means that its mass is less than 20 tons, light enough to be considered negligible for game purposes.

► **NASA** also has a full Hand, she likes her cards and doesn't want to sell any, but she has an idea. She will split her mission into two stages: send a robonaut first to Mars, and the refinery and potentially the Crew later. To put that plan into motion, she boosts the *flywheel tractor robonaut* (Mass 2) and the *atomic layer deposition refinery* (Mass 3) into LEO. She has just enough Aquas (5) to complete this Operation. She earns 1 Aqua from the boost, but only after she has fully paid for the *boost operation*.

► **ESA** is almost ready to build a Rocket, but seizes the chance to auction the *kuck mosquito robonaut* and get it into her Hand for 0 Aquas, as the other players pass.

At the end of Year 6, all of the Factions appear well-placed with cards, but all need funds. Once again, use the *situational table* to check the game state. These tables will continue to appear periodically; use them as you see fit.

tD3. Years 7-9 Stacks & Free Actions

We are now reaching the end of the initial phases of this tutorial. In these next few Turns you are going to learn more about some of the *free actions* (**G**) you can undertake and more about Stacks (**E2**). Let's start with Stacks. You've seen three Stacks created in LEO, one by each Faction, and you've been exposed to the idea of the Hand. When you boosted some of the cards into LEO, you created a Stack (of cards) and placed them onto the playmat on the LEO Space. You are limited in the number of Stacks you can have on the map at the end of your Turn (**E3**): a single Rocket Stack, a LEO Stack, and two Outpost Stacks (**E2**). If you have more, then you need to *Decommission* the excess (we will learn this important process later). A Stack can be any size (space is really big, **E2a**).[12] Stacks generally have Figures associated with them (a rocket piece for the Rocket Stack, for example), but LEO Stacks are not represented by Figures on the map (**E2b** and **E3b**) since they are always in the same Space.

Since you are now familiar with the early game Operations, we will condense the next three game Turns.

Y7-8-9

► In these three Turns, **CRP** picks up the *rock splitter robonaut* in an auction for free with the intention of selling it on the free market and then accomplishes that in Year 8 to earn 3 Aquas. In Year 9, he initiates an auction for the *fluidized bed refinery* and wins it for 0 Aquas (no competing bids), netting a full 3 Aquas over the three Turns.

► Meanwhile, **NASA** collects 3 Aquas for selling the *neutral beam robonaut*, acquires the next robonaut in the deck, the *MET steamer robonaut* for 0 Aquas in an auction since nobody wanted it, and then sells it in Year 9 for 3 Aquas, earning 6 Aquas at the end of her three Turns.

[12] SPACE DEBRIS is an event in the Core Rulebook, and does not appear in *Race for Glory*. Although it makes for good Hollywood, the vastness of space in LEO is routinely underestimated when evaluating the hazards of the 128 million pieces of debris smaller than 1 cm in diameter in LEO. The notorious Kessler syndrome, in which a big collision creates a cascade of further collisions in a positive feedback loop, was put to the test in 2009, when the satellites Iridium 33 and Cosmos 2251 collided. A huge debris field of 2000 tracked fragments was created, but most of this deorbited within a few years without further incident. SpaceX wants to launch 42,000 Starlink satellites into orbit, but even this should not approach the Kessler density.

► **ESA** has a more complex sequence of actions to take. Having decided she's ready to go to Mars, she free markets the *kuck mosquito robonaut* for 3 Aquas. Now it's time for her to get a Rocket[13] ready. On this same Turn, she undertakes a *cargo transfer free action* to *create rocket/outpost stack* (**G1** and **G1d**) to move the robonaut and refinery currently in LEO on the ESA playmat to the Rocket Stack position on the playmat. <<image of cards moving from LEO to Rocket and the placement of the Rocket figure on the LEO space. Text showing that the create rocket action is free>> A cargo transfer free action is the basic mechanism to move cards between Colocated Stacks and to convert between Fuel and FTs. Remember, having decided not to send the Crew, it remains in LEO. At the same time, she places her green Rocket Figure (representing this Stack) onto the LEO Space on the map. Now that a Rocket Stack has been created, she needs to do some more work on the playmat. She determines the Mass of the Rocket by summing the Masses of the Rocket's component cards and places a Dry Mass Chit onto the Fuel Strip on her playmat at the point marked '5'. She also takes a blue Wet Mass Chit and places it atop the Dry Mass Chit. This shows that the Rocket has a Dry Mass of 5 and no Fuel yet. <<image of the two cards in the rocket Stack, showing the masses, and a fuel strip with the wet and dry mass chits on the 5 space>>

<<<*Free actions* can be performed as many times as you'd like during your Turn, and you can even repeat the same free action multiple times.

	4	7	9
	02 14 27 28	01	
	Cr 05	Cr 16 25	Cr
			15 26
	06	20	29

ESA sells the *ponderomotive VASIMR thruster* on the free market for another 3 Aquas in Year 8, returning it to the bottom of the thruster deck. She is almost ready to go to Mars, but would like a bit more Fuel first, so in Year 9 she takes 1 Aqua using an *income operation*. <<<Get your missions going early! You only have one Rocket Stack at a time, and getting it out to exploit the solar system quickly puts you ahead of other players.

For ease of the narrative we followed each Faction's Turns in sequence, rather than following the normal Turn order. To make sure your patent decks are correct, the last 4 cards on the robonaut deck should be in the following order (bottom to top) based on when they were sold on the free market: *MET steamer, rock splitter, kuck mosquito, neutral beam.*

tE. 'Red Planet or Bust'

The second phase of this tutorial will demonstrate how your playmat works, and will teach you how to fuel a Rocket to get to Mars. Factions will still be undertaking the other Operations that you've seen before, but we will skip the details and focus on the new rules.

tE1. Years 10-12 Fuel & Movement

Let's examine the playmat in front of you, in particular, the top half. Along the very top are the numbers 1 to 15. This is the **net thrust track**, where you will record your Rocket's net thrust. Directly below that is a zig-zag line starting at 1 and going to 32. This is the **Fuel Strip**, where you record the Dry and Wet Mass of your Rocket using Dry Mass Chits and Wet Mass Chits (blue for water-based fuel and gray for dirt fuel). The

[13] SPACECRAFT in this game are of two kinds: Rockets and Sails. A Rocket carries its own Fuel and propellant, and uses the Fuel as a source of energy to throw the propellant out the back. Courtesy of conservation of momentum (as famously described in Newton's First Law), this maneuvers the vehicle. Imagine sitting on a merry-go-round in the playground with a pile of rocks in your lap. Throw a rock off and you start to move. The food you've eaten is your chemical fuel, providing the energy you need to toss your propellant. But Sails don't need fuel or propellant. A typical photon sail maneuvers by balancing gravity with the pressure of solar photons in a manner similar to the age of sail in human history.

Fuel Strip is divided into a series of bands (wisp, probe, scout, transport and tug) that define the Rocket's **weight class modifier** and the associated thrust modifier that is used to help determine the net thrust.[14] A Rocket in the 'wisp' weight class, for example, would have its net thrust increased by 2. <<image of the playmat with each zone carefully labelled>>

Y10

► **CRP** remains short of funds and he has a full Hand, and so he sells the *fluidized bed refinery* for 3 Aquas.

► **NASA** uses a *research auction operation* to pick up the *blackbody-pumped laser robonaut*, again for nothing.

► **ESA** takes an *income operation* to collect 1 Aqua, bringing her total to 10. She then decides to fuel her Rocket. To do so, ESA converts some of the Aquas to Fuel on-board her Rocket using an *internal tankage* (**G2**), which is a *free action*. From here, follow the figure below to see what is going on.

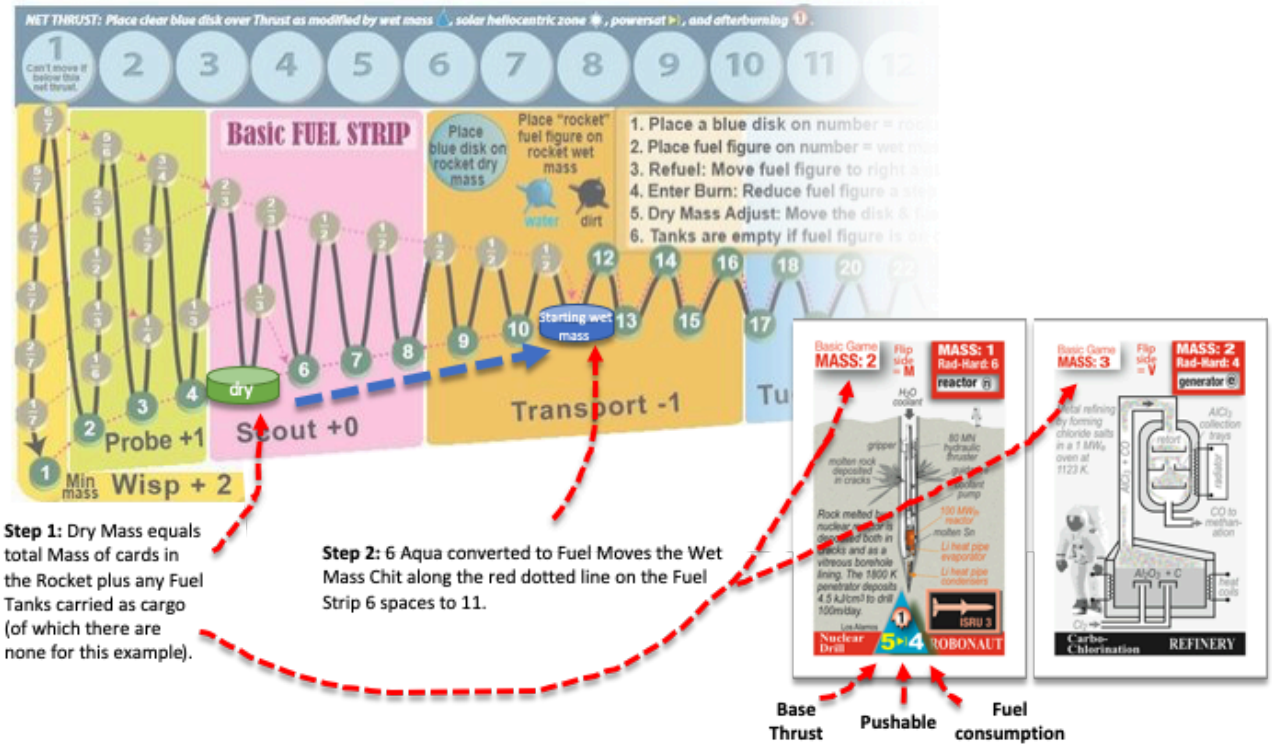


Figure 1

ESA has already placed a Dry Mass Chit on the '5' position of the basic Fuel Strip representing the Rocket's "empty weight" (Fig 1, **Step 1**). She plans to add enough Fuel to get to Low Mars Orbit (LMO)

[14] WEIGHT CLASS MODIFIER simulates the effect of Newton's Second Law of Motion (F=m**a**) on a rocket's acceleration. Higher mass (m) rockets have lower acceleration (**a**) for a given thrust (F), which means it takes longer for them to achieve the required Δv. Slower acceleration results in more time spent in a given Burn Space, resulting in fewer Burns per Turn (which is a fixed amount of time). The adjustment also accounts for gravitational forces during liftoff and landing (a rocket with a thrust lower than the force of gravity -- m**a** is less than m**g** -- will never liftoff, no matter how long the engine runs for). Strictly speaking, the *weight class modifier* represents the impact of mass on acceleration.

and then aims to follow the brown dotted path through the Aerobrake Hazard <<aerobrake icon>> to arsia mons caves.

