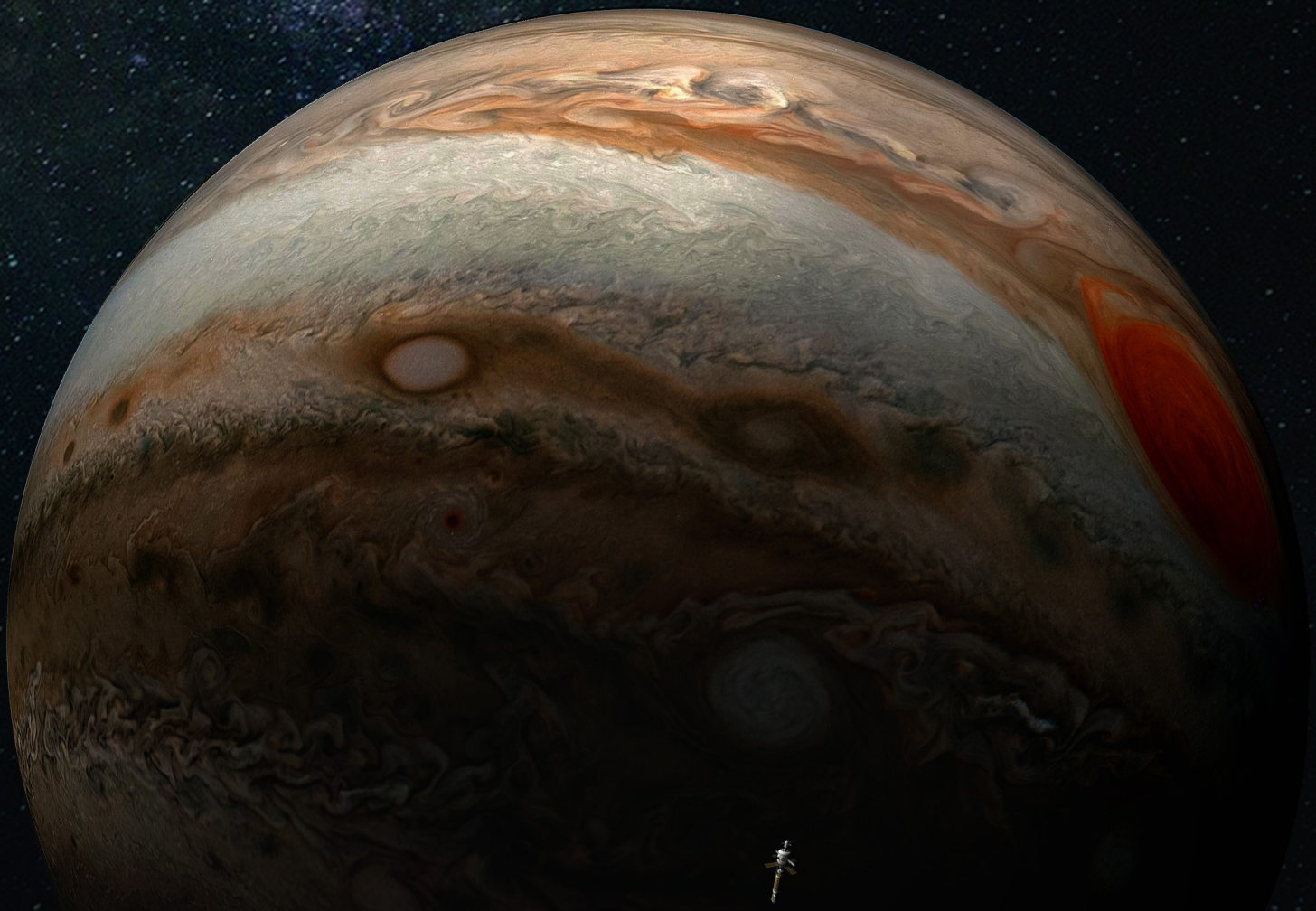
HIGH FRONTIER

4 ALL | BY PHIL EKLUND



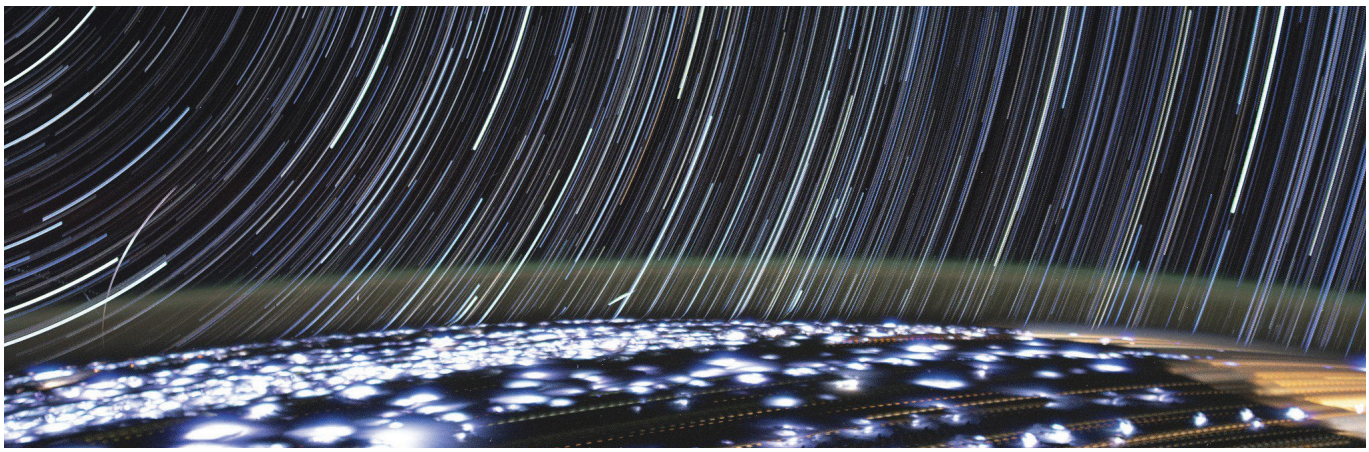
CORE RULES

BY PHIL EKLUND

ION GAME DESIGN

SIERRA MADRE GAMES

A game of exoglobalization for 1 to 5 players.
Updated Feb, 2021.



A. Introduction

These Core rules (including the glossary at the end) comprise the base game, and are expanded by the tutorials, variants, and modules.

A1. Core Overview

Players, representing the spacefaring factions of Earth, bid for patents (space technology cards) and boost them into Low Earth Orbit (LEO) to be assembled into Rockets and their Cargos. Water in LEO is used both as commodity currency and as rocket propellant, and each water container there is called one **Aqua.** Once loaded with Fuel Tanks (FTs) of water, Rockets fly to promising industrial and science Sites (planets, asteroids, etc.). If prospecting succeeds, a Claim is made. A Claim can be upgraded to a Factory to produce useful new equipment. By extracting water from a Site, FTs are produced both for water propellant and as money ("Aqua") if shipped back to LEO.[1]

a. Core Game Victory. At the end of 48 years (48 Turns per player), the winner is the player with the highest victory point (VP) total.

b. Sunspot Cycles. Each Turn in *High Frontier* is one year, and the length of a game is measured in Sunspot Cycles of 12 years. Thus the standard Core Game described above is 4 Sunspot Cycles, Core Game plus Modules 1 and/or 2 is 5 Sunspot Cycles, and Core Game plus Modules 1, 2, and Futures is 7 Sunspot Cycles.

A2. Metarules

a. Terms being defined are listed in **bold**, or *italicized* if defined elsewhere. Capitalized terms are defined in the glossary. These terms are general ones that appear throughout the process-oriented rules (next bullet).

EXAMPLE [A2a]

In general, VP are scored for off-world Claims and Factories, the stock price of industrialized Sites, and glories (exploration achievements).



b. Sequential Processes are presented in the order listed in the sequence of play, and are introduced by a simple overview followed by specific bullets.

c. The Golden Rule. If the text on a card, scenario, tutorial, or variant contradicts these rules, that text prevails.

d. The Modular Rule. Rules in blue font are modular rules that are ignored unless playing with the relevant Module. ◊ indicate a rule not used in the *Race for Glory* game, and a ♦ indicates an alternate version of the rule is used in the *Race for Glory* game. Moreover, rules in the Modules supersede these core rules. If a conflict occurs between Modules, use the publication date as the final arbiter.

e. Learning this Game. See the included tutorial. Also see ***www.ionsmg.com*** under the "Video" tab for the link to a YouTube video tutorial produced by Heavy Cardboard.

f. Poster Map. You may wish to purchase an updated "High Frontier 4th Edition Poster-Map" from Zazzle that combines the basic and expanded maps. Go to your country's Zazzle and search "High Frontier".

EASILY MISSED: Water is a commodity used as money, but only counts as money if it is in LEO (Low Earth Orbit). You can't pay people with water on Mars! [A1a]

A3. Introductory Games

Space Diamonds introduces the map and moving, *Starship Builder* (at the end of the *Space Diamonds* book) introduces the cards, and *Race For Glory* introduces the core rules prescribed here using a detailed tutorial, with the exception of *Radiation Belts* **(H10)**, *supports* **(J)**, & *events* **(D2)**.

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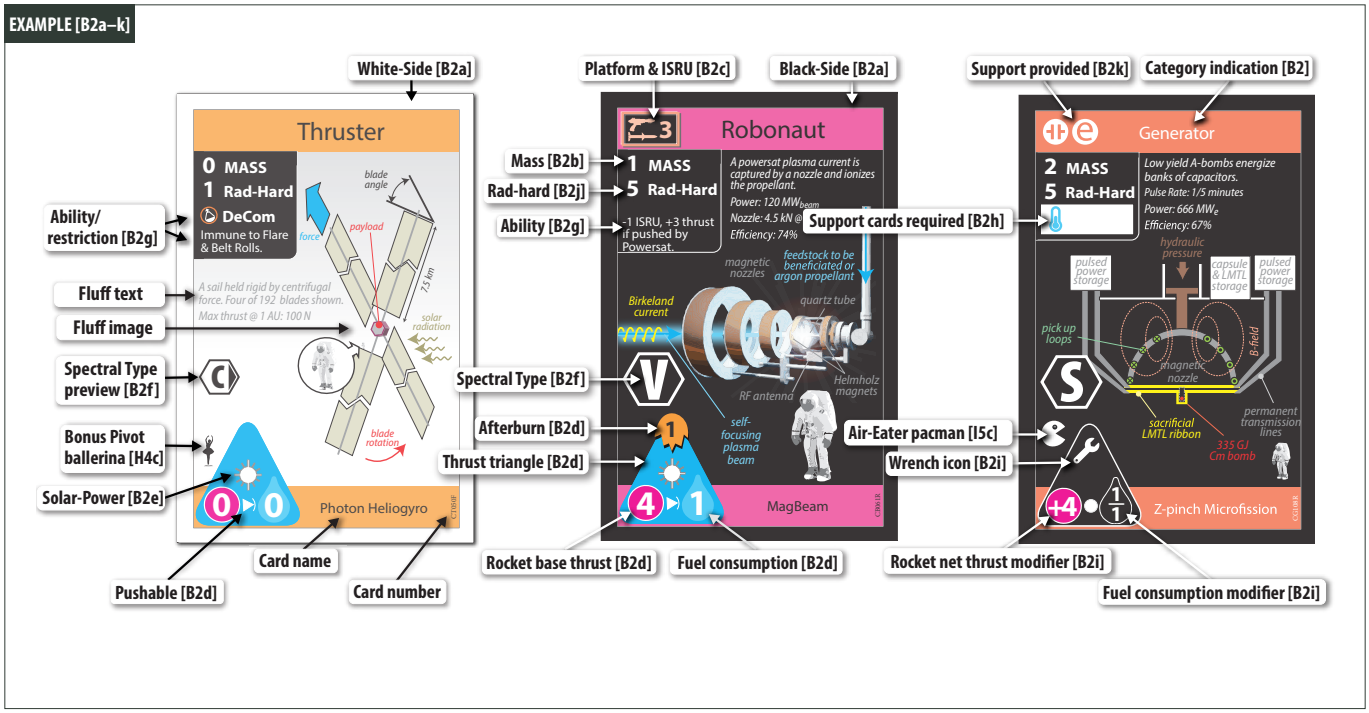
1 WATER, THE KEY TO THE SOLAR SYSTEM. No place in space has resource value without a local supply of water, primarily for rocket propellant and "exofuels", but also for chemical and mineralogical processing, dust control, crops, and life support. Water is a storable and convenient source of hydrogen, the superior propellant for thermodynamic rockets. Water is a natural shield against energetic protons, kilo for kilo better than regolith or even metals. Finally, without recycling, each man-year requires 10 tonnes of water. (Although it is worth noting that human metabolisms convert carbohydrates plus oxygen into carbon dioxide and water, thus we are stoichiometrically net producers rather than consumers of water.)
— Glenn MacPherson, ***Oxygen in the Solar System,*** Lunar & Planetary Institute, 2008.



B. Components & Anatomies

B1. Component List

See "Read Me First".

B2. ♦ Patent Cards

The 6 types of patent cards in core game are: **thrusters** (rocket engines), **robonauts** (remotely-powered mining machines), **refineries** (ore purifiers), **generators** (producers of pulsed or steady current), **reactors** (producers of 3 kinds of radiation energy), and **radiators** (providers of cooling Therms).

a. **White & Black-Sides.** The White-Side of a patent card shows a product built on Earth; the Black-Side shows an improved product built in space. Until you build your first Factory on a Site, you will only be using the White-Side of the patent cards.

b. **Mass.** Listed in the upper left corner, chiefly used to determine its boost costs and its contribution to the Dry Mass on the Fuel Strip.

c. **Platform & ISRU.** Cards that have an In Situ Resource Utilization (**ISRU**) rating inside a **platform icon** can be used to *ISRU refuel* **(I5a)** and *prospect* **(I6)**.[2]

d. **Thrust Triangle.** Cards with a *thrust triangle* **(H2)** are capable of moving Stacks. The number on a thrust triangle's left side is its **base thrust** and the number on its right side is its **fuel consumption**. The color of the triangle indicates its *fuel grade* **(F4b)**. If it has a flame icon at its apex, it can *afterburn* **(H3a).** If instead of a dot icon, it has a push icon ▶) in its lower center, it is *pushable* **(H3d).**

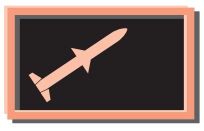
e. **Solar-Power** indicates a modification to thrust based upon how far from Sol the Spacecraft is located **(H3c)**. It is separate and independent from all other numbers and icons in the thrust triangle or on the thruster itself. These modifiers apply only if the card is part of the *support chain* **(◊ J1c)** for an activated *thrust triangle*. A Solar-Powered Card becomes *non-operational* **(J2)** if in the Neptune ♆ Heliocentric Zone or beyond **(◊ J3a)**.

f. **Spectral Type.** The letter shown on the Black-Side of a patent **(C, S, M, V, D,** or **H)**, and previewed on the front side, indicates what type of Factory can build it as an *ET product* **(I8)**.[3]

EXAMPLE [B2c]



Buggy Platform



Missile Platform



Raygun Platform

2 WATER AVAILABILITY is greatest on worlds with icy cores, where simply injecting steam into a wellhole produces water. On drier worlds, where water only occurs as tiny ice crystals or hydrated silicates, the regolith would need to be crushed, sealed in a vessel at 1 atm, and cooked to 700 K to extract water as vapor. The vapor is then liquified by cooling to 280 K and separating solids and gases. The liquid water (some of which is recycled to the first step) is degassed briefly in a vacuum to remove dissolved gasses, and placed in storage. Assuming 4% water content in 70% of the top 2 meters of regolith, four tonnes of regolith must be scavenged to obtain 120 kg/day of water. In one year, one game FT is extracted from an excavated area of about 1100 m^2 (about 24 X 24 meters). —Lewis et al., *Resources of Near-Earth Space,* 1993.

3 SPECTRAL TYPE is the asteroidal composition as measured by spectral reflectivity. The game's spectral types are:

C = "carbonaceous chondrite". The most common asteroid type in the inner solar system, marked by coal black deposits of fluffy graphite and tarlike organics. Up to 20% water as hydrides. Some may have ice cores.

D = "dark kerogens". The most common asteroid type in the outer solar system, presumed dormant comets with reddish-black organics and pyroxene.

H = "helium-3". A rare isotope of helium found in gas giants and SWIV (solar wind implanted volatiles), essential for clean aneutronic fusion.

M = "metalliferous iron". These are presumed to be the iron-nickel core of an unresolved planet. The Fe-Ni kamacites are very tough at daytime temperatures, but at night undergo a ductile-to-brittle transition that makes them easy to crush. Little carbon. Included with type **M** is the rare type **E** (enstatite, a titanium alloy) and type **W** ("wet metalliferous", with hydrated silicates). An example on the map of type **E** is Nysa, and of type **W** is Hertha, both in the Nysa family.

S = "stony chondrite". Silicates, sulfides, metals, and possible uranium and thorium fission fuels. However, little carbon or water. Most NEAs (Near Earth Asteroids) are of this type.

V = "vestoid". These bright worlds contain howardites, eucrites, diogenites, and metals, but little carbon or hydrogen.

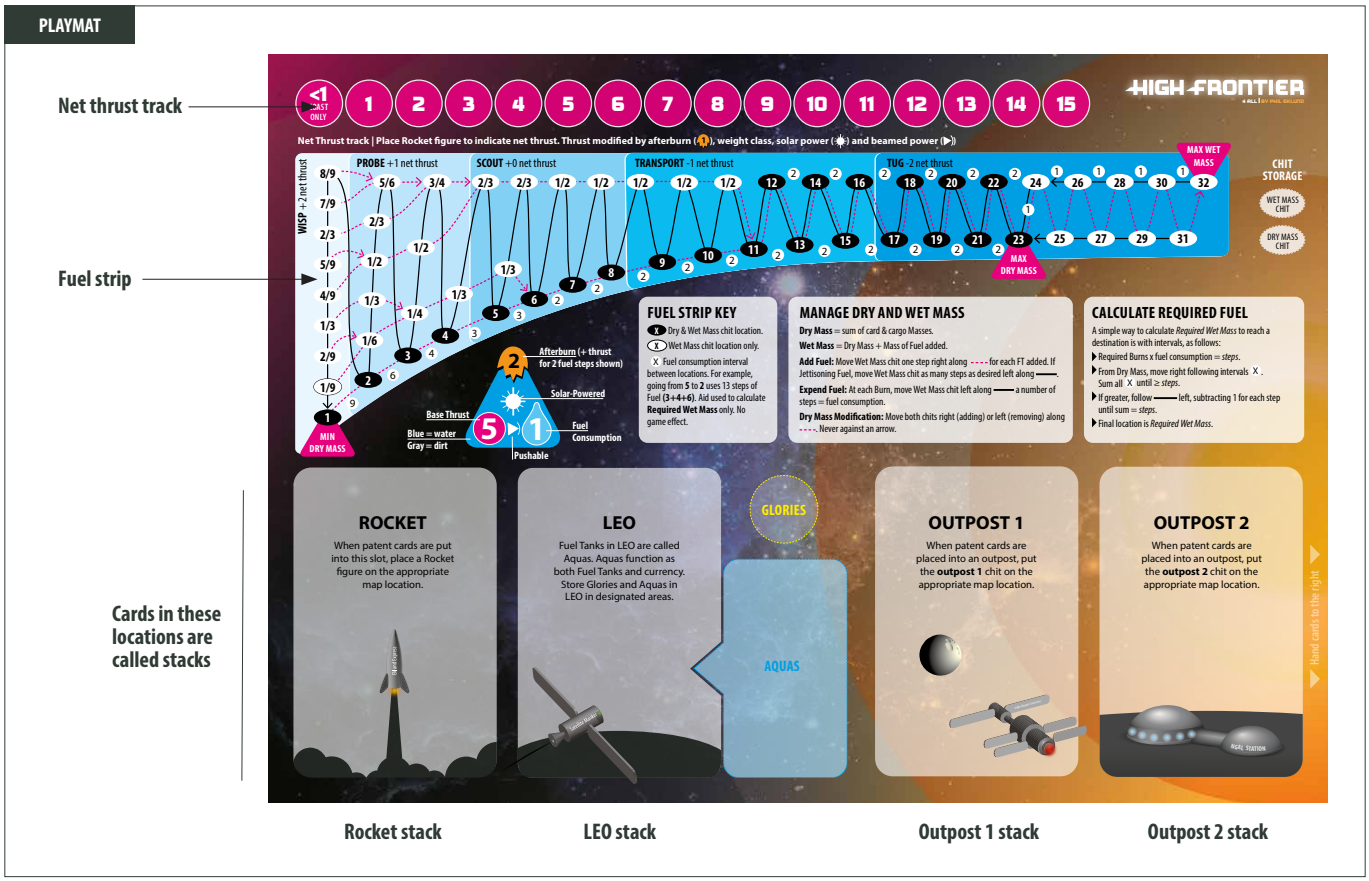
g. ◊ **Ability & Restrictions** are printed in the colored band of the card **(◊ J2e)**. These apply if the card is *Operational* **(◊J3)**.
h. ◊ **Support Cards Required** to make the card *Operational* **(J1)** are listed here. The example data field shown requires one Therm of cooling **(J1d)**.
i. ◊ **Wrench Icons** indicate *movement-modifying supports* **(◊ J5)**. These modifiers apply only if the card is part of the *support chain* **(◊J1c)** for an activated *thrust triangle*.
j. ◊ **Rad-Hardness.** Resistance to solar flares **(◊ K2d),** and Radiation Belts **(◊ H10)**.[4]
k. ◊ **Support Provided.** Icons in the top left indicate which *supports* a card provides **(J).**

B3. Glory & Heroism Chits

The 9 glory chits, placed on the map per **C7**, are worth 1 VP each when claimed by a Human plus variable VP if brought back to LEO/Bank by a Human **(L)**. Each of the 4 Heroism Chits are always worth 2 VP. Both are shown in example **A2a**.

B4. Playmats

Each player starts with a **playmat** for storing their cards and **Aquas** (the blue beads stored in your LEO Stack, used for money and fueling).[5] It contains a Fuel Strip and net thrust track (used to keep track of the Fuel and ***net thrust*** of their Rocket Stack).[6]



4 RAD-HARDNESS is rated on the accumulated dosage of environmental radiation a piece of equipment can survive, as measured in krad (Si). 1 krad (Si) = 10 J/kg of silicon. The chief radiation hazards are high energy protons from CMEs (Coronal Mass Ejections) and radiation belts (electrons & gammas are more easily shielded). Both sources of protons increase 1000X after a major solar event. Electronics and photovoltaic cells are particularly affected. Because shielding beyond a centimeter of aluminum has little effect, the rad-hardness of electronics is improved by using circuits that do not readily latch-up or upset, and guarded by error-correcting and watchdog timers. Such circuits include Radiation Hard CMOS and AsGa circuits, with rad-hardness 5 (about a Mrad).

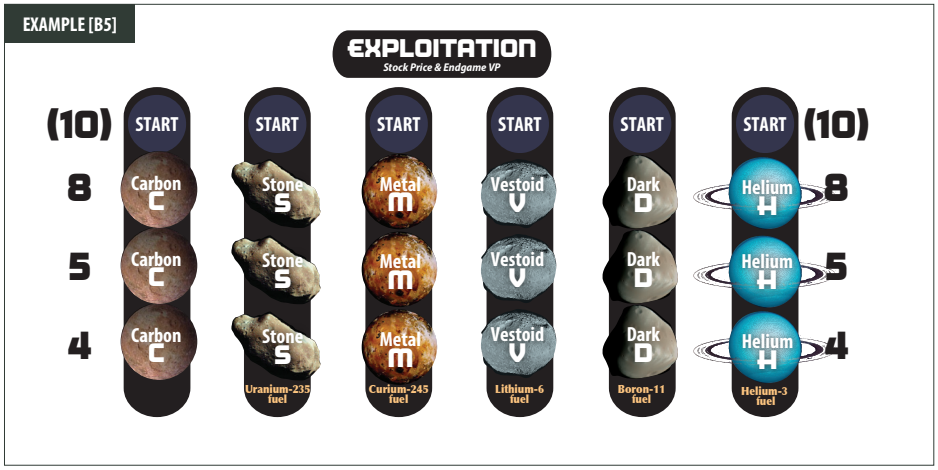
5 AQUAS are 40 tonne tanks of water propellant orbiting in LEO. Boosting out of Earth's 9.5 km/sec gravity well puts orbital water at the same price per kilo as gold! The Russian Proton boosts at $4000/kg, and the Shuttle boosted at $10,000/kg. For half the delta-v (required change in spacecraft velocity), a rocket tanker can haul ISRU water to LEO from the martian moons or NEAs (Near Earth Asteroids). Water is valuable in LEO, which is drier than the Sahara. People get thirsty, but at least human water needs can be recycled. A rocket is far more thirsty than 100 people, and the water it consumes is lost forever.

6 ROCKET SCIENCE mainly concerns getting propellant to intercept fuel energy efficiently. This energy is usually radiation and energetic particles from chemical or nuclear reactions. Lines and windows characterize the opacity of a propellant across a radiation spectrum; lines are where the radiation is absorbed and windows are where the radiation gets through. Dirty reactions are those that generate products that are not easily absorbed by water or hydrogen propellant. This deals a double whammy: not only is escaping radiation wasted, but it also creates waste heat that must be rejected by radiators (other than radiation passing directly into space; for instance, half of proton-antiproton energy escapes via neutrinos). Examples of dirty reactions are high neutron fission, D-T fusion, and antimatter reactions. Clean reactions include chemical rockets and aneutronic fusion like ^{3}He-D and H-B.

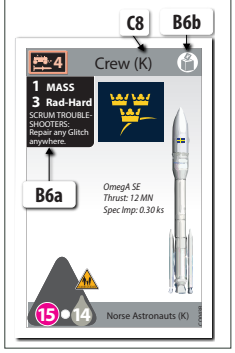
B5. Solar System Charts

The six **Exploitation Tracks** (showing Spectral Types **C, S, M, V, D**, and **H**) are found on the map. There are two placards: Sol Sunspot Cycle and *Sol political assembly* **(O1)**.

EXAMPLE [B5]



EXAMPLE [B6a–b]



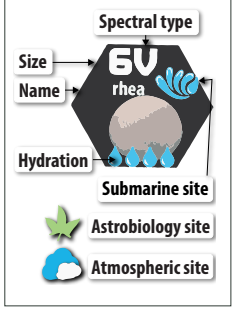
B6. Crew Cards

Your Crew has a player color, Mass, ISRU platform, rad-hardness, a thrust triangle, and a "humans on board" triangle. The latter means it is Human (see glossary). A Crew is useful to defend against Felonies or repair Glitches. All rules about Humans apply to stacks where the card is located. It cannot be traded, sold, or Discarded (but see **N3d**).

a. **Faction Privilege.** This Ability, listed below the rad-hardness, is active in the core game except during *Anarchy* **(K2e)**. They include Blink Telescope, Dharma Refuel, Felonious, Launch Fees, Marketeer, Mooncable, Open Source FINAO, Powersat, Secretary-General, Scrum Troubleshooters, Skunkworks, and Taxes (see glossary). All faction privileges are assumed to be the result of space facilities in LEO. If Module 2 is used, these space facilities are Home Bernals, and faction privileges are disabled until this space station is Anchored in a Home Orbit.

b. **Faction Ideology.** (Module 0). Used for placing *delegates* **(O2c)**.

EXAMPLE [B7a]



B7. Solar System Map

The map shows the **Spaces** (i.e. the orbits in the Solar System where a Rocket can "halt"), and the routes between the Spaces.[7] Some of the most useful routes are colored and labeled with signposts (e.g. "Earth-Mars"). The various kinds of Spaces are described below:

a. **Sites.** Black hexes representing areas of planets, moons, and asteroids that can be landed on. Site features include:
   - **Size** is a number indicating the surface gravity--the larger the number the more likely prospecting will be successful but the more powerful your Rocket has to be to takeoff/land there.
   - **Spectral Type (C, S, M, V, D,** or **H)** indicates what can be mined and factory-produced there.
   - **Atmospheric Site** is indicated by the cloud icon in the Site hex.
   - **Hydration** (zero to four waterdrops) indicates how easy it is to obtain water there.[8]
   - **Astrobiology Site** is indicated by the leaf icon.
   - **Submarine Site** is indicated by the blue wave icon.[9] A Factory or Colony here is in a subsurface ocean.
   - **Push Site** is indicated by the push icon ▶). A Factory here yields the Powersat Ability.

7 THE HIGH FRONTIER MAP divides space into two topographies: circumplanetary lander burns (steep gravity wells around planets), and interplanetary Hohmanns (shallow heliocentric gravity fields). It scales to energy, not distance! Note that each Space represents a stable orbit, so rockets do not "drift". To change orbits, you must achieve a "velocity increment" that costs mass and energy.