Let's pause for a moment so you can learn how to use the playmat information to determine how much Fuel is required to make any journey. <<image of playmat showing the intervals and indicating the box that describes how to use them>> On the Fuel Strip, you see numbers in white circles <<illustration>> in-between each of the whole-numbered Mass locations <<illustration>>. These numbers, called **intervals**, show you how many steps of Fuel there are between each of these locations. This helps determine the Fuel needed to attain the proper Wet Mass for a specific journey. Follow this process:

a. Count the number of Burns you need to go from where your Rocket is now to where it needs to be (don't count any Burns that you go through for free).
b. Multiply the number of Burns by the fuel consumption of the thruster you are using. If you plan to do it in stages, then do this for each stage, and then add up the final number. This is the required number of fuel steps you use to make the trip.
c. Starting at the Dry Mass of your Rocket, follow the intervals to the right <<interval icon>>, adding them up until you either reach or exceed the number of steps previously calculated.
d. If the total you've come to is equal to your target number from step 2, then you have now stopped on the Wet Mass you need for your Rocket to make the trip. If the total exceeds your target, follow the black line back to the left a number of steps equal to the difference (this will generally only be 1 step backwards unless you are dealing with very low Mass). Now you've reached the Wet Mass figure you need.
e. From there, add FTs to add to get your Wet Mass up to the target Wet Mass. Each FT added moves your Wet Mass one step right along the red dotted line on the Fuel Strip.

***Example**: Let's say you are planning a journey that requires 5 burns. You are using a Rocket with a thruster that has a fuel consumption of 3. So you need to expend 5 x 3 = 15 steps of Fuel to get where you want to go. Your rocket has a Dry Mass of 3, so you place a Dry Mass chit on the '3' position on the Fuel Strip. Now you follow the intervals, adding them up as you go until you reach or just exceed your target of 15. You end up on the '9' location on the Fuel Strip, having added the intervals until you reached the sum of 16. This is actually one more than you need, but you can't add half tanks so this is now the Wet Mass your Rocket requires to make the journey you want. You could have also done this by actually counting the steps along the black line (try it), and you would have come to the same final required Wet Mass. The intervals just make it easier.*

ESA determines the Wet Mass she needs to make the trip. To get to arsia mons caves, she'll need to make three Burns, as shown in figure 2.[15] Her thruster has a fuel consumption of 4 (figure 2). Multiplying the two, she gets 12. In other words, when her Rocket makes this trip, it will expend 12 steps of fuel using the 3 Burns. Her Rocket has a Dry Mass of 5. Following the intervals on the Fuel Strip from 5, she arrives at the Mass position of '11', 13 intervals from the '5' position (the intervals added are 3+2+2+2+2+2). This is one more than the 12 she needs, so the Wet Mass she will actually need is 10½, but she can't add half a tank of Fuel. She now needs to Fuel her Rocket. <<<IMPORTANT: A Rocket must be in the same location as the FTs to convert FTs to Fuel. In this case both are in LEO. Each Aqua she converts to Fuel moves the Wet Mass Chit (currently sitting blue-side-up on ESA's Dry Mass Chit) one step to the right along the red

[15] BURN SPACES. Why do only Burn Spaces count? Why doesn't every space cost movement points, like every other game? Because the game map was designed using delta-v maps of the solar system, it is a map of energy, not distance. "Delta-V" is shorthand for saying the change of velocity required to go to places in space. For instance, Earth orbits at a speed of 30 km/sec, but Mars orbits slower, only 24 km/sec. So the delta-v between Earth and Mars is at least 6 km/sec. Since each Burn in the game is a delta-v of 2.5 km/sec, one must traverse at least 2 Burns to get to Mars, plus extra to escape Earth.

dotted line (**G1b**). Counting out six steps (Fig 1, **Step 2**), she now has the Wet Mass Chit sitting on the '11' position (which is where she determined she needs it). She's just undertaken a *wet mass adjustment* (**F3**) for which she pays 6 Aquas to the Supply. This is now the Rocket's Wet Mass (the total Mass of ESA's Rocket when it has Fuel in it). ESA has fueled a Rocket!

With a Rocket and Fuel, you are ready to learn about *movement* (**H**), a complex yet procedural process: 1) adjust Dry and Wet Mass, as we saw above; 2) activate a thruster in your Rocket Stack for the Turn; 3) calculate your Rocket's *net thrust;* and 4) move your Rocket until you either decide to or are forced to stop. <<<When you begin carrying cargo such as robonauts and refineries, you will be tempted to build high mass Rockets to carry everything at once. However, it can be better to split your cargo into multiple loads and ferry each load separately - but only if you are able to keep the masses of the Stacks low enough to get multiple Fuel steps from each Aqua.

Net thrust (**H3**) can be affected by a range of factors and is determined in this order: application of *afterburners* (**H3a**), the Rocket's *weight class modifier* (**H3b**), the Heliocentric Zone modifier if you are using a Solar-Powered thruster (**H3c**), and the use of *beamed-power* (**H3d**). The final net thrust determines how many Burns (**H5c**) you can take in your Turn, and where you can land and liftoff (**H6a**). <<<The order of determining *net thrust* is important, because afterburners can reduce Wet Mass and drop the *weight class modifier* of the Rocket as a result.

Some basic principles apply to movement:

a. When you start movement, you can head off in any direction along a route (**H4a**).
b. To enter a Burn Space you must pay the cost in Fuel as determined by your thruster's *fuel consumption* (**B2d**) value. If you can't meet this condition, your Rocket must stop on a Space before the Burn Space.
c. You can stop anywhere except on *lander burns* while en-route (**H4b**).
d. Since you cannot stop on a *lander burn*, you must be able to move to the next Space after the lander burn. If the next Space is a Site, then you must have the means to land.
e. You can turn for free at any Space with an icon (these *free turns* are described in **H4d**), but to turn at a Hohmann requires you to perform two Burns with your Rocket (**H4c**). This is called performing a Pivot. Revisit the graphics in the section of the tutorial that discusses components (**tB**) to remind yourself of what a Hohmann is.
f. However, you may not do U-turns (**H4e**).
g. If you have an activated thruster, you get to *coast* (**H2b**), which is following a route using a negligible amount of Fuel until you need to enter a Burn space.

<<<REMEMBER: Fuel at LEO can be converted back into Aqua as a *free action.*

► **ESA** needs to examine the details of her *thrust triangle* to properly execute movement. She is going to activate the *nuclear drill robonaut* to propel her Rocket Stack. It has a thrust of 5 and a *fuel consumption* of 4 (which means that a single Burn will cost 4 steps of Fuel). It also has a *pushable* icon (), meaning it can receive a +1 to its *net thrust* if supported with *beamed-power* (**H3d**), such as through ESA's special ability. <<<The *beamed-power modifier* is also available if you own a Factory on Mercury, Venus or Io. This doesn't matter in Race to Mars, but it could apply in other RfG scenarios. Lastly, it has an afterburn symbol <<afterburn symbol>> with the number 1 in it allowing for a +1 thrust for the expenditure of one step of Fuel (**H3a**).

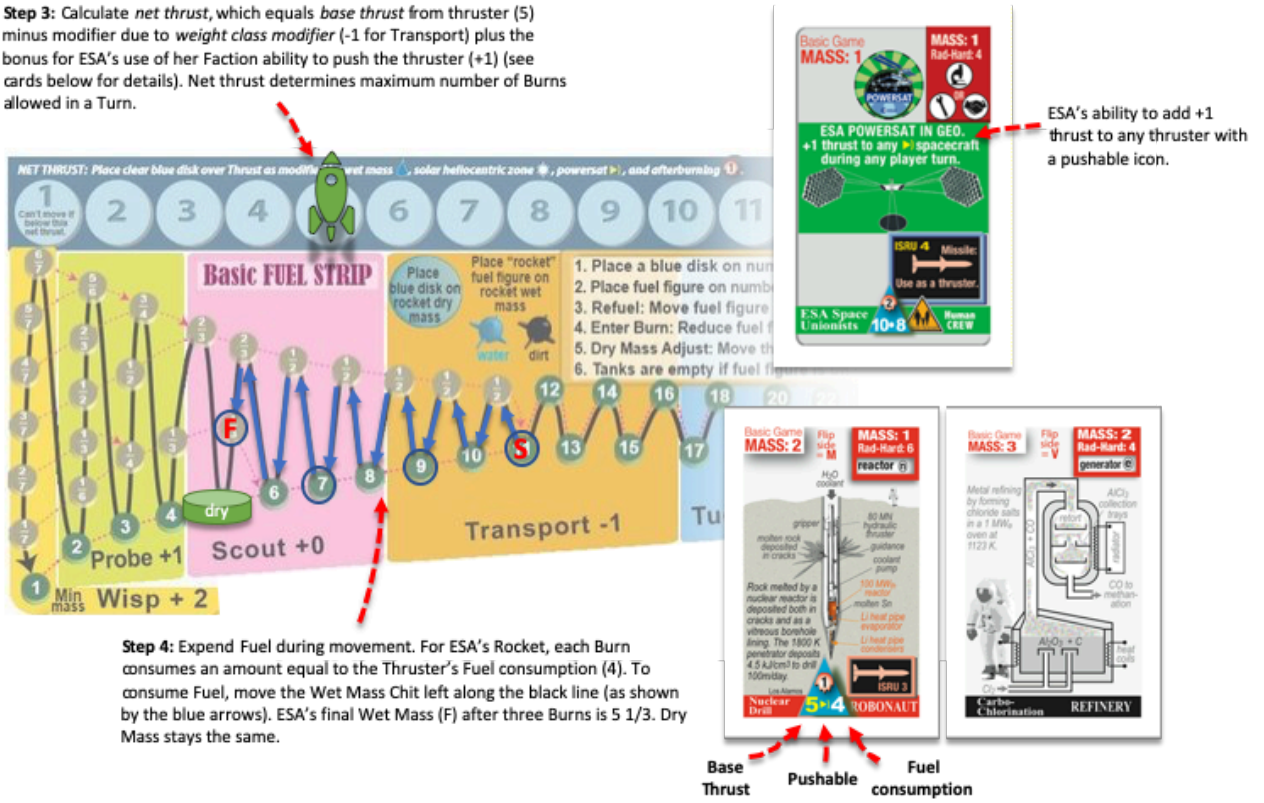


Figure 2

► **ESA** can now calculate the *net thrust* for her Rocket (Fig 2, **Step 3**). Starting with the *base thrust* of 5, she chooses not to use the afterburner. The thrust is reduced by 1 because of the Rocket's *weight class modifier* (**H3b**) (transport class) on the Fuel Strip, taking the thrust to 4. She uses her Faction's special Ability to gain the advantage of the *beamed-power modifier* (**H3d**), pushing the thrust back to 5. Now that the net thrust has been determined, she places her other green Rocket Figure on the net thrust strip at the top of her playmat at the '5' position. This means that she can undertake a maximum of 5 Burns (**H5c**) during this movement, provided she has enough Fuel. Each time a Rocket attempts to move onto (enter) a Burn Space, it expends the number of Fuel steps indicated by the *fuel consumption* number in the *thrust triangle*, in this case 4 (**H5a**). She is going to follow the blue line to Mars. To follow along with her Rocket use Figure 3.

<<map showing each step with lettered arrows indicating the movement, burn count and fuel use for each leg as shown below.>>

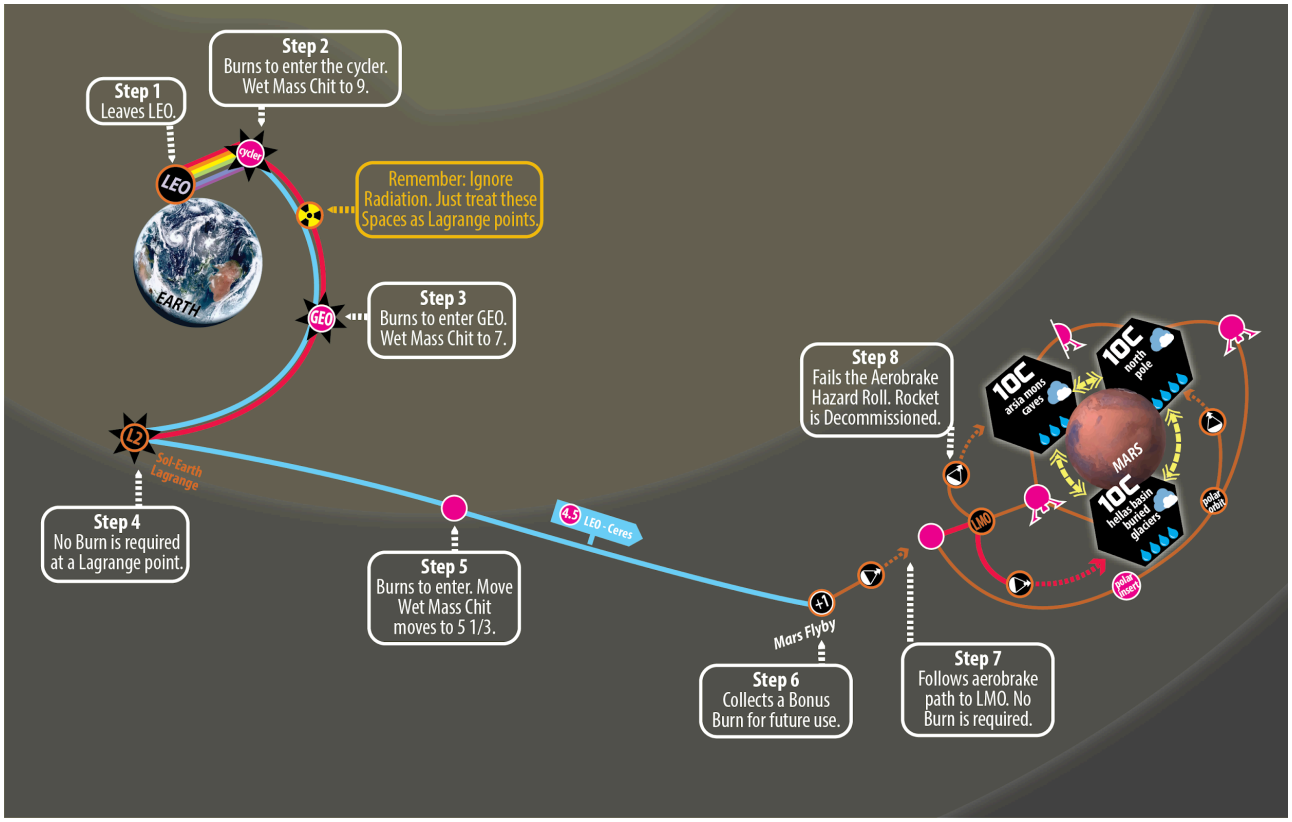


Figure 3

ESA moves her Rocket from LEO (Fig 3, **Step 1**) onto a highly elliptical orbit, the cycler[16] Burn Space (Fig 3, **Step 2**). To enter a Burn Space, she expends the requisite amount of Fuel, moving the Wet Mass Chit on her Fuel Strip 4 steps to the left, following the black line, taking the Wet Mass from 11 to 9 (Fig 2, **Step 4**) (**F3d**).[17] Once through the Burn Space, her Rocket can *coast* (**H4g**) to geostationary Earth orbit (GEO is another Burn Space as indicated by the magenta circle) (Fig 3, **Step 3**). She ignores the Radiation Belt icon, because radiation plays no part in RfG, although the Space still functions as a Lagrange. Again, to enter this location requires a Burn and the Wet Mass Chit is moved four more steps to the left following the black line, to the 7 position (Fig 2, **Step 4**). After GEO, her Rocket can now coast to the L2 Sol-Earth Lagrange, which is not a Burn Space. Recall that a Rocket can leave a Lagrange (any non-magenta circle intersection) along any line (**H4d**). Her Rocket can exit the Lagrange along the blue line (still coasting) (Fig 3, **Step 4**), but would have to stop unless there is enough Fuel to enter the next Burn Space, which

[16] A CYCLER is a transfer orbit that links LEO to other orbits of interest. The cycler Burn Space represents several possible orbits, including the geostationary transfer orbit (GTO) that allows a Spacecraft to move from LEO to geostationary orbit (GEO). Cyclers are typically highly eccentric, an elongated ellipse rather than a circle. The GTO cycler intersects LEO at perigee and GEO at apogee.

[17] FUEL STRIP DECODED. When you add Fuel to your Rocket, you move the Wet Mass Chit along the red line, but when you use Fuel to Burn, you move the Wet Mass Chit along the black line. Why? Because of the rocket equation. Neglecting air resistance and relativity, a fixed change in velocity Δv (which *High Frontier* models as a Burn Space) uses up a fixed fraction of the Wet Mass of the Rocket (M_f). So if you have a Rocket with a Wet Mass of 200,000 kg, and your M_f for a Burn is 0.1, then you will use 20,000 kg of Fuel to enter that Burn Space. If you have a Rocket with a Wet Mass of 100,000 kg, then you only use 10,000 kg of Fuel. Fuel tanks (FTs or Aquas) are fixed amounts of water (40,000 kg). When you add Fuel to your Rocket you do it in fixed amounts of mass, but when you use it you remove a proportional amount. In the example here, a single Burn for a Rocket with a mass of 200,000 kg uses half a FT, but a single Burn for the 100,000 kg Rocket only uses ¼ of a FT. So at low mass, the black line is 'longer' than the dashed red line. Which just proves that the game designer (he doesn't know I've written this) is a genius!

there is (Fig 3, **Step 5**). Another 4 steps of Fuel are expended, taking the Wet Mass Chit down to 5⅓ (Fig 2, **Step 4**).

ESA's Rocket no longer has enough Fuel for further Burns, but it can *coast* provided it doesn't enter any more Burn Spaces. So it coasts again to the *flyby* Space at Mars (Fig 3, **Step 6**). Her Rocket earns a Bonus Burn here (indicated by the +1 on the flyby Space)[18] by using Mars as a gravitational slingshot (**H8**). This would be really useful if she were going farther, but Bonus Burns can't be used to enter *lander burns* (**H5e** and **H8b**). The flyby Space is a Lagrange, so she can choose the direction to exit and selects the dotted *Aerobrake Path* (**B7e**) taking her to the Burn Space just before LMO (Fig 3, **Step 7**). She uses her 4 remaining Aquas to avoid making a Hazard Roll (**H7**) using Failure Is Not An Option (FINAO) (**H7e**) to get to LMO. There is one more Aerobrake Path to pass through to reach arsia mons caves. "No guts no glory", she says as she moves her Rocket onto the aerobrake location and rolls for this final stage of entry (Fig 3, **Step 8**). Disaster strikes when she rolls "1". Her Rocket crashes and explodes!<<<TIP: If you are following a route with multiple Hazards and you only have enough Aqua to deal with some of them, make the Hazard Rolls you have to make first. If things go badly you haven't wasted Aqua. All cards from the Rocket Stack undergo involuntary *Decommission* (**E7**), forcing the cards back to her Hand, the removal of her Rocket Figure, and the loss of all Fuel on-board. She never reaches her planned destination. 'Red Planet or Bust' indeed. <<<TIP: In case you are wondering why the "destroyed" cards return to a player's Hand, remember that these cards are just "ideas" when in Hand and thus wouldn't have been consumed in the explosion. Patented ideas can be employed to build another Rocket.[19]

Notice through the tutorial that there are many paths that can be taken to get from point to point on the *High Frontier* map. So far, we've illustrated the blue route that allows low Mars orbit (LMO) to be reached with three Burns in a single Turn from LEO, but forces your Rocket to risk an Aerobrake Hazard to enter LMO. The more conservative red LEO to Mars route takes more than one Turn if done with only three Burns. It also has fewer Hazards. The colored paths and the signposts provide you with guidance, but in the end the decision is yours to make. <<image showing the multiple routes from LEO to LMO>>

Y11

We are now in Year 11, and CRP and NASA still need funds before they can follow ESA to Mars.