8 HYDRATION. For worlds in the Jupiter zone and beyond, surface ice is common since it won't sublimate if shielded from solar heat. Some of the larger outer worlds, like Ceres, Ganymede, and Europa, have polar ice caps and may have subterranean oceans. The **D**-type asteroids, common in the Trojans and other outer reaches, have never been hot enough to chemically bind their water to minerals, and their water may be still be sequestered as primal icy cores. Closer in, solar heat has bound the water of **C**- and **W**-types into hydrated silicates and clays. (Hertha and Lutetia are actually **W**-type, and not **M**-type as stated on the map.) A few main-belt "asteroids" are active comets like 133P/Elst-Pizarro. These must have lost their surface volatiles long ago, but were "revived" by recent collisions that exposed buried ices. **M**-, **S**-, and **V**-types are drier, but the larger ones may have primeval water protected by a permafrost layer. The moons of Earth and Mars, while anhydrous on the surface, may have buried ice crystals in the polar regions, or in places impacted by aqueous comets or asteroids. Missions such as the 2009 LCROSS impactor suggest water ice lies in the south lunar pole. One can find ice even on Mercury, in permanent shadows on the north pole.

9 SUBSURFACE OCEANS. Some icy worlds may have liquid water underneath the ice, heated by radioactivity or tidal kneading. Pockets of volcanic gases floating in the water under the ice may be suitable places to establish submarine bases.

b. Intersections. The intersection between two routes is a Space called a **Hohmann** if the two lines touch or form a corner unmarked by any icon or circle.[10] This includes each corner in the zigzag routes such as those common in the outer solar system.
- **Lagrange & Lander Spaces.** A Space is not a Hohmann if it is marked by any icon (e.g. a hollow or filled circle or lander icon).[11]
- **Bridges.** If the lines don't touch, they do not intersect and are therefore neither a Space nor a Hohmann intersection.
- **Changing direction** during movement at a Hohmann requires a Pivot **(H4c).**
- **Home Orbits.** The Home Orbits for Bernals are marked with a 7-pointed star icon.

c. Burn Spaces. These Spaces are magenta-colored on the map. There are two types: Lagrange Burns and *lander burns* **(H5e)**.[12] Each time a Rocket enters a Burn Space, it must expend a number of fuel steps equal to its fuel consumption.

d. Spaces may also be marked with *Hazard* **(H7)**, *flyby* **(H8)**, or Radiation Belt **(◊ H10)** icons.

e. Aerobrake Path is a route with a dashed brown line. Using this path, a Spacecraft can parachute to a Site by ignoring *net thrust* requirements and without using Fuel. Entering an Aerobrake Hazard requires either a Hazard Roll or FINAO payment **(H7e)**. A Spacecraft can never move along this path against the arrow's direction.[13]

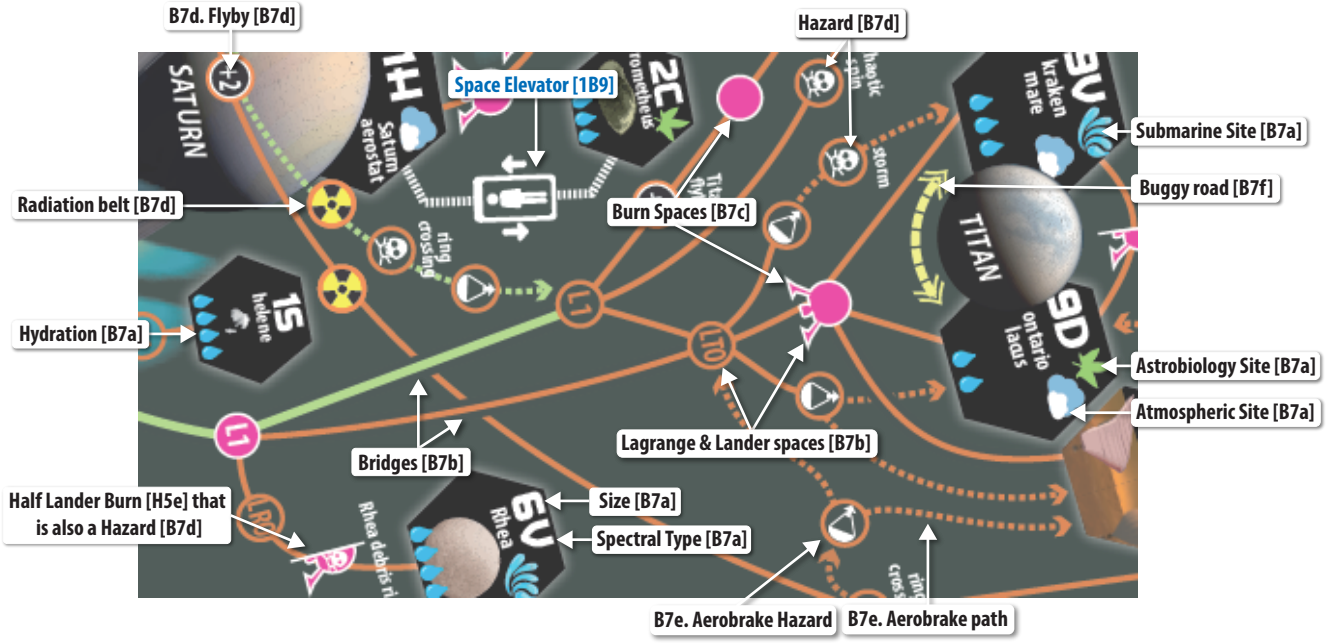
f. Buggy Road is a route with a dashed yellow line. It is used during buggy prospecting, but can also be used to move Crew **(H9a)**.

EXAMPLE [B7b]



TIP: Many Lagrange intersections are labeled (L1, barycenter, cycler, etc.). These labels have no gameplay impact. [B7b]

EXAMPLE [B7a–f]



TIP: The majority of Burn Spaces are either around planets or at the outer edge of each Heliocentric Zone. Closer to the sun, there are routes through the edges of Heliocentric Zones which don't have Burn Spaces, representing the Interplanetary Travel Network. Use these to trade fuel consumption for time. [B7c]

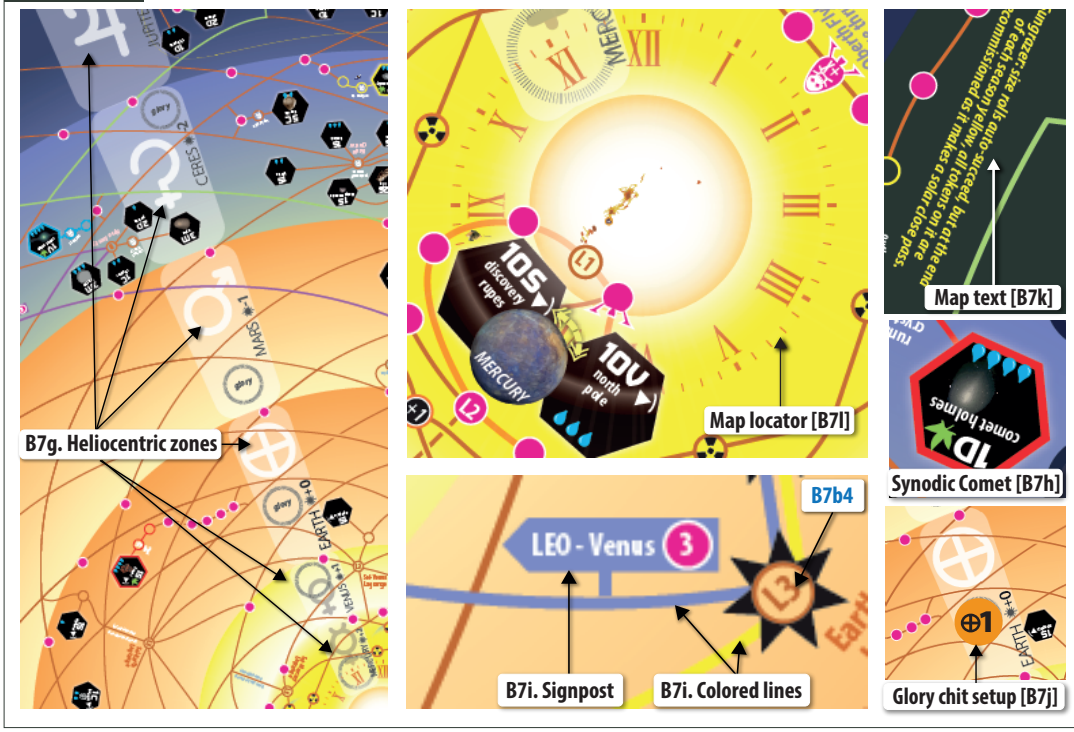
10 HOHMANN TRANSFER. If a rocket in a circular orbit makes an impulsive thrust in any direction, it flies into an elliptical orbit. By thrusting again at the extreme limit (periapsis or apoapsis) of this ellipse, it can enter a destination orbit either higher (superior) or lower (inferior) than its starting one. This elliptical route, requiring a high thrust at each end and a lot of coasting in-between, is called a Hohmann transfer. The Hohmann is usually the trajectory requiring the lowest delta-v to reach a destination orbit. The routes on the map are modeled on Hohmann ellipses. The Hohmann requires that the destination and embarkation bodies be close to opposition (at opposite sides of Sol). Therefore, the launch windows for a Hohmann can be considerable, varying from 3.5 months for Earth-Mercury, to just under 6 years for Earth-Saturn. The Hohmann transfer is illustrated in the Appendix **(W3.Q5).**

11 LAGRANGE POINTS. In any two-world orbital system (like the Earth-Luna system shown), there are five points where very little or no energy is required for a spacecraft to maintain formation with both worlds. These points, called Lagrange Points, are denoted L1 through L5. They are analogous to GEO in that they allow a satellite to be in a "fixed" position, with no "launch windows" within the system. Even more significant, Lagrange Points are embarkation spots for the Interplanetary Transit Network. Of the five points, L4 and L5 are the only stable ones.

12 BURN SPACES show the velocity increment required to travel between orbits, often called **delta-v.** Each game Burn is 2.5 km/sec of delta-v. The delta-v of a rocket is defined by the rocket equation: Delta-v = Ve ln (Wet Mass/Dry Mass), where Ve is the exit velocity of the propellant in km/sec. Assuming a minimum energy (Hohmann) transfer, the delta-v to fly from LEO to some nearby destinations is: Nereus = 4.5 km/sec, Venus capture = 5.5 km/sec (neglecting aerobrake), Phobos/Deimos = 5.6 km/sec, lunar base = 5.7 km/sec, Earth's surface = 9.5 km/sec, and Mars base = 10.2 km/sec (again assuming no aerobraking). Notice that the martian moons are closer to us than our own moon, in terms of fuel and energy.

13 AEROBRAKE. A spacecraft can lose approach velocity and enter a capture HEO by making a close aerobrake pass through the atmosphere. Repeated atmospheric passes at the low (periapsis) point circularizes the HEO into a low circular orbit. Any solar panels and radiators will need thermal protection, possibly using foamed ceramic heat shields fabricated from asteroidal rocks.

EXAMPLE [B7g–l]



g. **Heliocentric Zones** divide the solar system into concentric circles to mark the decreasing solar energy as you move farther away from Sol. Each zone is named after a planet (from Mercury ☿ to Neptune ♆). These zones modify the thrust of Solar-Powered Rockets and Sails **(H3c)**. Solar-Powered Cards are not Operational in the outermost zone.

h. ♦ **Synodic Comet Site.** A Site with a red, blue, or yellow border, which represents a comet whose extreme orbit causes it to become accessible only during the season of the Sunspot Cycle matching its border color.[14] See glossary for details.

i. **Signposts & Colored Lines.** These have no impact on gameplay and are merely informational. They highlight a possible route to the depicted location and list the number of Burn Spaces to the destination, assuming no Pivots **(H4c)** and using *flybys* **(H8)**. The number of Burns, multiplied by your *fuel consumption* **(B2d)**, equals the fuel steps you will need for a one-way trip.

j. **Glory Setup**. Circles labeled "glory" or "heroism" start with a *glory or heroism chit* **(C7).**

k. **Map Text** is merely descriptive except for some printed rules at the *kreutz sungrazer* **(B7h)**, *Venus flyby* **(H8c)**, *solar oberth* **(H8e)** and Luna (**I6**).

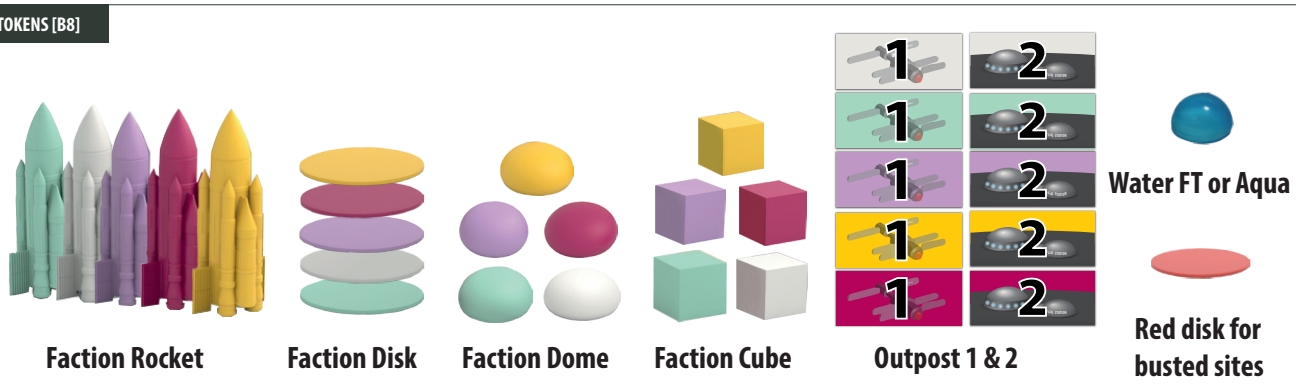
l. **Map Locator.** A clockface is depicted around Sol as a Site locator, in conjunction with the Heliocentric astronomical icons. For instance, Earth/LEO is located at 3:30 ⊕.

TOKEN LIMITS: Cubes and disks in player colors are limited to those supplied. For other Tokens, use substitutes if you run out. Substitute domes do not count for VP in the endgame scoring. [B8]

B8. Tokens

Includes blue beads (80 water FTs or Aquas), translucent red disks (40 Busted Sites), opaque disks in player colors (Claims, 9 per player), cubes in player colors (Factories, 7 per player), domes in player colors (Colonies, 7 per player), and Rocket Figures in player colors (2 per player).