► **CRP** takes an *income operation* to gain 1 Aqua.

► **NASA** uses a *free market operation* to gain 3 Aquas by selling her *blackbody-pumped laser robonaut*.

► **ESA** takes an *income operation* to earn 1 Aqua.

At the end of the year, ESA is pretty much starting from scratch, due to her mishap. NASA is in good shape with the components she needs – a good robonaut, refinery, an efficient thruster (not yet in LEO with the other components) – and plenty of Aquas. CRP is ready to boost everything into LEO and get a Rocket underway.

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[18] FLYBY. Exchanging momentum between a rocket and a planet will increase or decrease the relative speed of both. This maneuver, called a *flyby* in *High Frontier* but also referred to as a *gravitational slingshot* or (more formally) a *gravity-assist maneuver*. It essentially provides free Δv. Voyager conducted a series of gravity-assists to build up the speed necessary to escape the solar system, using Jupiter, Saturn, Uranus and Neptune.

[19] RETURN TO HAND. The XRISM is a remarkable x-ray calorimeter instrument launched by the Japanese Space Agency (JAXA) in 2016. Unfortunately a glitch in the inertial measurement unit of the Hitomi satellite that was carrying the XRISM to spin and fragment. This sent the X-ray telescope "back to the Hand". XRISM is due to be launched by the JAXA H-IIA rocket in January 2022.

Y12

► **CRP** decides to boost the *cat fusion Z-pinch torch robonaut*, and *CVD molding refinery* into LEO, at a cost of 6 Aquas. NASA earns her 1 Aqua.

► **NASA** now has 11 Aquas. She boosts the *metastable helium thruster* into LEO, spending 5 Aquas but getting 1 back. Next, she uses a *cargo transfer free action* (**G1d**) to create a Rocket from her Stack in LEO consisting of the *metastable helium thruster* and the *flywheel tractor robonaut* and, like ESA, she decides not to send the Crew. She also places a white Rocket Figure onto the LEO Space on the map. She has split her payloads, opting not to add the *atomic layer deposition refinery* to the Rocket. This is a valid strategy driven by the cards she has available, but it is not the only possible approach. She might have chosen to wait longer and load more Fuel to send the refinery too.

NASA puts her white Rocket on the LEO Space. NASA's Rocket first must get to LMO, then she can either take the *lander burn* route down to one of the Mars Sites, take the Aerobrake Path and pay for FINAO (see glossary), or take the Aerobrake Path and risk the Hazard Roll. Let's have a closer look at the red route signpost (**B7i**) that marks the route she is using.<<red route signpost>> The signpost tells us that the minimum requirement to get to Mars is three Burns. To travel this route with only 3 Burns would take two full Turns, because there is a Hohmann just beyond L2 where a Rocket either has to stop and wait until the next Turn to leave in a new direction, travel straight through to L5 (which is not helpful to get to Mars), or Burn twice to change direction and keep moving in the current Turn.[20] NASA decides that she can afford to use the extra two Burns to make a Hohmann Pivot if she can make sure there is enough *net thrust* and Fuel to get all the way to Mars in one move. <<<TIP: Signposts always show the minimum number of Burns required. They aren't always the fastest route, but they are generally economical.

NASA needs five Burns to get to Mars along the red route: one at the cycler and then another at GEO, two to make the Hohmann Pivot, and one to reach LMO (Fig 4). In addition, to make five Burns in one move, her Rocket needs a *net thrust* of at least 5 (**H5c**). Her Rocket has a Dry Mass of 7 due to the Masses of the thruster and the robonaut. The *metastable helium thruster* is very fuel efficient (fuel consumption=1) and has a *base thrust* of 5. Using the interval method, she multiplies the number of Burns needed by her rocket's fuel consumption, getting 5. Adding intervals from a Dry Mass of 7, she ends up with a required Wet Mass of 10 (actually 9½, but 10 suits here, providing one extra step above what she actually needs) She adds 3 Aquas of Fuel, adding to the Rocket's Dry Mass of 7 to get to a Wet Mass of 10. She puts a Dry Mass Chit on the '7' space on the Fuel Strip, and a blue Wet Mass Chit on the '10' space. Her Rocket's base thrust is 5. She uses her Rocket's afterburner to add 1, increasing it to 6. This costs 1 step of Fuel, dropping her Rocket's Wet Mass to 9 ½ (the extra step she added was important after all). Her Rocket's final net thrust is 5 because of the -1 modifier for being in the 'transport' weight class. She places her other white Rocket on the '5' space on the net thrust track. <<image showing NASA Rocket's map movement and associated fuel track for each movement step for the whole NASA move this turn>>

From LEO, **NASA** spends 1 Fuel step to enter the Burn Space at the cycler, moving the Wet Mass Chit to 9, then another at GEO (Wet Mass Chit to 8½) before turning at the Hohmann just beyond L2 at the cost of two Burns, using two more steps of Fuel, to take the Rocket's Wet Mass to 7½. The Rocket can turn freely at the next Lagrange (Sol-Mars Lagrange L2), and make a final Burn (the fifth of this move and

[20] IF HOHMANNS were always the minimum energy route, the map would be pure spirals. But this ignores the effects of gravity at the embarkation and destination planets. Lower energy routes wind between the Lagrange Points, which are unstable gateways to highly perturbative, chaotic trajectories to all other Lagrange Points in the solar system. These routes, called the Interplanetary Transport Network, require almost no Fuel, but they are glacially slow. Additionally, launch windows are sometimes decades or even centuries apart.

therefore the last) to enter the Burn Space near LMO, (move the Wet Mass Chit one more step along the black line to 7), and then *coast* to LMO. From here, her Rocket can't reach Mars using a *lander burn* because the *net thrust* is not higher than the Site Size of 10 (**H6a**), she has no Fuel left, and she has used her maximum allotted Burns for the move. <<<TIP: *Lander burns* can be found at all Sites of Size 6 or greater. Lander burns on Sites of Size 6 are *half lander burns*, requiring only half the Fuel. Sites of Size 5 or less have weak enough gravity so as not to require a Burn to land. She has planned for this and simply follows the *Aerobrake Path* to touch down on arsia mons caves. She spends her final 4 Aquas (FINAO) to ensure a safe landing. NASA is the first Faction to make it to Mars! <<<TIP: How are Aquas earned in LEO used to pay for FINAO moves occurring millions upon millions of miles from Earth? "Money" is used on Earth to pay for the expertise, software updates, modeling, tracking and other technologies that guide the Rocket safely through the Hazard.

► **ESA** is left to lament her poor luck. She conducts a *research auction operation*, which she wins uncontested, picking up the *magma electrolysis refinery*.

In the end, each movement is a series of questions balanced against the physical properties of your Rocket, your specific thruster, your destination and route. To avoid getting stranded, ask yourself: How many Burns will it take? Is there a route that might take longer but requires less Fuel? What is the Size of my target Site? Do I have a means to land there, using aerobrake (for Sites with an atmosphere) or a *powered lander burn*? Will I be able to takeoff again? Am I going to be able to refuel at the Site? Can I use a more efficient thruster for some of the journey and then switch to a less efficient thruster later on when I need to land?

	2	0	1
	02		15 26 29
	Cr 05 14 27	Cr 25	Cr
		01 16	
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tE2. Years 13-16 Prospect Operations & Outposts

You've learned a lot. In addition, you've been diligent in moving the Sunspot Cube, so now it should be back on the start space of the Sunspot Cycle, right? And you've removed a Seniority Disk too, right, because whenever the Sunspot Cube passes the *seniority threshold*, a Seniority Disk must be removed? Good. If not, go ahead and do those things now.<<image showing current position of the sunspot cube, just past the seniority threshold, and the seniority disk being removed>>

Y13

► **CRP** desperately needs funds, so he immediately takes a *research auction* to pick up the *photon kite sail thruster* for 0 Aquas as nobody else bid.

► **NASA** is on Mars. Now it's time to put martian resources to good use by staking a Claim, which will earn her victory points, and then exploiting it. First, she uses the *cargo transfer action* to *jettison* (**G1g**), which is a voluntary *Decommission* (**E7**), the *metastable helium thruster* back to her Hand because she can't bring it back any other way (its thrust is too low to escape Mars' gravitational pull). To account for the lost Mass, we move both the Dry and Wet Mass Chits five spaces to the left along the red dotted line on the Fuel Strip to the '2' space. She then converts the Rocket Stack into an outpost on Mars using another *cargo transfer free action* (**G1e**), swapping what's left of her Rocket Stack for an Outpost Stack, removing the Rocket Figure from arsia mons caves and replacing it with an outpost marker. These basic *free actions* are all examples of cargo transfers, and they are really useful for swapping Stacks, creating Stacks, moving cards between Stacks and returning cards to your Hand. We place the *flywheel tractor robonaut*

into the outpost #1 position on her playmat. <<<You can only ever have two outposts in play at the end of your Turn. If you have more, you must *Decommission* the excess until only two remain.

Now **NASA** uses her one Operation this Turn to undertake a *prospect operation* **(I6)**. To prospect, she needs a Stack on the Site being prospected (**I6.1**) containing a card with an in-situ research unit (ISRU)[21] rating equal to or less than the Hydration level of the Site (**I6.2**). Then she must roll the Site's Size number or less on 1d6 (unmodified) (**I6.3**). If successful, a Claim, represented by a disk of her Faction's color (**I6.4**), is placed. If not, a translucent red disk is placed marking the Site as a Busted Site (**I6.5**). Once Busted, a Site can never be prospected again.

NASA's *flywheel tractor robonaut* has an ISRU of 3 (equal to the Hydration level of the Site) and a special prospecting capability, a buggy (see **I6a-c** for rules on the various types of prospecting platforms). The buggy allows the robonaut to prospect one Site twice **or** any number Adjacent Sites once each if they are connected by a buggy road (yellow dashed lines). She can't fail to roll equal to or less than the Site's Size (10) on a 1d6, so instead she prospects arsia mons caves and the two Adjacent Sites, hellas basin buried glaciers and north pole. She automatically succeeds on all three and stakes her first Claims, placing white disks on all three Sites. Way to go NASA! Her plan now is to leave the robonaut behind on Mars on the outpost and transport a refinery to Mars to allow her to undertake an *industrialize operation* (**I7**) later in the game. <<<Buggy and raygun prospectors have distinct advantages. You've already seen the utility of buggy prospectors. Raygun prospectors allow prospecting from orbit, provided the Site doesn't have an atmosphere. As an example, a raygun prospector with an ISRU rating of 3 could prospect ceres, minerva, and aegis moonlet from any SIte, or from orbit, in the Gefion system (located next to Mars).
<<insert image of raygun, buggy and missile prospecting icons, and text explaining the differences, and then show three claims disks being placed on the three Mars sites due to the buggy icon on the flywheel tractor robonaut card>>

► **ESA**, like CRP, needs funds, and free markets the *magma electrolysis refinery* for 3 Aquas.