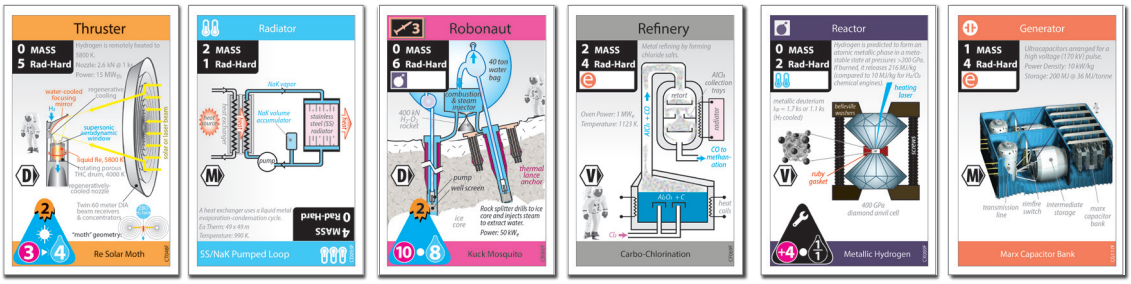
TOKENS [B8]



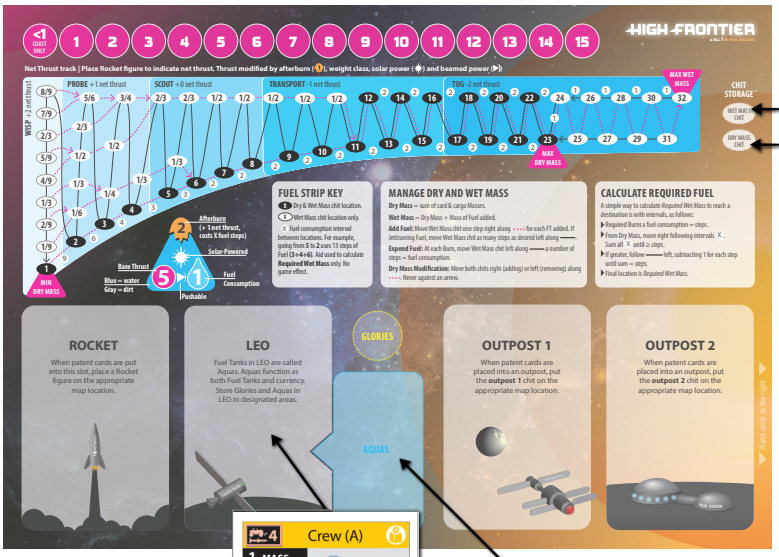
14 SYNODIC COMET is a world with a high inclination (>10°), which brings it well out of the plane in which most of the solar system orbits. It also has a much higher eccentricity (>0.5), contrasting its oblong orbit with the mostly circular orbits of the other sites. The capture delta-v of a synodic comet is sensitive to the point in the orbit that you attempt to enter it (i.e. short entry window). The delta-v for exit must be installed as a small fraction of the orbital period, implying high accelerations (and short exit windows as well). In game terms, synodic comets are accessible but once every dozen years or so, and have additional Burns for orbit matching (calculated using Edelbaum's Equation and Shoemaker Tables). Except for Halley's (and beyond), all worlds are shown at their proportional semi-major axis from Sol.

CORE SETUP [C]

C4. Patent Decks (6 in Core)



C3. Playmat (one per player)



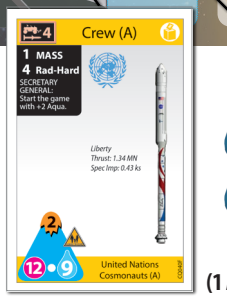
C3a. 2 Rocket Tokens

C3b. Wet Mass Chit

C3b. Dry Mass Chit

C3f. 2 Rectangular Chits (for Outposts)

C3c. 7 Small Cubes (for Factories)



C3. Crew Card

C3d. 7 Domes (for Colonies)

C5. Starting Aqua (1 Aqua per patent deck, 6 in Core)

C3e. 9 Disks (for Claims)

01d. Star (for Active Law) (Module 0 only)

C. Core Setup

The number of players can be from 2 to 5 (or 1 in some scenarios). Before starting, decide on any Modules or variants (separate booklet). Note the *quick start game* **(V1)** (recommended for 4 or more players), the Space Diamonds chit variant **(iA)**, and the *solitaire/cooperative variant* **(V4)**.

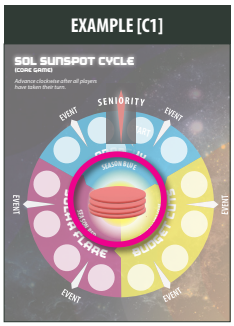
C1. ♦Seniority Disk Placement

Use the "CORE GAME" side of the Sol Sunspot Cycle placard. Place 4 translucent red disks in the center (over the Sol icon).[15] These will count the game's solar cycles, so one disk will be removed each time the seniority threshold is crossed, indicating the completion of one 12-year cycle.[16]

C2. Assign Factions & Crew

Deal each player a random Crew, then each player secretly chooses one side of the card that they will play as.

EXAMPLE [C1]



PLAYER GRAY: There are no gray components provided for Norse Astronauts/SpaceX. If you wish to play with one of these Factions, you must use components from an unused Faction color. These components are considered gray in color for all purposes, including starting delegate (01b). [C2]

15 SENIORITY. Each player represents a genius visionary, and the seniority disks measure his/her lifespan. To get your age in Earth years, add 10. For example, on Turn 46 you are 56 years old. The plot of the game is to accomplish as much as possible before you die on the final seniority threshold.

16 THE SOLAR CYCLE of our sun ranges from minimal sunspots and storm activity to maximum in about 11-years. Solar storms often emit flares, a burst of radiation across the spectrum, that triggers radio blackouts and storms in the magnetospheres of planets throughout the solar system. The power density in the x-ray region determines the flare category: **B, C, M,** or **X**. The **X**-class flares are the biggest, endangering space electronics, solar cells, and astronauts (who have about 15 minutes to get into their storm shelters). Solar storms also emit expanding blobs of particles called Coronal Mass Ejections (CMEs). Being particles rather than radiation, CMEs are rather localized, and propagate slower (1 to 4 days to reach 1 AU), but they can pack more punch when they hit.

C3. Reserves Setup

Each player takes a playmat and places their Crew into the slot labeled "LEO" with the chosen Faction faceup. Near their playmat, they place the following components in their player color in their Reserve:

- **a.** 2 Rockets (one for map, one to indicate net thrust).
- **b.** 1 Dry Mass Chit and 1 blue/gray Wet Mass Chit for their fuel strip.
- **c.** 7 small cubes (for Factories).
- **d.** 7 domes (for Colonies).
- **e.** 9 disks (for Claims).
- **f.** 2 rectangular chits (for Outpost Stacks).

C4. ♦ Patent Deck Setup

Separately shuffle each of the six decks of patent cards (thruster, robonaut, refinery, generator, reactor, radiator), and place them White-Side up near the map.

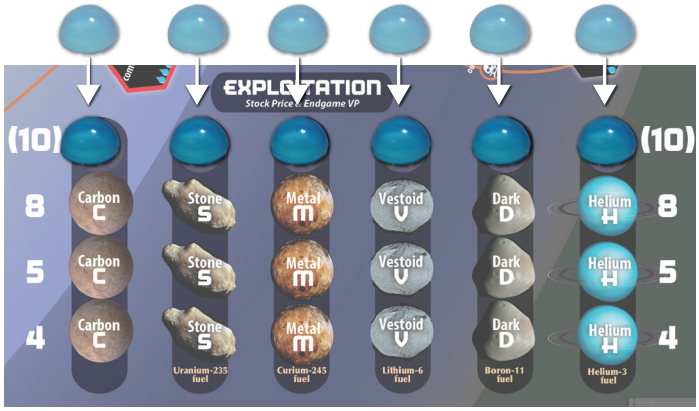
C5. ♦ Starting Aquas

Give each player as many blue Aqua beads as there are patent decks (but not queues) in the game. In the core game, this is 6 Aquas, placed into the LEO slot on their playmat.[17] If ***quick start*** **(V1)** is used, start with zero Aqua.

C6. Exploitation Track Setup

Place a blue bead on each of the 6 starting positions of the Exploitation Tracks on the map.

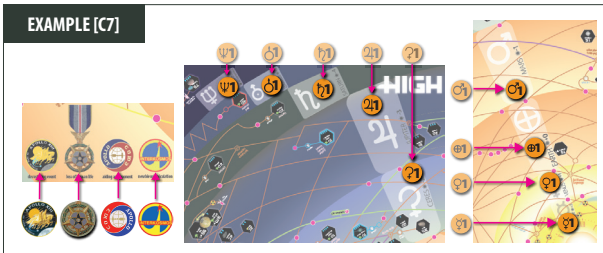
EXAMPLE [C6]



C7. Glory & Heroism Chit Setup

Place 1 glory chit on each Heliocentric Zone in the spots marked with the corresponding astronomical icon: Mercury (☿), Venus (♀), Earth (⊕), Mars (♂), Ceres (⚳), Jupiter (♃), Saturn (♄), Uranus (♅), and Neptune (♆) **(B7j)**. Place all glories with their "1 VP" side faceup. Unless playing solitaire or 2-player, place 1 "heroism" chit in each of the 4 Heroism spots (medallions) in the lower center of the map.

EXAMPLE [C7]



EXAMPLE [C8]



C8. Clout, 1st Player, & Sunspot Cube

Every Crew card has a rating from **A** to **M**, where "**A**" has the most **clout** (political influence).

- **a. 1st Player.** The player with the most clout becomes the "Sol secretary-general" (**1st Player**).
- **b. Sunspot Cube.** The 1st Player places a cube of his color (the **Sunspot Cube**) on the "start" position of the Sunspot Cycle, and then starts the game by taking his *Turn* **(D1)**.

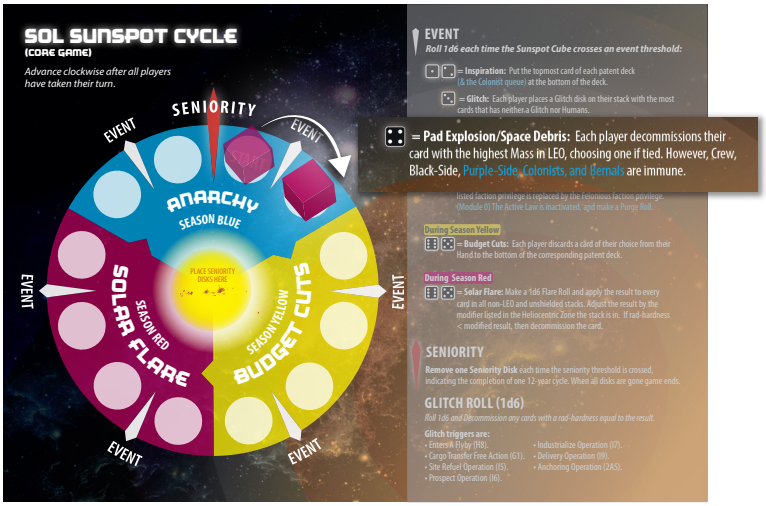
17 WATER-BASED CURRENCY. The discovery of the California goldfields in 1848 led to gold being abundant relative to local commodities. For instance, a single egg could cost 1 gold dollar, containing one-twentieth of an ounce of gold. Thus it was cheaper to buy almost everything outside of California, leading to gold rapidly finding its way to other states and other lands. The same would happen in a water-based currency if water was discovered on Luna. In an exchange market in LEO, where water is in extreme demand for outgoing rockets, lunar water would need only two Burns to import (delta-v = 5 km/sec), half that of water boosted from Earth (10 km/sec).

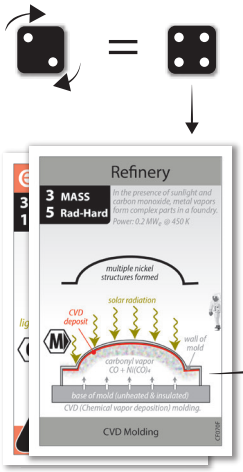
D. Yearly Play Sequence

After Setup, *High Frontier* proceeds as a series of **years**. Each year consists of:

a. **Player Turns**. Starting with the 1st Player and going clockwise, each player takes one *Turn* **(D1)**.
b. **Sunspot Cycle Advance**. If a threshold is crossed, see **(D2a,b).**

EXAMPLE [D2a]





A pad explosion is rolled. The 1st player has two Mass 3 cards in his LEO Stack and chooses one to Decommission. Then, the other players in clockwise order pick one of their heaviest LEO cards to Decommission.



Returned to the player's Hand.

D1. Player Turn Phase

In this phase, each of the players takes a Turn. You may do either or both of the following on your Turn, in any order: move your Rocket and/or perform an Operation. Except during movement or an Operation, you may perform any number of *free actions*.

a. **Movement (H).** You may move your Rocket once per Turn. Some Modules allow multiple Spacecraft, and if so, you may move each of them once per Turn.
b. **Operation (I).** You may perform one Operation per Turn.
c. **Free Actions (G).** You may perform any number of *free actions* on your Turn, including the same free action multiple times.

TYPICAL TURN: ET
Produce a Black-Side Card at Factory (operation). Place Black-Side Card at Outpost at same location. Land Rocket at Outpost (move). Cargo transfer to add Black-Side Card to Rocket (free action). [D1]

D2. Advance Sunspot Cycle Phase

The *1st Player* **(C8)** advances the Sunspot Cube clockwise, which may trigger a threshold:

a. ◊ **Event Threshold.** If the cube crosses an "event" threshold, make an *Event Roll* **(K2)** and resolve the event (which is applied to all players, starting with the 1st Player).
b. **Seniority Threshold.** If the cube crosses the "SENIORITY" threshold, remove a Seniority Disk. If no disks remain, the game immediately ends with *scoring* per **M2**. Player order can change if using Module 0 **(O6b)**.

E. Hands & Stacks

Hand Cards represent patented know-how. By moving a Hand card into a **Stack** (either White-Side up by boosting it to LEO or Black-Side up by *ET production* at a Factory in space), it becomes a tangible object.

E1. Hand Cards

Store your Hand cards to the right of your playmat.

a. **No Hand Limit.** Your Hand can contain any number of cards. However *academia hand limits* apply **(I2a)**.
b. **Open Hands.** Your FTs, Hand cards, and Stacks are free for anyone to examine.

E2. Stacks

A Stack is a collection of cards and/or FTs, placed in a designated slot on your playmat. In the core game, you can have up to 4 Stacks: **LEO, Rocket, Outpost #1**, and **Outpost #2**. Store these in the named slots on your playmat. Each has a location on the map as indicated by the location of its Figure.

a. **No Card Limits.** Your Stacks can contain any number of cards or FTs. However, you may not move a Rocket if its Wet Mass is greater than 32 or its Dry Mass is greater than 23.
b. **Stack Figures.** If a Stack is created (except for LEO), place a Figure/outpost chit on the map to indicate its location **(E5, E6)**. Except for LEO, you cannot create a Stack if you do not have a Figure/outpost chit for it.
c. **Stack Creation.** Stacks are created by *cargo transfer* **(G1)**, *boosting* **(I4)**, *site refuel* **(I5)**, or *ET production* **(I8)**.
d. **Stack Swapping & Negotiated Transfer.** See **G1e** and **N3.**
e. **Empty Stacks.** If no cards or FTs remain in a Stack, Discard its Figure or outpost chit from the map.
◊ Also Discard any Glitches.

EASILY FORGOTTEN:
A Stack can be made up of just FTs on an Outpost. A Stack could also be made up of a collection of cards (e.g. a Rocket) and its FTs. [E3]

EASILY FORGOTTEN:
In the core game, you are only allowed one Spacecraft, your Rocket Stack. [E3a]

MISSION PLANNING TIP: If you are preparing for a huge mission, get a small interim mission going. A 2 card Rocket Stack (or a one card robonaut/ thruster Rocket Stack) can do something, anything! A Crew plus 5 tanks of Fuel can claim Mars (although be careful, they could become trapped there). Or a Crew with an efficient thruster can claim a glory chit. [E4a]

EASILY FORGOTTEN:
Note that FTs carried as Cargo are not the same as water loaded as Fuel. The mass of FTs carried as Cargo is included in the Dry Mass Chit, while the mass of loaded Fuel affects the position of the Wet Mass Chit. [E5c]

MISSION PLANNING TIP:
Carefully calculate how much water you will need to get to a destination where you can refuel. First, count the number of Burn Spaces to your destination, and then multiply this number by your fuel consumption (B2d). This gives the minimum required number of fuel steps between the Wet and Dry Mass Chits, following the black line leftwards. [E5d]

E3. Number of Stacks Permitted

To represent the limits of mission control and spacesuited Humans, you are strictly limited to one each of the following Stacks at the end of your Turn:

a. **Rocket Stack** – represented on the map by your Rocket Figure.
b. **LEO Stack** – is always at the Space on the map marked LEO, and is not represented by a Figure.
c. **Outpost Stack 1** – represented on the map by your #1 Outpost Chit.
d. **Outpost Stack 2** – represented on the map by your #2 Outpost Chit. During your Turn you may create as many Outpost Stacks as you wish, but by the end of your Turn you must have no more than two of them.
e. **Freighter Stack** (Module 1) – represented on the map by your big cube.
f. **Kalpana Bernal Stack** (Module 2) – represented on the map by a finned sphere figure of your player color.
g. **Stanford Bernal Stack** (Module 2) – represented on the map by a torus figure of your player color.

E4. LEO Stack Creation

Your **LEO Stack** is like an outpost that is permanently located in Low Earth Orbit (marked "LEO" on the map). Its cards and Aquas reside in the "LEO Stack" slot on your playmat. Unlike other Stacks, this Stack does not have its own Figure.[18]

a. **Creation.** See **E2c**. The *boost operation* will normally be used to create your first LEO Stack.

E5. Rocket Stack Creation

Designate a Stack as a **Rocket Stack** by placing its cards and/or FTs in the designated Rocket slot on your playmat.[19] It must include an *activated thruster* to move **(H2)**, but a Crew is not required and any Stack can be designated a Rocket Stack. Indicate its location on the map using a Rocket Figure. Place a Dry Mass Chit on your playmat's Fuel Strip according to the Rocket's Mass.

a. **Creation.** See **E2c**. The *cargo transfer free action* will normally be used to create your first Rocket Stack in LEO by transferring cards from your LEO Stack to your Rocket Stack.
b. **Rocket Stack Limit.** You may only have one Rocket Stack at a time. If you already have a Rocket Stack, before another is created you must first either Decommission your existing Rocket Stack (*free action* per **G6**) or turn it into an Outpost Stack (*free action* per **E6**).
c. **Place Dry Mass Chit.** Your Dry Mass is the sum of each card's *Mass* **(B2b)** plus 1 for each FT in the Rocket Stack. Place your Dry Mass Chit for your Rocket in the spot on your Fuel Strip with this number **(F2b)**.
d. **Fueling & Wet Mass Chit.** When first created, a Rocket's tanks are empty. Indicate this by selecting a **Wet Mass Chit** of the same *color* **(F4b)** as the Spacecraft's *thrust triangle* and placing it on top of your Dry Mass Chit. If you wish to immediately add Fuel to your Rocket, either by *cargo transfer* **(G1)** or *site refuel* **(I5),** move the Wet Mass Chit to the right per **(F3b)**

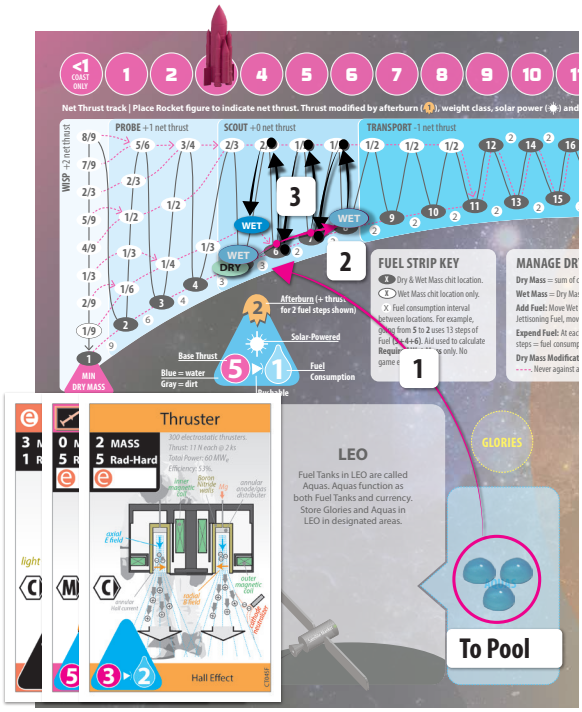
EXAMPLE [E5]

You create a Rocket Stack in LEO with a hall effect thruster (mass 2), supported by a cascade photovoltaic generator (mass 3), plus a tungsten resistojet robonaut (mass 0) in Cargo. You place both the Dry and Wet Mass Chit on 5. This shows the Rocket starts with no Fuel.

Your intended destination is Mars along the red signpost route (B7i), which is 3 Burn Spaces away. Since the fuel consumption of the active thruster is 2, the number of steps of water required is 2 x 3 = 6.

You will need to load up with 3 tanks of water, taken from your Aqua (1), moving your Wet Mass Chit 3 steps along the red dashed line (2). This gives you 7 steps of water to burn going back along the black line between '8' and '5'.

When moving the Rocket to Mars, it crosses 3 Burn Spaces. Its Wet Mass goes down 6 steps along the black line (3).



18 LEO (Low Earth Orbit) is from 350 to 1400 km above Earth's surface. It is normally below the protective shield of the Van Allen Belts. However, during solar storms the belt can impinge on this orbit creating higher radiation than in GEO.

19 ROCKET is a vehicle that expels reaction mass, also called propellant, to make itself change its velocity by the law of action/ reaction. The faster the propellant is expelled, the smaller its propellant consumption. Two common types of rockets are **thermodynamic** and **electric:** (a) Thermodynamic rockets accelerate propellant by heating it and allowing it to acquire its velocity and direction in a nozzle. The fuel consumption varies inversely with the square root of the temperature of the hot gases divided by the propellant molecular weight. Thus light elements such as hydrogen are favored as propellants in thermodynamic rockets. (b) Electric rockets use electricity to accelerate propellant. Because they are limited by the electrical power available (assumed to be 60 MWe in this game), they have very low (milligravity) accelerations.

E6. Outpost Stack Creation

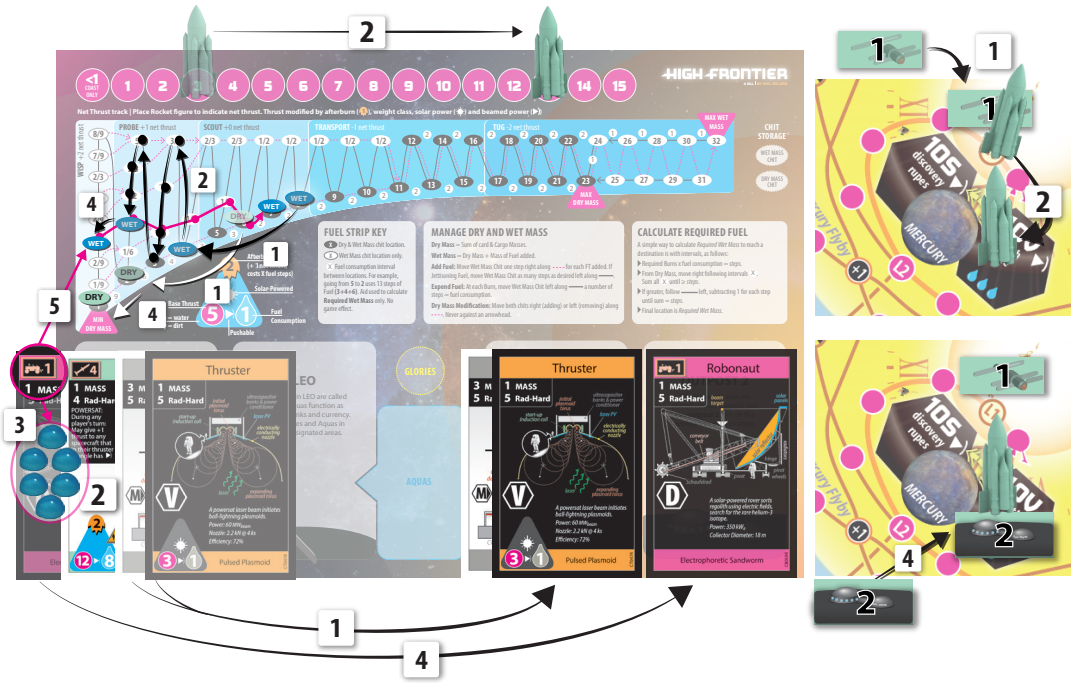
As a *free action* **(G1d,e)**, you can create or convert a Stack into **Outpost #1** or **Outpost #2** by placing the #1 or #2 outpost chit of your color. You are limited to 2 outposts by the end of your Turn.

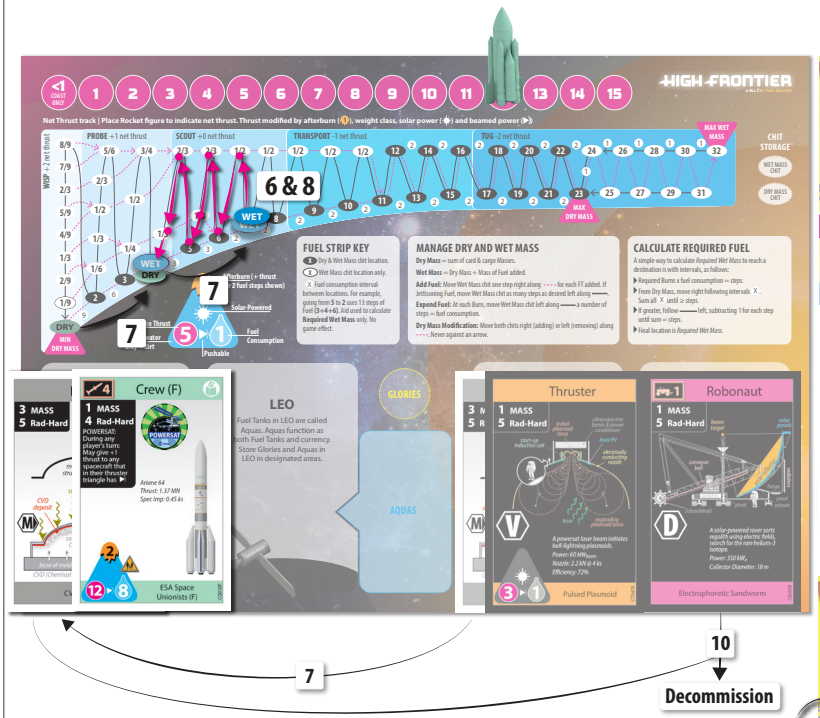
a. Creation Methods. See **E2c.**

b. Location. You can create outposts anywhere, e.g. at a Site where your Rocket is Decommissioned after dropping off Cargo, at a Factory performing *ET production*, or at a Hohmann transfer where your Rocket has been disabled by a Glitch.

EXAMPLE [E6b]

A big Rocket Stack arrives at Mercury L1, with a net thrust too low for a powered landing on Mercury (Size 10).







1. The thruster and refinery are made into Outpost #1 at L1, leaving the Crew and sandworm robonaut as the Rocket.

2. On the next Turn, the Rocket activates the thrust triangle of its 12•8 Crew. This allows the Rocket (probe class with Dry Mass = 2 and Wet Mass = 4) to make a powered landing (modified thrust = 13). The Wet Mass goes down 8 steps for the Lander Burn (to 2 ⅓).

3. During 2 Turns of ISRU refuel operation, the sandworm (IRSU = 1) adds 6 FTs to the Rocket Stack.

4. The sandworm is made into Outpost #2 on the surface of Mercury, adjusting the Rocket's Wet and Dry Mass.

5. The 6 FTs are added to the fuel strip, using cargo transfer (free action, **G1b**).

6. The Crew makes a powered liftoff (scout class with Dry Mass = 1 and Wet Mass = 7) delivering the Crew to rejoin Outpost #1.