NASA's Claim of all three Sites is a potentially game-winning play, unless the other players can find ways to reverse the damage. ESA and CRP have ideas for how they might do that, as you'll soon find out.

Y14

► **CRP** *Decommissions* two cards in LEO to his Hand (the *CVD molding refinery* and the *cat fusion z-pinch robonaut*) and free markets the refinery for 3 Aquas.<<<TIP: CRP is being undone by indecision here. In Y12, he boosted these two cards and now he is *Decommissioning* them. It will take time to really understand this game, but having a clear plan in mind will prevent wasting Turns.>>>

► **NASA** puts the top card of the thruster deck up for auction (the *photon heliogyro thruster)* and earns 1 Aqua from the CRP player's winning bid.

► **ESA** takes an *income operation* for 1 Aqua.

Y15

► **CRP** sells the other patent in his Hand, the *cat fusion Z-pinch torch robonaut*, for another 3 Aquas.

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[21] WELL WATER can be extracted from the icy core of a small world by injecting steam into a wellhole. Water extraction from an anhydrous world, with water in the form of hydrated silicates or as tiny ice crystals in the regolith, is more challenging. Crushed matter is sealed in a vessel and heated to 700K with steam at 1 atm pressure. The vapor is removed, and cooled to 280K to separate solids and gases. The liquid water (some of which is recycled to the first step) is outgassed briefly in a vacuum to remove dissolved gases, and placed in storage. Assuming 4% water content in 70% of the top 2 meters of regolith, four tons of regolith must be scavenged to obtain 120 kg/day of water. In one year, a single game water tank is extracted from an excavated volume of about 1100 m^3 (about 24 X 24 meters X 2 meters deep). —Lewis *et al., Resources of Near-Earth Space*, 1993.

► **NASA** takes an *income operation* for 1 Aqua.

►**ESA** auctions the *tungsten resistojet robonaut*, winning it in a tie with NASA for 1 Aqua, and then she pays 1 Aqua to the pool.

Y16

► **CRP** sells the *photon kite sail thruster* in his Hand to earn the funds that he hopes will get his taikonauts safely to Mars. <<<TIP: For a round trip to Mars, the *photon kite sail* is of little use, because it has zero thrust and relies on solar radiation, which will diminish as Mars is approached. With a Sail's very low thrust, any Rocket with a weight class of 'transport' or greater will likely have a net zero thrust or lower. This means Sails are limited in the mass of cargo they can move at any one time. But they can be *Decommissioned* and cheaply boosted again to save on return trips. He doesn't see any legitimate chance of industrializing Mars at this stage of the game, but he is making a play for the Mars *glory* (**B3** and C7), which is worth potentially up to 2 victory points. He takes a *free action* to create a Rocket with the *Re solar moth thruster* and the CRP Crew. He places his Rocket Figure on the LEO Space and stacks a Wet and Dry Mass Chit on the '1' space on the Fuel Strip.

	10	2	4
	02 07	01 22	15 21 26 30
		Cr 25	Cr
	Cr 05		
		16	
	08	23	31

► **NASA** auctions, and wins for 0 Aquas, the *solar-pumped MHD exciplex laser robonaut*.

► **ESA** sees the wisdom in NASA's move and does the same, picking up the *basalt fiber spinning refinery* in an auction, also for no cost.

tE3. Year 17 Negotiation

Y17

► **CRP** free markets the *hall effect thruster* he has in Hand for 3 Aquas. He converts 8 Aquas to Fuel for his Rocket, taking the Wet Mass of the Rocket to 9 (**G1b**). Calculating the *net thrust*, he ends up with 2 (*base thrust* 3 from the *Re solar moth thruster* and -1 for transport class), which isn't great but is enough to make the journey. <<<TIP: There are two other factors that could have increased the *net thrust:* afterburn and the Heliocentric Zone modifier indicated by the ☀ on the *thrust triangle*. However, CRP chose not to use the afterburn, and the Heliocentric Zone modifier for Earth is zero. Nonetheless, it is important to realize such modifiers exist when calculating net thrust, particularly in other parts of the solar system where the Heliocentric Zone modifier is not zero.

CRP decides to follow the blue LEO-Ceres route, one of several possible routes he can use to get to Mars. He will need a *net thrust* of at least 3 for his Rocket if he wants to make it to LMO in one move. He decides to *negotiate* (**N**) with ESA to take advantage of ESA's special faction ability (**N4a**) to add an extra point of thrust to a *pushable* (**H3d**) thruster. The ESA player needs funds to have any hope of making it to Mars herself, and is open to cooperating if CRP gives up his *photon heliogyro thruster*. <<<The *academia hand limit* prevents players with four or more cards in Hand from initiating or participating in an auction, but doesn't prevent players from obtaining cards any other way, such as through *negotiation*. This would allow ESA to make a quick 3 Aquas on her Turn. CRP wants to get to Mars this Turn and also have enough Fuel to get back, so he too needs Aquas. Countering, he asks for 1 Aqua from ESA for the patent. ESA "counters the counter" by mentioning that she thinks that NASA is winning the game and it would help if CRP would leave the north pole Site on Mars alone for ESA to later claim, assuming CRP is willing to help with a little corporate espionage (you'll understand what this is about later). CRP agrees. <<< Be very careful if your *negotiation* includes

conditions that extend into future Turns. In our example, CRP is under no obligation to honor his promise to ESA that he would leave the north pole alone after the Turn in which the negotiation was conducted.

The *negotiation* ends positively. **CRP** transfers the thruster from his Hand to ESA's (**N2**) and ESA hands over one Aqua (**N1**). Transfer can't be done during movement or in the middle of an Operation or *free action*, but that isn't a problem here. ESA honors the agreement and CRP's Rocket ends up with a *net thrust* of 3 using ESA's assistance. His Rocket moves to the cycler, GEO and then via L2 to the *flyby* at Mars, where he uses the Aerobrake Path and pays 4 Aquas to safely get his Rocket to LMO. His Rocket now has a Wet Mass of 4.[22] He can't make any more Burns this Turn anyway, having made three Burns and hitting the limit set by his Rocket's net thrust of 3. But regardless, to do a *powered landing* on Mars he needs to switch thrusters, and that can't be done mid-move. <<<The *Re Solar Moth thruster* consumes 4 steps of Fuel per Burn and there were three Burns. Moving along the black Fuel Strip line, three Burns at four steps per Burn, takes the Wet Mass Chit from 9 to 4.

► **NASA** needs funds but she also needs the two patents she currently has in her Hand for what she has in mind. She needs to get to Mars to turn those Claims into Factories if at all possible (**I7**) and to protect her Claims from Felonies committed by CRP, but each *industrialize operation* requires Decommissioning a refinery and a robonaut. She has one robonaut in place on outpost #1 already, but no refinery, and to industrialize all 3 Claims will be expensive and take time. She wants something to sell on the free market so she auctions the *free-electron laser robonaut.* Nobody is interested so she gets the patent for free.

► **ESA**, frustrated by her earlier disaster and current lack of progress, sells the *photon heliogyro thruster* for 3 Aquas.

	2	2	6
		01 22 23	15 21 26 30
		Cr 25	Cr
	Cr 05		
		16	
	08	24	31

tE4. Years 18-19 Claim Jumps & Site Refuel Operations

CRP is now in an enviable position, with a Rocket almost to Mars carrying a Crew. Nobody expects CRP to build a Factory but NASA is nervous about losing a Claim. There is also a *glory chit* at stake and it looks increasingly likely that CRP will get it.

Y18

► First off, **CRP** takes an *income operation* for 1 Aqua. It's now time for his Rocket to make its final approach. The Dry Mass remains 1 (Crew + *solar moth*) and the Wet Mass is 4. Sticking to his agreement with ESA, the CRP player intends to land the Rocket on the hellas basin buried glaciers Site. This requires a *net thrust* of 11 (greater than the Site's Size, as per **H6a**), so he activates the Crew's thruster with 14 thrust and *fuel consumption* of 9. The Rocket's net thrust with Wet Mass of 4 is actually 15 (probe class), satisfying the minimum net thrust requirement to land on Mars with the Site Size of 10. The final *lander burn* (**H5e**) costs 9 fuel steps, leaving the Rocket with a Wet Mass of 2 ⅛ . China is the first nation to land a human mission in the Mars Heliocentric Zone, and the West is in an uproar! Now the CRP player can use his Faction's special Ability to steal NASA's Claim (**G4**). He also takes the *glory chit* for this Heliocentric Zone because he has managed to land a human Crew, placing its low value side up on his

[22] ROCKET EQUATION. The game evaluates a Rocket's Wet Mass at the beginning of a year's turn, and this mass is assumed to be constant the whole year. In reality, a Rocket's Wet Mass continuously changes as it burns fuel, and the rocket equation must be used to accurately obtain the delta-v accomplished over the year. This game simplification allows the players to move Rockets without resorting to differential equations or calculus.

Rocket Stack. That chit is worth 1 victory point but, if it is returned to LEO with the Crew intact, is worth 2 victory points (**M2b**). <<< Always be aware of threats to your strategy. The CRP Faction has a special Ability allowing Felonies and one such Felony is to jump someone else's Claim.

CRP commits the *Claim Jump* Felony (**G4**), a *free action*. He plants the Chinese flag firmly on NASA's Claim on hellas basin buried glaciers, removing the US flag and replacing NASA's white Claim disk with a purple Claim disk. Claim Jumps can only be committed by a Faction with the Felony Faction privilege and only with a human Crew on the Site being jumped. It can't be done if a Human opposed to the Claim Jump is present on the Claim, if the Claim is Colocated with a Factory, or if the Faction committing the Felony has run out of Claim disks (**G4a**). <<image showing CRP Rocket, and a white claim disk being removed to be replaced by a red claim disk. Image next to it showing that the move is not legal if an opposing human is present, such as a colony or a Rocket with Crew>>

► Frustrated, **NASA** can only keep pushing to industrialize her last remaining Claims on arsia mons caves and the north pole, and that requires more funds than she currently has. NASA free markets the *free electron laser robonaut* for 3 Aquas.