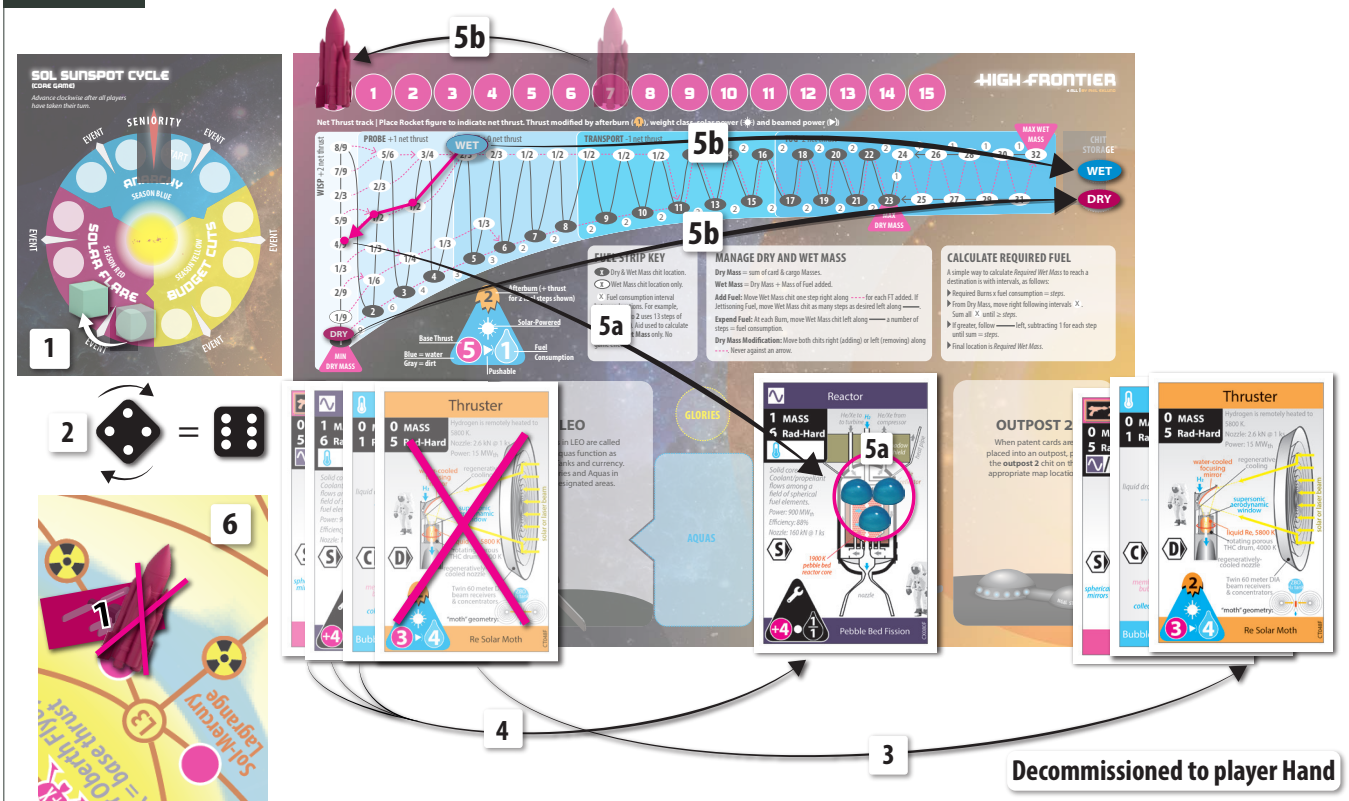
7. The Crew picks up the CVD molding refinery (Mass = 3) from Outpost #1.

8. On the next Turn, the Crew and refinery (scout class with Dry Mass = 4 and Wet Mass = 7) land on Mercury.

9. In the same turn a prospect operation (**I6**) places a Claim disk on Mercury.

10. The following Turn a Factory is built using an industrialize operation (**I7**). This Decommissions the robonaut and refinery. As there are no cards left in Outpost #2, the chit is returned to the player's Reserves.

EXAMPLE [E6c]



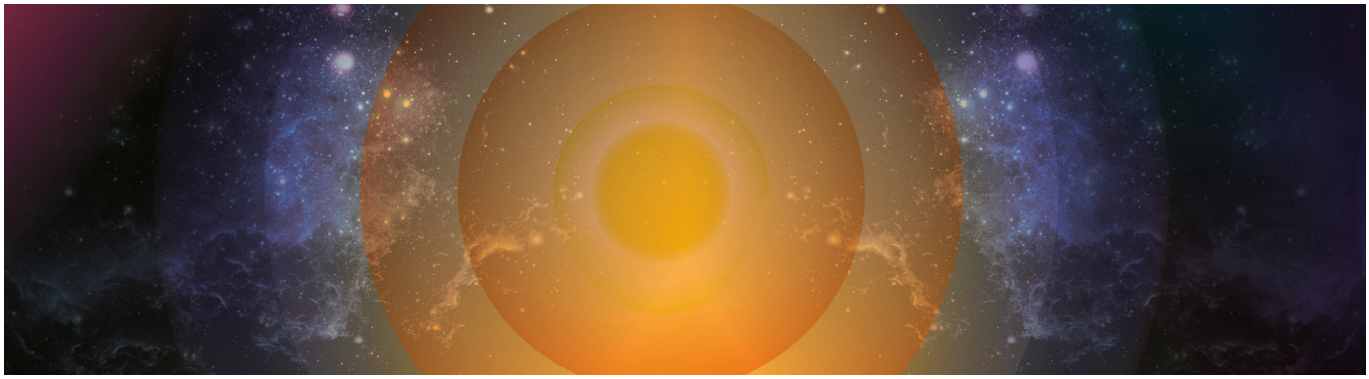
An event (1) results in a solar flare (K2d). The CME Roll (2) has severity = 4. Your Rocket Stack is in the Mercury Zone with a +2 modifier, so the modified severity of 6 knocks out all the cards of your Rocket Stack except the reactor (3). At the start of your Turn, you choose to convert the Rocket Stack into Outpost Stack #1 and move all the surviving cards and FTs to this slot on your playmat (4). Net thrust and Dry/Wet Chits are returned to your Reserves (5b). This allows you to form a Rocket Stack elsewhere, potentially as a rescue mission. You have the option to change Fuel into 3 FTs, which are put on top of the Stack (5a).

c. **Fuel Outpost.** You can create an Outpost Stack by producing FTs at a Factory **(I5b)**.
d. **Swapping Outposts.** Because of the 2 outpost limit, if you create a third, you must Decommission or redesignate **(G1e)** one by the end of your Turn.

E7. Decommissions

A Decommission returns a card to your Hand. Decommissions can either be **voluntary:** *jettison cargo* **(G1g)**, *Phileas Fogg* **(G2c)**, *build colony* **(G3),** *voluntary decommission* **(G6),** and *industrialize* **(I7)**, or **involuntary:** e.g. Glitch Rolls, *Hazard Rolls* **(H7)**, Belt Rolls, CME Rolls, or *pad explosions* **(K2c)**.

a. **Rocket Fuel.** If a Spacecraft Stack loses its last card with a *thrust triangle* **(B2d)** to involuntary Decommission, remove its Dry and Wet Mass Chits.
b. **FTs.** If the last card in a Stack is involuntarily Decommissioned, Discard its FTs to the Pool.
c. **Humans.** If your Crew suffers voluntary or involuntary decommission, move them to your LEO Stack/Bank. You may not voluntarily decommission Humans (including Crew) except in certain circumstances (see "Crew" and "Murder/Suicide" in the glossary).
d. **Radiator Ablation.** A radiator card played in its heavy Orientation *(see glossary)* rotates to its light Orientation instead of being involuntarily decommissioned upon failing Glitch Rolls, *Hazard Rolls* **(H7)**, or *Belt Rolls* **(H10)**. Ablation can also occur in *jettison* **(G1g)** or *Phileas Fogg* **(G2c).** Any other involuntary Decommission will entirely Decommission the radiator card.



F. Spacecraft Mass & Fuel Management

Each player has a Fuel Strip printed on their playmat for tracking the Fuel Mass steps of their Spacecraft.

a. **Dry Mass** is your Spacecraft's Mass assuming its tanks are "dry" (empty). Thus it includes just the Mass of its FTs and cards.
b. **Wet Mass** is your Spacecraft's Dry Mass plus the Mass of the Fuel onboard.
c. **Indicators.** Each Fuel Strip has a Dry Mass Chit in the player's color and a blue or gray Wet Mass Chit

F1. Wet Mass Fuel, FTs, & Aquas

Fuel can be stored on a Spacecraft in two ways: as **Wet Mass Fuel** (tracked on the Fuel Strip) or as **Cargo** (fuel tanks or **FT**s). Players can internally *change* between these tankage forms as a *free action* **(G2)**.

a. **Wet Mass Fuel.** The amount of Fuel is indicated by the number of steps on the black line of the Fuel Strip between the Dry Mass Chit and the gray/blue Wet Mass Chit.[20]
b. **Dry Mass FTs.** Each FT bead placed on your Spacecraft Stack is considered Cargo. Each Cargo FT has a Mass of 1. Adding FTs as Cargo will adjust both Wet and Dry Mass **(F2b)**.
c. **Aquas.** These blue beads in your LEO Stack serve as the game's currency, and are used for *boost operations* **(I4),** *research auction operations* **(I2)**, *negotiation* **(N)** and paying for FINAO to avoid *Hazards* **(H7).** They also function simultaneously as Water FTs to be used for fueling and carried as Cargo.

EASILY FORGOTTEN: You can stop at small wet worlds along the way to ISRU refuel with water, or any small world to ISRU refuel with dirt. [F1]

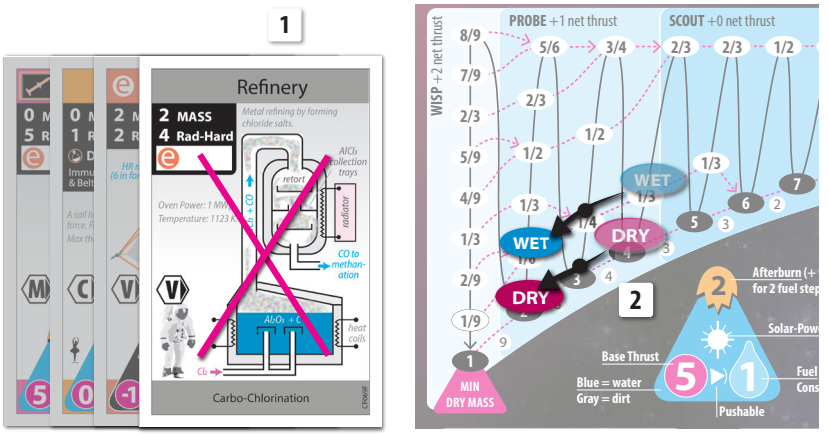
F2. Dry Mass Adjustment

A Spacecraft's Dry Mass Chit on the Fuel Strip indicates the Spacecraft's Mass ignoring Fuel. This includes the Mass of its cards and its FTs (note that FTs are regarded as Cargo and not Fuel). Adjust a Spacecraft's Dry Mass before its Movement **(H).**

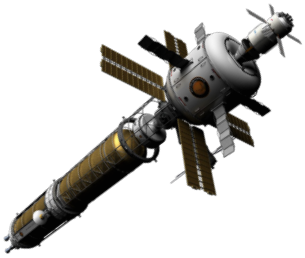
a. **Max & Min Dry Mass.** In order for a Spacecraft to move, its Dry Mass Chit must somehow be reduced to '23' or below, as indicated on the Fuel Strip. A Spacecraft with a Dry Mass of '0' is considered to have a Dry Mass of '1'.
b. **Wet/Dry Mass Adjustment.** For each unit of Dry Mass (cards or Cargo Fts) gained/lost, move the Dry Mass Chit one step to the right/left along the dashed red lines. Then, move the Wet Mass Chit an equal number of steps again along red lines in the same direction. If given a choice of paths, never go against the arrowhead.

EXAMPLE [F2b]

Your Rocket has a Dry Mass Chit on the "4" spot and a Wet Mass Chit on 4-⅓. You drop off Cargo with a Mass of 2. (1) Move the Dry Mass Chit two steps left to the number "2" spot. Move the Wet Mass Chit two steps left as well, to the 2–⅙ spot. (2)



c. **FT Dry Mass Adjustment**. When changing *internal tankage*, either changing FTs into Fuel **(G2a)**, or changing Fuel into FTs **(G2b)**, move only the Dry Mass Chit in the same way as the previous bullet.



20 WET MASS "FUEL" in this game is often not actually fuel at all, but rather **propellant:** the stuff expelled in one direction to make the rocket go the other direction. Fuel is not reaction mass, but rather the stuff that contains the rocket's energy. A nuclear rocket might use uranium as fuel, but water as propellant (and needs far more propellant than fuel). My rules are sloppy in this terminology. In this game, only chemical and isotope rockets track fuel, all other rockets track, not fuel, but propellant. A rocket that runs out of fuel is crippled, but not dead: space is suffused with energy. A rocket that runs out of propellant is dead: space is notably lacking in mass.

F3. Wet Mass Adjustment

A Spacecraft's Wet Mass Chit indicates the Spacecraft's total Mass, and can never be less than its Dry Mass. Like the *Dry Mass adjustment* **(F2)**, make this adjustment for a Spacecraft at the beginning of that Spacecraft's Movement **(H)**.

- **a. Max Wet Mass.** Before a Spacecraft can move, its Wet Mass Chit must be reduced to '32' or below, by e.g. *jettison* **(G1f,g)**.
- **b. External Wet Mass Adjustment.** If Fuel is added from an external source *(refueling or cargo transfer)*, move the Wet Mass Chit one step to the right along the dashed red lines for each tank of Fuel added **(G1b)**.
- **c. Internal Wet Mass Adjustment.** When changing the *internal tankage* **(G2)**, the Wet Mass Chit does not change, since an internal transfer does not change the total Spacecraft Mass **(F2c)**.
- **d. Burning Fuel.** Move the Wet Mass Chit to the left along the **black** lines during a *Burn* **(H5)**, *afterburn* **(H3a)**, or when *jettisoning fuel* **(G1f)**.
  - **• No Negative Propellant.** The Wet Mass Chit must never cross the Dry Mass Chit.

EXAMPLE [F3d]

Your mission is to take a Mass 3 refinery from LEO to Mercury. You use a 12•8 thruster, a 0•0 Sail card, and 4 tanks of water on the fuel strip (for landing).

1. The Rocket's Dry Mass = 4 and Wet Mass = 8. Its weight class is scout, so it has no thrust modifiers and a net thrust of zero using the Sail. The 12•8 Thruster has to be activated instead. The 4 tanks of water provide 10 steps of Fuel. This is only enough for 1 Burn of the 12•8 thruster.

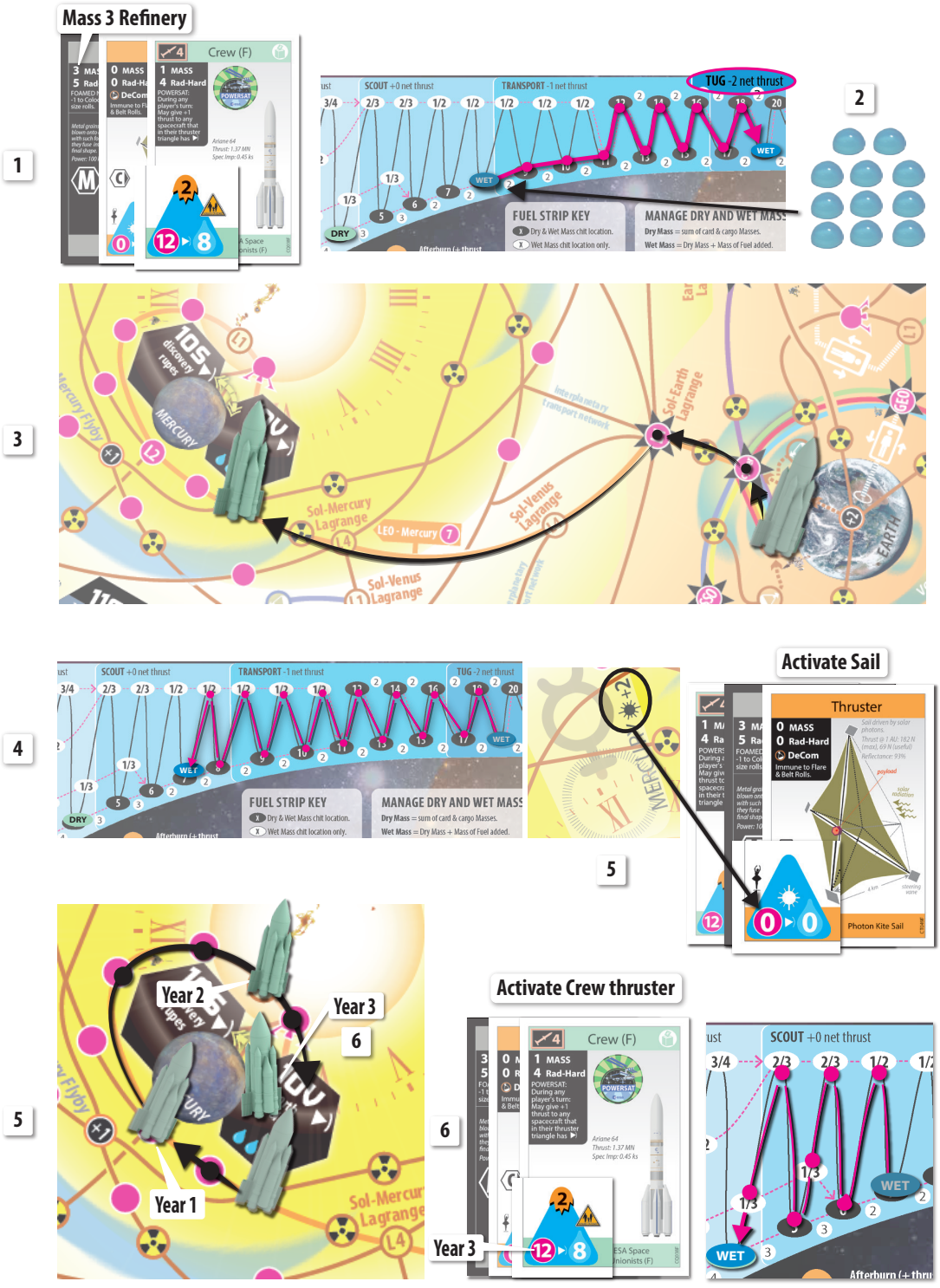
2. 11 Aquas are loaded to the fuel strip to bring the Wet Mass Chit up to a Wet Mass of 19.

3. The 12•8 thruster is activated to get through the first 2 Burn Spaces in the orange signpost route.

4. This lowers the Wet Mass Chit 16 steps to 7, and the Rocket is now in the Mercury Heliocentric Zone, which gives a +2 thrust to Sails.

5. The Rocket is scout weight class. Next turn the Sail is activated, for a net thrust of 2. This is enough to sail to L1 just outside the lander burn of Mercury over the next 2 Turns.

6. On the next Turn, the 12•8 thruster is activated, and expends the last 8 steps of Fuel.



F4. Fuel Grades & Mixing Fuel

Fuel and FTs come in three grades: **dirt** (gray), **water** (blue) or **isotope** (gold). This is represented by an appropriately colored Wet Mass Chit for Fuel and blue and gold beads representing water and isotope FTs respectively.

a. Wet Mass Chit must be gray, blue, or gold, representing loading dirt, water propellant, or isotope fuel, respectively.

b. Fuel Grades. From lowest to highest, the fuel grades are: dirt (gray), water (blue), and isotope (gold). This is relevant for ***activation* (H2)**, ***fuel mixing* (F4d)**, and the rate of ***refuel* (G1c, I5)**. A Spacecraft can only have a single grade of Wet Mass Fuel **(F4d)**.

c. Thruster Fuel Compatibility. A Spacecraft may be fueled with any type of Fuel, but it cannot expend Fuel in a Burn or use an ***afterburner* (H3a)** if the color of the activated ***thrust triangle*** is of a higher grade than the color of the Wet Mass Chit.

- Assuming a Spacecraft must expend Fuel, a dirt thruster can be activated with any color Wet Mass Chit, a Water Thruster can be activated with a blue or gold Wet Mass Chit, and an Isotope Thruster can only activate with a gold Wet Mass Chit.

EXAMPLE [F4c] **You cargo transfer 2 blue FTs to your mass driver (a dirt rocket), moving its gray Wet Mass Chit from 20 to 22. Per G2b, dirt fuel cannot subsequently be converted into FTs, as the water has been "lost".**

d. Fuel Mixing. If a Spacecraft adds Fuel of a different grade than the color of its Wet Mass Chit, all of its Fuel becomes the lower of the two grades (swap its Wet Mass Chit to the correct color, if necessary).

- Fuel can be ***jettisoned* (G1f)** or changed to FTs **(G2b)** before mixing if you wish to avoid this.
- A Spacecraft with no Fuel does not cause Fuel mixing (swap its Wet Mass Chit to whatever you load it with).
- A Spacecraft can carry both blue and gold grades of FTs.

G. Free Actions

Except during Spacecraft movement or during an Operation, each of the following **free actions** may be performed any number of times and in any order during your Turn. They are called "free" because they do not expend your single Operation that you are allowed each Turn.

G1. Cargo Transfer

This free action transfers any number of cards, Fuel, or FTs from one Stack to a Colocated Stack.

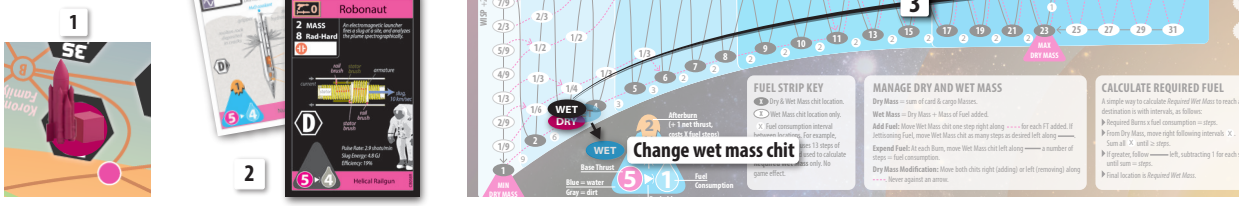
a. Dry Mass Cargo. Perform a *dry* and *wet mass adjustment* **(F2)** if your Spacecraft Stack had gains or losses of Mass, (e.g. loading or unloading Cards or FTs). Each FT has Mass 1 and is considered Cargo when loaded. Place the FT marker on the Stack.

b. Fueling Rocket. FTs can be loaded directly as Fuel onto the Fuel Strip. For every FT discarded into the Pool from a Colocated Stack, move the Wet Mass Chit 1 spot to the right along the dashed red lines **(F3b)**.
If mixing fuel grades, either consider the higher fuel grade loaded being downgraded into the color indicated by the Wet Mass Chit **(F4b)**, or swap the Wet Mass Chit per **(F4d)**.

EXAMPLE [G1b] **You create a Rocket Stack in LEO with Dry Mass of 6. You cargo transfer 4 Aquas, placing a blue Wet Mass Chit on the "10". [G1b]**

c. Dirt Refueling. If your Spacecraft with an activated dirt thruster is on a Site and has (or changes to) a gray Wet Mass Chit, and you have either a Factory, or any card present (robonaut or Human) with an Operational ISRU platform, you can ***cargo transfer*** dirt fuel. This is regardless of the ISRU rating of the card or the Site's Hydration (regolith is easy to find). Adjust your ***Wet Mass* (F3b)** to any desired value (for non-crew dirt thrusters), or (as once-per-turn free action) by one fuel tank (Crew dirt thrusters).[21]

EXAMPLE [G1c]



Using ET Production, you ET produce a helical railgun robonaut (2) (which has a gray 5•4 thrust triangle) on Psyche (1). On this same Turn, you create a Rocket Stack (together with a previously-produced triggered decay nuclear battery as a support), set Dry Mass to 3, cargo transfer dirt for a Wet Mass of 32 (the max Wet Mass) (3), use factory-assist to launch, and then move your dirt rocket.

21 FLUIDIZED REGOLITH. A few Crew cards are dirt rockets, and these represent solid fuel thrusters which can be refueled by regolith. If the regolith fines are small enough, the reaction surface area for the alkaline metals and oxidizing compounds found in the dust is high enough for it to become combustible or even explosive in oxygen. The Isp is poor, perhaps 0.15 ks. A more refined regolith rocket would use aluminum and oxygen refined from lunar anorthite for an Al-O_2 hybrid booster at 0.27 ks. A non-crew dirt thruster such as a mass driver provides the grinders required to create infinite solid fuel given an infinite amount of regolith. The grinders are necessary to support dust explosion combustion.

d. Create Rocket/Outpost Stack (E5, E6). You may also use *cargo transfer* to create a new Stack (e.g. Rocket or Outpost) composed of cards or FTs (restricted as per **E3d**).

e. Swapping Outpost/Rocket. You may exchange any of your Rocket or Outpost Stacks on the map with another of your Rocket or Outpost Stacks. Swap their Figures/outpost chits on the map and swap the Stacks (including cards, Glitches, and FTs) to the appropriate new slots on your playmat.

- **Flush Fuel.** Any Fuel on the Fuel Strip in the original Rocket is lost unless changed into FTs before swapping per **G2b.**
- **Convert Outpost Into Rocket.** Set the Dry and Wet Mass Chits to be equal to the Mass of the original outpost **(F2)**.

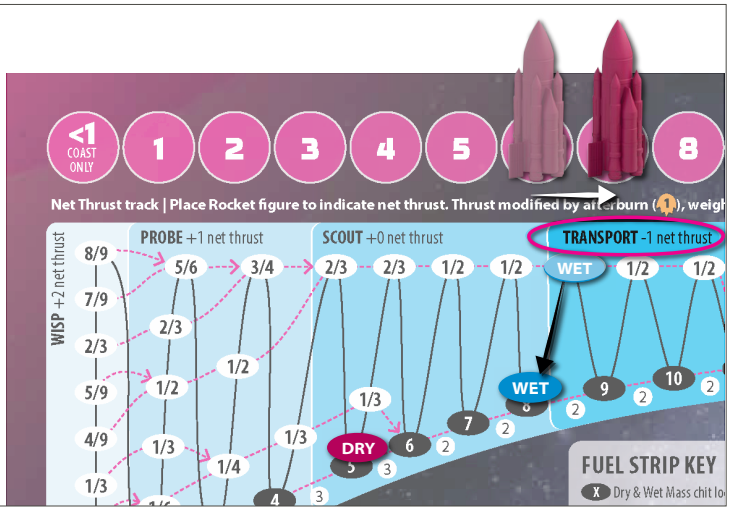
f. Jettison Fuel. Move your Wet Mass Chit any number of steps to the left (following the **black** line). The Fuel is considered lost to space.

g. Jettison Cargo or FTs. Decommission the desired cards and FT beads from any Stack. If it is a Spacecraft Stack, move both the Wet and Dry Mass Chits a number of steps to the left (along dashed red lines, taking the lower path if you have a choice) equal to the Mass removed. Radiators can be partially jettisoned, see Orientation (glossary) or example **G2c**.

h. ◊ Infectious Glitch. If transferring Cargo and either the giving or receiving stacks are Glitched, performing a *cargo transfer* is a Glitch Trigger (see glossary) for both Stacks and both Stacks end up with a Glitch.

EXAMPLE [G1g]

Your base thrust is 7 and you wish to make a powered landing on Ceres (Size 6). However, your Wet Mass is 8-½ which puts you into the transport class (-1 thrust). This makes your net thrust = 6, yet you need 7 to make a powered landing. If, before your move, you jettison one step of Fuel, your Wet Mass decreases to 8 which is scout class (+0 thrust). Now your net thrust is 7, enough for a powered landing.



REMINDER: If you exceed the maximum Dry Mass (F2a) or Wet Mass (F3a), as indicated on your Fuel Strip, your Rocket will not be able to move until you make further mass adjustments. Don't panic! These actions are nearly identical to G1 but are listed separately because no mass is entering or leaving the Stack. If converting Cargo FTs to Wet Mass Fuel or vice versa, the total weight of the Spacecraft (Wet Mass) does not change. For every 1 Dry Mass of FT Cargo you change to Wet Mass Fuel, your total Dry Mass decreases by 1, and the amount of Fuel in your Spacecraft increases by 1. Thus the Wet Mass Chit remains where it is, and the Dry Mass Chit is moved 1 step down the dashed red line. [G2]

G2. Internal Tankage

Fuel can be on your Spacecraft stack either as Wet Mass Fuel **(G1b)** or Cargo **(G1a)**. The following free actions allow you to change your tankage between these two forms within your Spacecraft **(F3c)**:

a. FT to Fuel. Move the Dry Mass Chit any number of steps to the left (following the dashed red line) and lose that many FT of the same color as your Wet Mass Chit.

- **Wet Mass Chit** is left unmoved, as the total Mass of the Stack remains the same.
- **Fuel Grade.** See *fuel mixing* **(F4d)** if the color of the FTs does not match that of the Wet Mass Chit.
- **Reminder.** A Spacecraft's Wet Mass must never be less than its Dry Mass.

b. Fuel to FT. Move the Dry Mass Chit any number of steps to the right (following the dashed red line) and gain that many FT of the same color as your Wet Mass Chit. This cannot be performed if your Wet Mass Chit is gray, since there are no gray FTs.

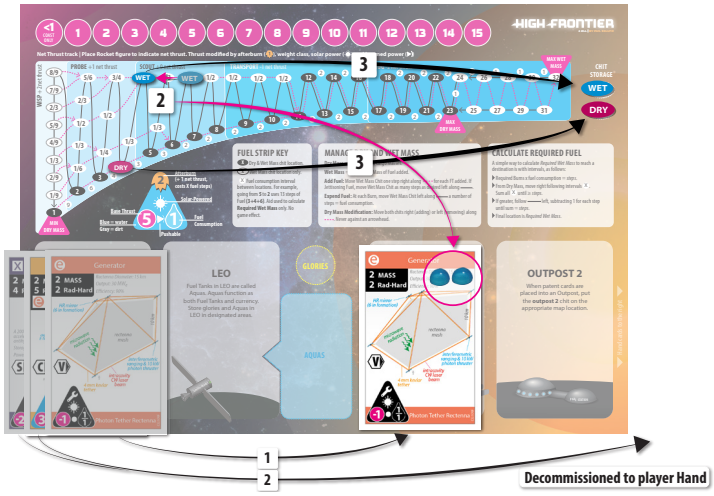
EXAMPLE [G2b]

Your Rocket delivers a generator to your Claim, in anticipation of industrializing it later.