► Finally, **ESA** sells the *basalt fiber spinning refinery* for 3 Aquas on the free market.

Y19

The *site refuel operation* (**I5**) is a method to generate water-based FTs from a Site. If the Site contains a Factory (that is, it is an industrialized Site) it will generate 7 water FTs per Operation (**I5b**), but without a Factory the amount of water FTs generated at a Site is equal to 1 plus Site Hydration minus the ISRU value of the operational card (**I5a**). <<<Sites are typically drier the closer they are to the sun. Dirt fueled Rockets have a significant advantage as they can refuel at any Site hex, Hydration does not matter. Low mass Rockets are quicker to refuel en route because they get multiple Fuel steps per Aqua of Fuel while their Wet Mass remains low. It is possible to ISRU refuel even if the Site is Busted or contains someone else's Factory (**I5a**), but a *factory-refuel operation* (**I5b**) can only be done using another Faction's Factory if committing a Felony or if allowed by the other Faction (**N7**). An alternative to the *refueling operation*, which produces water-based FTs, is to use the *cargo transfer free action* to *dirt refuel* (**G1c**). This is only useful for dirt thrusters, and only a few of them exist in the RfG game. <<<Remember: adding Fuel changes the Rocket's Wet Mass, and to do so, you move the Wet Mass Chit along the red dotted line to the right. Adding water-based Fuel to a dirt thruster (a gray *thrust triangle*) is useful, but adding Dirt Fuel to a water thruster is of little value. A thruster can not be activated, Burn or afterburn, if the Fuel it carries is of a lower grade than the thruster itself (**F4c**). If you mix different Fuel grades, you always treat that Fuel as the lowest grade (using the appropriately colored Wet Mass Chit (**F4d**).

► **CRP** begins his refueling Operations. He has no Factory at this Site, so he can't undertake a *factory-refuel op* to gain 7 FTs. Instead, he undertakes ISRU refueling. The operational card he is using is his Crew, which has an ISRU rating of 4. The Site has Hydration 4, meaning each *site refuel operation* (**I5a**) generates one water FT (1 + 4(Site Hydration) - 4(ISRU value of operational card) = 1). CRP immediately discards this newly generated FT in order to add Fuel to his Rocket, moving the Wet Mass Chit 1 step to the right following the red line to 3 ¼ . <<<TIP: We are adding Fuel in this example but if you ever had to subtract whole units of Mass from a Rocket (such as through a *FT to Fuel free action,* (**G2a**), always adjust the Mass along the red line taking the lower option if presented with a choice. For example, the correct placement is from 4 ⅔ to 3 ½ on the fuel strip, not 4 ⅔ to 3 ¾.
<<<REMEMBER: You can use the interval method to calculate the Fuel you need, but we haven't bothered showing the process here since you've seen it twice already. But try it for yourself anyway, and see if you end up with the right Wet Mass for the trip.

3	5	9
	01 22 31	08 15 21 26
	Cr 25	Cr
Cr 05		
	16	
09	24	32

► **NASA** auctions the *electroforming refinery* and gains it for free.

► **ESA** auctions the *monatomic plug nozzle thruster* and also wins it for free.

tF. Pale Blue Dot

We are now in the final phase of the tutorial, where you'll learn about how to build a Factory, establish a Colony and manufacture extraterrestrial products for sale or further exploration. You'll also see the end game process and how scoring works.

tF1. Years 20-23

Y20

► **CRP** performs another *site refuel operation*, converting a second FT to Fuel on-board his Rocket, resulting in a Wet Mass for the Rocket of 4⅓. He now has enough Fuel to get the Rocket back home. Using the Crew thruster and the +1 thrust (probe class), CRP's Rocket has a *net thrust* of 15, which is enough for a *powered liftoff* from a Size 10 Site (**H6a**). <<<"Ant-Lion Traps": don't make the mistake of thinking you can take off from any Site you land on - the additional Fuel needed for the return trip may increase the Rocket's *weight class modifier* to the point where you have insufficient thrust. You can often avoid paying for a return trip by *Decommissioning* your thruster and boosting it again - noting that this may strand your Crew.

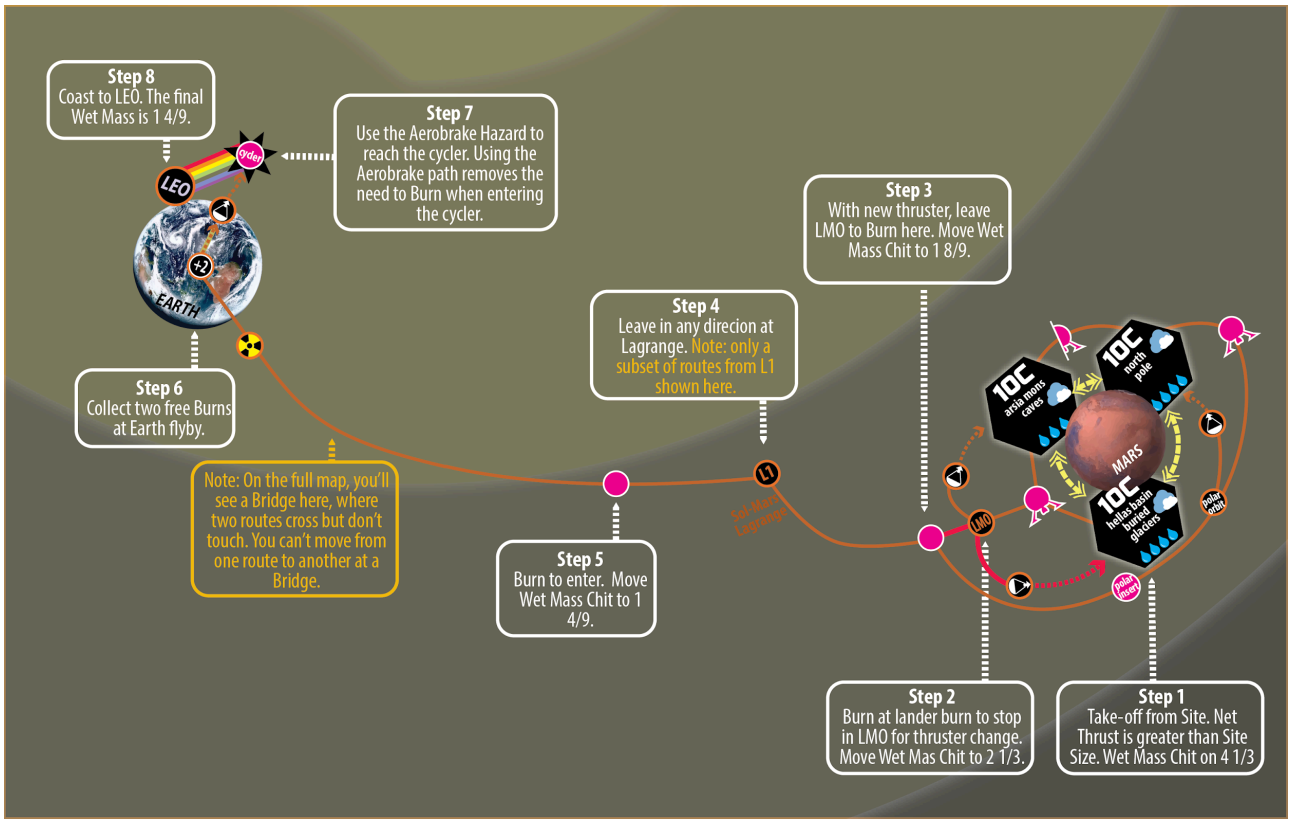

Figure 5

CRP launches from Mars (Fig 5, **Step 1**). His Rocket Burns at the *lander burn* (**H5e**), dropping the Rocket's Wet Mass by 9 steps along the black line from 4⅓ to 2⅓ and then stops at LMO so that in his next Turn he can switch to a more efficient thruster for the rest of the journey (Fig 5, **Step 2**). <<<On Sites Size 6 or smaller, a Factory can provide an assist to a Rocket's launch, with some risk as represented by the need to make a Hazard Roll. Keep this in mind when you are thinking about whether or not to land a Rocket with a low thrust on a Site.

► **NASA** has one last shot at winning this game: get back to Mars and build a Factory by the end of Year 25. To do that, she boosts the *metastable helium thruster* into LEO, which costs 5 Aquas, but again gets the 1 Aqua bonus for her Faction's special Ability.

► **ESA** also sees staking a Claim and building a Factory as the only way to win, and to do that she has to get to Mars quickly and convince CRP to help her Claim Jump one of NASA's two remaining Claims. She is going to use the same strategy she tried the first time to get to Mars, but she is hoping for better results. She boosts the *nuclear drill robonaut* and *carbochlorination refinery* to LEO for 5 Aquas, earning NASA another 1 Aqua for the boost, and then she creates a Rocket Stack without the Crew, placing a Dry Mass Chit on '5'**.** She then uses a *cargo transfer* to fuel the Rocket (consuming her remaining 4 Aquas), which now has a Wet Mass of 9. Unfortunately, this is not yet enough Fuel to take a shot at Mars.

Y21

► **CRP** takes an *income operation* to grab that all-important fourth Aqua for a possible future FINAO exception. Then he completes his Rocket's move to LEO. Switching to the *Re solar moth thruster*, the *net thrust* is 3 (base 3, +1 for probe class, -1 for Heliocentric Zone modifier for Mars). The moth's fuel consumption = 4. Leaving LMO (Fig 5, **Step 3**), he does a Burn to reach L1 (Fig 5, **Step 4**), and then another Burn (Fig 5, **Step 5**) before passing over the *bridge* (**B7b**) (Fig 5, **Step 6**), through the Radiation Belt (that we can again ignore in the RfG scenarios) to reach the Earth *flyby* space (Fig 5, **Step 7**), where he picks up two *Bonus Burns* (**H8b**) (although he only needs one). Now the Rocket's Wet Mass is 1 ⅓ . No more Burns are required because he gained 2 Bonus Burns in the Earth flyby to reach the cycler (Fig 5, **Steps 8,9**). Paying 4 Aquas to use FINAO to avoid the Aerobrake Hazard Roll, the Rocket passes the cycler and settles in LEO (Fig 5, **Step 10**).

CRP is the first to send a human Crew to Mars and then bring them back, earning 2 victory points for the *glory chit.* Bravo! He places the chit in LEO high value side up and his taikonauts are heralded as heroes! <<<STRATEGY: A good player is aware of all opportunities to gain points. Always keep *glories* in mind because they just might provide the extra victory points needed to put you on top in the end!

NASA and ESA are racing against the clock to finish their planned strategies. Both will be sending desperate unmanned missions to Mars.

► **NASA** free markets the *electroforming refinery* for 3 Aquas.

► ESA free markets the *monatomic plug nozzle thruster* in her hand for 3 Aquas and then immediately transfers the Aquas to the Rocket (**G1b**), moving the Wet Mass Chit to 12, following the red line.

Y22

► **CRP** is satisfied with his achievement, but it is probably not enough to win. Now he needs to think about what else he might possibly do. One option is to try another mission to Mars, and maybe build a Factory, but that requires getting a refinery and a robonaut there, and that will take funds and time. For now, he takes an *income operation* for 1 Aqua to start building up funds to bargain with.

► **NASA** needs funds, so she takes an *income operation* for 1 Aqua in preparation for getting back to Mars. She doesn't want to free market the card she has in her Hand because it is going to become useful for an *ET production operation* (**I8**).

► **ESA** sells the *tungsten resistojet robonaut* on the free market for 3 Aquas this Turn. Time to get underway! ESA uses 2 more Aquas to take her Rocket's Wet Mass to 14 (enough for four full Burns). ESA's Rocket has a *base thrust* of 5, again transport class deducts 1 from the *net thrust* calculation but her Faction privilege moves it back to a net thrust of 5. ESA follows the blue route and makes Burns at the cycler, GEO, and then at the Burn directly after L2, then *coasts* to the Mars flyby. From there, with the Wet Mass Chit now at 6½, ESA takes the Aerobrake Path, rolling a 5 for the Hazard Roll. Turning 'right' before LMO, she expends her remaining Fuel to enter the polar insertion burn,[23] moving the Wet Mass Chit for her Rocket from 6 ½ to 5. With no more Fuel, her only option is to follow the Aerobrake Path to the martian north pole. She could stop her Rocket here and wait until she has accumulated enough Aquas to pay for FINAO, but she decides to risk it, aware that the game could end very soon. She rolls for the Aerobrake Hazard, where she is favored with a result of "6". Her Rocket touches down on Mars; the game abruptly shifting in her favor. <<<TIP: Take winning risks. A strategy with a slight degree of risk is more likely to be successful.

Y23

► **CRP** research auctions the *phase-locked diode laser robonaut*, but ESA sees a real opportunity here, and tries to get in on the auction bidding her 1 remaining Aqua. NASA's hand is forced and she commits 2 Aquas to outbid her emerging rival. <<<The *neutral beam robonaut* has been revealed beneath, as we have finally cycled through one of the patent decks. ESA is frustrated, NASA is relieved, and CRP gains 2 Aquas from the auction. <<<***The phase-locked diode laser robonaut*** is a Spectral Type **C** card, which makes it valuable in terms of victory points and that is why ESA wanted it. This late game auction might very well be the deciding factor. It is one of those cases where the auction is focused on preventing another player from securing a valuable card. Now NASA has two Spectral Type **C** cards in her possession and ESA has none. Viewed in this light, the cost to NASA is immaterial.

► **NASA** commits to returning to Mars this Turn, but she knows it will take two Turns to get there unless she decides to take risks, and that isn't in her nature. She takes a *cargo transfer free action* to turn her LEO Stack into a Rocket this time with the Crew. The Dry Mass Chit is on 9 on the Fuel Strip. She takes another cargo transfer to convert 2 of her Aquas to Fuel, moving the Wet Mass Chit to 11 (following the red line) and sees that her Rocket is in the 'transport' weight class. She decides to move using the *metastable helium thruster*, which is very efficient with a *base thrust* of 5 and a *fuel consumption* of only 1. She chooses not to afterburn so after accounting for her Rocket's weight class, her final *net thrust* is 4.

NASA's Rocket can now move. With a *net thrust* of 4, it can undertake up to four Burns this Turn. She takes the red route to Mars. Leaving LEO, she Burns at the cycler and GEO, *coasts* through L2 and then stops at the Hohmann. Her Rocket's Wet Mass Chit is now at 10. She could have gone farther, but she would have run out of Fuel before reaching Mars because of the required double Burn to pivot at the Hohmann.

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[23] A POLAR ORBIT allows an orbiting body to travel over the poles of a planetary body rather than around the equator. Entering a polar orbit from an equatorial orbit such as LMO requires a lot of energy. The Δv to undergo a direct inclination change (Δi) from one circular orbit to another while maintaining the same orbital speed is equal to $2v.\sin(\theta/2)$. So, to go from equatorial LMO (i=0°) to a polar orbit around Mars (i=66°) requires a $\Delta v=2x3.5x\sin(33°)$, or approximately 3.8 km/s – about 1.5 burns in *High Frontier*.

Looking ahead to her next Turn, **NASA** knows that once she reaches LMO, she won't have enough funds to safely traverse the Aerobrake Path down to her Claim Site on arsia mons caves, meaning she would have to roll for the Hazard. To gain those funds, she free markets the newly obtained *phase-locked diode laser robonaut*, gaining 3 Aquas.

► **ESA** turns to the CRP player, and opens up a second round of *negotiation.* The only shot she has at winning or even competing with NASA is to work with CRP to jump NASA's Claim on the martian north pole. She asks straight up for CRP's help. The CRP player is well behind the other players and can't see a way to win, but he wasn't impressed with NASA claiming all three Sites first up, so he decides to help ESA at the cost of just 1 Aqua as a goodwill gesture. Using CRP's *negotiated* Faction privilege (**N4**), ESA can therefore *Claim Jump* NASA's Claim on the north pole. One moment the Claim disk is white, the next it is green. This Claim Jump now provides another advantage. Instead of using her one Operation to prospect, ESA can now immediately industrialize the Site.
*<<<**Apologia**. After the game was over, it was realized that claim jump is a Felony that requires a Human, and there is no Human in ESA's Rocket.*

To undertake an *industrialize operation* (**I7**) **ESA** needs a robonaut and a refinery Colocated with her Claim, and she has both. With all the necessary requirements, ESA uses an *industrialize operation* to build a Factory on the martian north pole, *Decommissioning* her robonaut and refinery to her Hand.
<<<Thematically, *Decommissioning* represents everything from repurposing technology to building a Factory on another world to losing your hardware in a mishap. But ideas never die, and so patent cards go back into your Hand to be sold on the free market or used again and the Crew card returns to LEO, representing another Crew ready to go. A space Factory has been born! She places a small green cube on her Claim with a sense of real satisfaction. This Factory has been built on a Spectral Type **C** Site, so now we move the blue bead on the **C** column of the Exploitation Track from its starting position to the 8 VP position (**I7d**). Only one Factory can exist on any given Site (**I7b**) and the Spectral Type of the Factory becomes the Spectral Type of the Site it is on (**I7c**). <<< Factories have a victory point value that goes down as the number of Factories of that Spectral Type increases. You might want to break another player's monopoly by building Factories of your own. Conversely, concentrate on neglected Spectral Type Sites as opportunities to improve your score.

4	5	0
	22	15 26
Cr 05		Cr
	Cr 01 25	
	16	
09	13	32

What a turn around for the unlucky ESA player, with a little help from her partner in crime CRP! NASA is frustrated and plots revenge for the next game of *High Frontier.*

tF2. Year 24 Industrialize Operations & Colonizing

Y24
The Factions are all trying for some final victory points.

► **CRP** doesn't expect to win, but he auctions the *neutral beam robonaut* anyway, trying to build a Hand. He wins the patent for nothing. Deep down, he feels a certain satisfaction at deflating NASA.

► **NASA** can now complete her Rocket's move to Mars. Her Rocket currently has a Wet Mass of 10 and a *net thrust* of 4. She has more than enough Fuel. From the Hohmann, her Rocket *coasts* directly to the L2 Lagrange, and then through the final Burn (reducing her Rocket's Wet Mass to 9½) before passing LMO

onto the Aerobrake Path. She errs on the side of caution once again and spends the 4 Aquas to use FINAO, landing her Rocket on arsia mons caves.

NASA then undertakes an *industrialize operation* (**I7**) by *Decommissioning* the robonaut in outpost #1 and the Colocated refinery in her newly arrived Rocket. She takes a small cube from her pile and places it on her Claim, and removes the outpost marker. This is the second Factory on a Spectral Type C Site, and so she adjusts the blue bead on the **C** Exploitation Track, moving it down to the 5 VP position (**I7d**). With a Factory now in place, she Decommissions her Crew using the *build colony free action* (**I7e**,**G3**) to create the first space Colony in the game and places a Colony dome on her Site on Mars. <<<Tip: Colonies can only be built where Factories exist. It earns you victory points, protects against *Claim Jumps* and also returns your Crew card to LEO. She places her Crew card back into the LEO slot on her playmat, representing a new and eager Crew ready to take on the next NASA mission. Finally, she Decommissions what's left of her Rocket, returning the remaining card (the *metastable helium thruster*) to her Hand. <<image showing movement of cards from rocket and outpost stack to hand to build factory (place cube) and removal of crew to build colony (place dome)>>

► **ESA** has turned her game around. She has a couple of options here to potentially secure a win: get her Crew to Mars and create a Colony; or find a Spectral Type C card and undertake an *ET production operation* (**I8**). She decides to aim for the latter, and starts the process of churning through the cards by picking up the *kuck mosquito robonaut* at auction for free.<<<Now you can see why that auction in Y23 for the Spectral Type C robonaut was so important. Had ESA won that auction, she'd already have the card she needs and would be ready to head back to Mars for some ET production!

	4	1	0
	13	01 16 22 25	15 17 26
	Cr 05	Cr	Cr
		@caves	
	09	18	32

tF3. Years 25-26 ET Production & Factory Refuel Ops

Y25

► **CRP** is now wondering whether there is any point in continuing, but research auctions the *ISRU sabatier refinery* anyway in an attempt to put together the pieces to build a Factory of his own. He wins the auction without a fight.

► **NASA** is now feeling confident of wrapping this game up with a victory. She uses an *ET production operation* (**I8**) to turn the *solar-pumped MHD exciplex laser robonaut* in her Hand to its Black Side, placing it as the *quantum cascade laser* onto outpost slot #1 on her playmat. <<insert image of RB022R being produced by flipping white sided card in Hand to black-sided card on Factory outpost>> She places an outpost marker back onto the Site containing her Factory. She could only do this because the Spectral Type (C) of the patent matches the Spectral Type (**C**) of the Site (**I8a**). *ET production* is used to produce Black-Side Cards (**I8b**), and only using your Faction's Factories, unless your Faction can commit a Felony, or you *negotiate* (**I8d**). <<<The only Sites capable of ET producing both robonauts **and** refineries are those of Spectral Types S, M, V, and D. Sites of spectral Type C can not ET produce refineries (there are no refineries of that Spectral Type), and Sites of Spectral Type H can not ET produce robonauts (there are no robonauts of that Spectral Type). Keep this in mind when you are planning to "leap-frog" your way from one Site to the next through ET production. Let's take a closer look at the new technology NASA has just created. RB022R *quantum cascade laser* has a Mass of 3 and an ISRU rating of 0, with the added bonus that it has a raygun prospecting icon. Now you can see the central reason to industrialize: conduct *ET production operations* to turn White-Side Cards (patents built on Earth) into Black-Side Cards (patents built in space). In future games with broader scope, Black-Side Cards are critical to really exploring the solar system, because they are generally lighter, with better capabilities.

► **ESA** is still looking for a Type **C** card, and so she places the *rock splitter robonaut* up for auction. She needs funds right now more than she needs the patent, so she is hoping that someone bids. CRP, still trying to build his pool of funds, bids a nominal 1 Aqua. NASA is not interested and ESA has no money anyway, so CRP gets the robonaut for the cost of 1 Aqua to ESA. However, much to ESA's delight, while the auction was going on, she noticed that the *MET steamer robonaut* (Spectral Type **C**) is the next card on the robonaut deck. If she's lucky, it might be there next Turn for her to grab.

We are now at the point in the game where a dice roll could end it, a "1" on a 1d6, as per the *Race to Mars* scenario rules. The game could also end before a "1" is rolled if a Faction undertakes an *ET production operation* and then sells the resulting technology on the free market to meet the last of the three game end triggers in the scenario. CRP rolls the first time for game end, getting a "3", and the game continues.

Y26

► **CRP** free markets the *ISRU sabatier refinery* for 3 Aquas. He may as well make money. <<<If the score is tied at the end of the game, the number of Aquas a Faction has is the only tiebreaker. CRP knows it probably won't matter for this game, but he is preparing just in case.

► **NASA** wants to get her new technology back to Earth to sell. Black-Side Cards can be transported to LEO with the *delivery operation* (**I9**), but without FTs she needs to produce Fuel at her Factory on Mars. A Factory can be used to produce FTs at the Site, which enables Rockets to refuel for further movement. NASA uses a *factory refuel operation* (**I5b**) to add 7 FTs to her Outpost Stack. Two more Turns, and she'll be able to get this precious cargo back to Earth and sell it, so all she needs now is a bit of luck with those end-of-game dice rolls.

► **ESA** is really pleased with herself. A Claim, a Factory and now the *MET steamer robonaut* on the top of the robonaut patent deck – just what she needs! She puts it up for auction, hoping that CRP won't interfere, which he doesn't. NASA can't win the auction, but she bids her 1 Aqua anyway forcing ESA to spend 1 Aqua to get the robonaut. This might matter in the case of a tie. <<<Seeing the situation more clearly than CRP, NASA could have attempted to *negotiate* with CRP to get him to grab that Spectral Type C robonaut that is so important to ESA. But for the purposes of this tutorial, we've kept NASA quiet. And given that the CRP player doesn't appear to have much sympathy for NASA, he probably wouldn't have complied anyway.

	6	1	0
	13 18	01 16 25	15 17 19 26
	Cr 05	Cr	Cr
		22R 7 FTs	
		@caves	
	09	20	33

CRP rolls the dice for game end: a "4"; and we play on!

tF4. Year 27 Delivery Operations

The game hangs in the balance. NASA and ESA are fighting for final advantage, and the winner might ultimately come down to the Turn on which the game ends. Unfortunately for the CRP, he is out of the running and he knows it. But he will soldier on regardless.

Y27

► **CRP** free markets the *neutral beam robonaut* for 3 Aquas. He may as well continue to make money.

► **NASA** is now ready to ship her Black-Sided Card back to LEO. Having collected 7 FTs at her outpost last Turn, now she uses the *delivery operation* (**I9**). <<<It is also legal to 'fly' a Black-Side Card back to LEO as part of a Rocket, but that is much more difficult to do. We will leave you to discover when that might be the better tactical play on your own.

The cost is FTs equal to twice the number of zones the delivery must enter excluding the starting zone (2 FTs in this case, because the Mars Heliocentric Zone is right next to the Earth Heliocentric Zone), plus an extra FT since the martian Site is Size 7 or greater. <<image of two zones, movement of card to LEO and cost in FT>> With 7 FTs on her Outpost Stack, NASA spends 3 FTs and returns the *quantum cascade laser robonaut* to LEO, moving the card from the Outpost Stack to the LEO Stack. The final 4 FTs remain at the outpost. <<<You can *Decommission* a Black-Side Card to bring it back to your Hand, but all the cards in your Hand must be on their White Side, so you lose the Black-Sided patent.

► **ESA** uses an *ET production operation* (**I8**) to flip the *MET steamer robonaut* in her Hand over to its Black Side and places it on the outpost #1 slot on her playmat. She also places an outpost marker to represent this. She has now produced the *nanobot robonaut*. It's possibly "too little too late" now, but it still feels good to have bounced back from an early mishap. <<<Have a Black-Side Card plan. If you create one or two Factories and you know which Black-Side Cards you will produce there, and you plan accordingly, you can crush your opponents by very rapidly leap-frogging from one Site with a Factory to another Site to build the next Factory, especially if your Black-Side Cards are a refinery and a robonaut.

	9	1	0
	18	01 16 25	15 17 26
	Cr 05	Cr 22R	Cr
		4FT	19R
		@caves	
	09	20	33

This time NASA rolls the dice to see if the game ends … "6", and the game continues.

tF5. Year 28 Game End

Y28

► **CRP** recognizes the game is essentially over for him, and sells the *rock splitter robonaut* for 3 Aquas. <<<He might not win, but he has more money than anyone else.

► **NASA** now only has to sell her ET produce. She free markets the *quantum cascade laser robonaut*. Selling a White-Sided patent earns 3 Aquas, but Black-Sided patents are much more valuable. The position of the bead on the Exploitation Track determines the selling price, so she earns 5 Aquas for this Black-Side Card. <<graphic showing exploitation track with bead on C5 position>> The card is placed back onto the bottom of the robonaut patent deck, White Side up. This actually meets the final game ending condition for this Scenario. The game will end at the end of Year 28.

	12	6	3
		01 16 25	15 26
	Cr 05	Cr	Cr
		4FT	19R
		@caves	
	09	20	33

► **ESA** sells her *kuck mosquito robonaut* for 3 Aquas, knowing it will likely make no difference.

tG. The Final Score

The game is done. Now it's time to determine the score (**M**). Each **Claim** is worth 1 VP (**M2a**). So that is 1 VP each for the CRP, NASA and ESA. On top of that, the *glory chit* is worth 2 VP (**M2b**), putting the CRP temporarily ahead at 3 VP. But space is about exploration and exploitation, and the CRP never managed to turn his Claim into something. NASA's Factory is worth 5 VP, as is ESA's, moving them into shared lead at 6 points (**M2b**). NASA also earns a point for being the first to land a Rocket on Mars, putting her at 7, and a point for her Colony (**M2c**), lifting her to 8 VP. Finally, NASA was the first to build a Factory on Mars, putting

her at 9 and the first to free market an ET product, putting her at 10 VP (note that all the “first to” VPs are specific to Race to Mars). <<image of scoring elements, showing the claims, colonies, factories and their value, glory chit for CRP in LEO, and the three scenario objectives>>
<<<Looking back to NASA’s decision to *Decommission* her Rocket in Turn 24, she could have left her Rocket on the map for an extra victory point. Alternatively, as a *free action*, every player could have moved their Crew cards from LEO to a Rocket Stack, thereby creating a Rocket, to score the same victory point in the last Turn of the game. Veteran players don’t miss little tricks like these.

Spoiler Alert: NASA is the winner!

tH. Other Than This

The following rules were not explicitly demonstrated in this tutorial, but they are all valid in RfG and we encourage you to use them.

- **Fuel Grades & Mixing Fuel** (**F4)**. Thrusters with a gray thrust triangle use dirt as Fuel instead of water. You are not allowed to use thrusters with a blue (water) thrust triangle if you are using dirt fuel. But you could use water to fuel a gray (dirt) thruster. If you mix dirt and water, treat all the Fuel as dirt (**F4d**).
- **Dirt Refueling (G1c)**. Dirt Fuel is produced at any Site provided you have a card with an ISRU value. Dirt is easy to come by, so you can refuel as much dirt as you want as a *free action* unless your activated thruster has a blue triangle or is a Crew thruster.
- **Jettison Fuel (G1f)**. This *free action* that lets you vent Fuel to space by jettisoning it. Just move your Wet Mass Chit as many steps as you’d like to the left along the black line.
- **Fuel to FT (G2b)**. This is generally used to create Fuel as FT cargo for transferring to another Stack.
- **Phileas Fogg (G2c)**. You can create Fuel from stuff Jules-Verne style! For each point of Mass *Decommissioned* back to your Hand, gain one FT of dirt fuel.
- **Voluntary Discard of Cards & Tokens (G6)**. If you have too many cards in your hand or tokens you no longer need, you can discard them as a *free action*.
- **Factory-assist Landing/Takeoff (H6c)**. If a Site has a Factory, a Spacecraft with an activated operational thruster may enter or exit that Site without needing a thrust greater than the Site Size, but you’ll need to make a Hazard Roll to do it. You can’t use this for Sites big enough to have a lander burn, except for Atmospheric Sites you can use *acetylene rocketplanes* (**H6c**) to takeoff.
- **Air-Eater Op (I5c)**. A Spacecraft Stack containing an operational “pac-man” card may refuel on an Aerobrake Hazard Space. This produces tanks of Fuel equal to 4 minus the Stack’s *fuel consumption*.
- **Raygun Prospecting (I6a)**. You can prospect multiple Adjacent Sites provided your card’s ISRU rating meets the Hydration requirement of each Site being prospected and the Sites involved don’t have an atmosphere.
- **Negotiated Factory-Assist and Factory-Refuel** (**N5-6)**. Making deals with opponents to use their Factories for refueling or takeoff or landing.