1. The generator is separated to form Outpost #1. The Rocket then has Dry Mass = 4, and Wet Mass = 6-½.

2. You change the Fuel into 2 FT, and add both FT beads into Outpost #1. This moves the Wet Mass Chit 2 steps left.

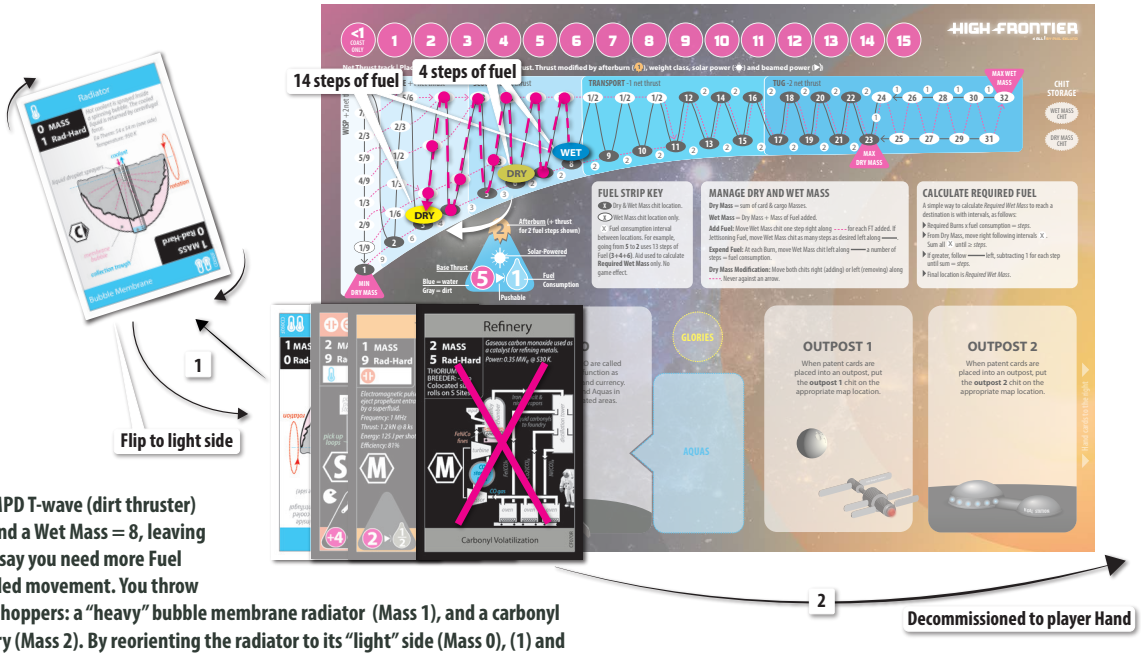
3. You Decommission the Rocket (which wastes the 2 remaining steps of fuel), so that it can be re-boosted to LEO to bring the robonaut and refinery.



c. **Phileas Fogg.** Voluntarily decommission any number of non-Bernal cards from your Rocket Stack to move its Dry Mass Chit one step to the left (following dashed red line) per unit of mass Decommissioned (as if changing FTs to fuel **(G2a)**). Because it simulates machinery ground up and fed into the engine hopper, this is considered to be adding dirt grade fuel (for *fuel mixing,* **F4d**).

- ♢ **Fogg's Heavy Radiators.** If you have a gray Wet Mass Chit and rotate your heavy radiator to its "light" Orientation (see glossary), move the Dry Mass Chit to the left (following the dashed red line, taking the lower path at intersections) a number of tanks equal to the difference between the masses of the Heavy and Light Orientations.

EXAMPLE [G2c]



Your Rocket with a MPD T-wave (dirt thruster) has a Dry Mass = 6 and a Wet Mass = 8, leaving 4 steps of Fuel. Let's say you need more Fuel steps for your intended movement. You throw some Cargo into the hoppers: a "heavy" bubble membrane radiator (Mass 1), and a carbonyl volatilization refinery (Mass 2). By reorienting the radiator to its "light" side (Mass 0), (1) and Decommissioning the refinery (2), you decrease the Dry Mass from 6 to 3, while the Wet Mass remains at 8. Now, instead of 4 steps of Fuel, you have 14 steps.

G3. Build Colony

Build a Colony by Decommissioning a Human Colocated with one of your Factories that does not already have a Colony and placing a Colony dome on it. Follow these steps:

a. **Workforce.** Decommission one Colocated Human card (Crew or Colonist). They have become settlers, so this is neither a Felony nor Murder. However, it is a Felony 😎 to colonize the kreutz sungrazer.
b. **Colony Figure.** Take a dome from your Reserve and set it on top of the Factory.
c. **Delegate** (Module 0). You may assign a cube from your Reserve as a *delegate* **(O2a)**. The Ideology must match the Ideology stated on the Crew/Colonist. This causes a *vote tally* **(O3a)**.
d. **Exomigration** (Module 2) If a Colony consumes a Colonist, perform *exomigration* **(2A6a)**.

VICTORY TIP: Colonies are worth more VP on Astrobiology or Submarine Sites, see M2b. [G3]

G4. Claim Jump

If you can commit a Felony 😎 (which requires Humans, see glossary), replace an opponent's Claim with one of your own unless it is Colocated with a Factory **(I7)** or a Human opposed to this Claim Jump.

a. **Disk Limit.** Your Reserve of Claims is limited. If you have no more Claim disks, then you may remove from another of your unindustrialized claimed Sites.
b. **Territoriality**. As long as no opposed Humans are present, Claim Jump allows you to claim Luna without the permission of the 1st Player **(I6.1)**.[22]

EXAMPLE [G4b] **Both NASA and Taikonauts have Rockets on encke's comet. NASA prospects successfully, placing a white Claim. On their Turn, the manned Chinese Rocket feloniously claims the Site, replacing the NASA disk with a purple disk.**

G5. Load Glory Chit

If you have Humans at a Site in a Heliocentric Zone with an unclaimed *glory chit* **(B3)**, you can add it to a Colocated manned Spacecraft Stack as a free action, low value side up. If this Human brings it to your Bank, it is automatically deposited into the "Glory" circular space on your playmat, high value side up, in a *ticker tape parade* **(La)**.

a. **Glory Carry Limit.** A Crew or Colonist can only carry 1 glory chit at a time.

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22 LUNA TERRITORIALITY. The Communist Party of China (CPC) under President Xi has worked to build alliance structures, signed memoranda of understanding (MoUs), and offered to collaborate on lunar missions with other countries. This is part of Xi's vision of creating a world order where China not only has capacity but also legitimacy as the country that champions a peaceful and harmonious world order. Using Sun Tzu dictums to claim a moral legitimacy of power, President Xi declared himself president for life while arranging for dissidents to disappear and threatening to smash protesters in Hong Kong with the military.
—Namrata Goswami, *China's grand strategy in outer space: to establish compelling standards of behavior,* 2019.

G6. Voluntary Discard of Cards & Tokens

During your Turn, you may either Discard or ***Decommission*** **(E7)** cards from your Hand or Stacks. Discarding sends cards to the bottom of the appropriate patent deck which can be helpful to participate in ***auctions*** **(I2a)**. If a Stack contains no more cards or FTs, Discard its Figure/outpost chit from the map into your Reserve. Other tokens can be Discarded into your Reserve with the following limitations:

a. **Factories** are made of two tokens: a cube sitting on a disk (Claim), and both must be the same color, unless *negotiated* during industrialization **(N3** or **N6)**. Discarding a cube makes the Claim available to be ***re-industrialized*** **(I7)**, and Discarding a Claim makes the Site available to be ***re-prospected*** **(I6)**.

b. **Colony Permanence.** A Colony dome is a Human, and neither it nor its Colocated Factory and Claim can be voluntarily Discarded, even if allowed Felonies.

EXAMPLE [G6b] **During your Turn, you anticipate participating in auctions that opponents will initiate. But you have 5 cards in your Hand. You choose one thruster to Discard to the bottom of the thruster deck, and one reactor to the bottom of the reactor deck. You now have 3 hand cards, allowing auction participation.**

G7. ♢ Glitch Repair

EASILY FORGOTTEN: **You can hire out your Crew (N7) to help (at great expense) a glitched and desperate opponent. [G7]**

Discard a Glitch **(♢ K2b)** on a stack Colocated with your Human (including Colonies and LEO).

EXAMPLE [G7] **There is a glitch event and your Rocket Stack suffers a Glitch. But your Rocket lands on a Colony which performs a glitch repair.**

H. Movement

Spacecraft are capable of flight. The types of Spacecraft include (with the proper Modules): 1 Rocket, 1 Freighter (plus Mobile Factories), and 1 Bernal. Each of your Spacecraft can move once during your Turn **(D1a)**, and (except for Freighters) follow these four steps:

1. **Adjust Mass Chits if needed.** Set Dry Mass Chit per **F2** and Wet Mass Chit per **F3**.
2. **Activate** a *thrust triangle* which will be used to move **(H2)**.
3. **Calculate Net Thrust** *(which, among other things, determines how far you can move)* **(H3)**. If the net thrust is less than 1, you are allowed *coasting* only **(H2b)**.
4. **Move** until you decide, or are forced, to stop **(H4)**.

H1. Movement Restrictions

TIP: Kludge is beautiful; don't fall in love with a card or a mission. Make do with what you have, and fly early. Every Turn counts! [H1]

EASILY MISSED: You can ET produce a card and fly with it in the same turn, because it will have moved only once. [H1b]

a. **Space Is Really Big.** There is no limit to the amount of Figures that can be on any given Space, except each Site can only have one Claim, Factory, and Colony.

b. **No Double Moves.** No component *(Figure, card, Fuel Tank)* may move (using the Spacecraft movement rules) more than once per Turn. Any component that moves at least one Space via the movement rules cannot be moved again (by any player) until the start of your next Turn.
- **For FTs,** this applies even if it is changed to Wet Mass Fuel and back.
- **Boosting (I4)** is not considered movement. Thus you can boost a Rocket and move it.

EXAMPLE [H1b] **Your Freighter (Module 1) delivers FTs into an outpost, which you convert into a new Rocket fueled with the FTs. This Rocket cannot move until next Turn, because the FTs would have moved twice.**

c. **No Interruptions.** *Free actions* **(G)** and *Operations* **(I)** can only be performed before or after each Spacecraft movement.

H2. Thrust Triangle Activation

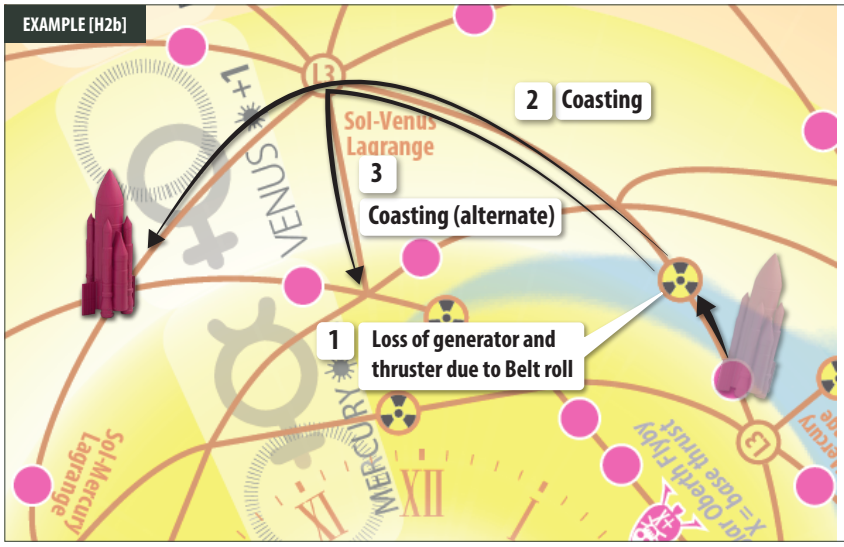
MISSION PLANNING TIP: **If your destination is a large one like Ceres or Callisto, activate a thruster with a good fuel efficiency for the cruise and then activate a high thrust engine on a later Turn for the powered landing. [H2]**

One card in the Spacecraft's Stack with a ***thrust triangle*** **(B2d)** must be chosen for **activation** at the start of each movement. The activated thruster must be *Operational* **(♢ J3)**. The specific cards in that thruster's ***support chain,*** **(♢ J1c)** must also be decided at this time. The thruster and its support chain cannot be changed mid-movement.

a. **Activation & Movement.** A thruster may be activated even if it does not have Fuel. The moment the activated thruster is lost or ceases to be Operational, the Spacecraft must immediately halt or coast (see next bullet). You may perform a dirt *cargo transfer* as a free action **(G1c)**, then activate a dirt thruster and liftoff.

b. **Coasting.** Provided it does not enter any Burns **(H5)** or make any Pivots **(H4c)**, a Spacecraft that started its move with an activated thruster is allowed to keep moving, even if it started with less than 1 thrust, ran out of Fuel, or has reached its *burn limit* **(H5c)**.
- **Coasting Examples.** As long as no Burns are used, a coasting Spacecraft can enter or land with *aerobrake paths* **(H6b),** use *factory-assisted* landings **(H6c)**, use accumulated Bonus Pivots or Bonus Burns (even if the thruster subsequently became non-operational), or (if Operational) pick up additional *Bonus Burns* **(H8b)** by entering flybys.

EXAMPLE [H2b]



1. Your Rocket loses its generator needed for its thruster while passing through a Radiation Belt. You have a spare generator, but can't use it until next Turn.

2. Your Rocket coasts several more Spaces, then halts just before a Burn.

3. Alternate destination for coasting. The Rocket can coast no further because of the Hohmann Pivot.

H3. Calculating Net Thrust

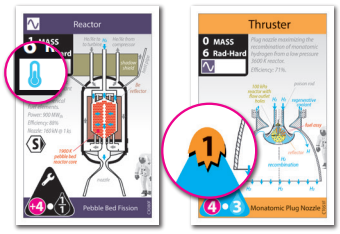
The left number on the *thrust triangle* is the **base thrust.** Various modifiers may add or subtract from this number to obtain the **net thrust**, which is the number of Burns you are allowed to perform during your Turn, and also must be larger than a Site's Size in order to make powered landings/liftoffs. The net thrust is calculated before each movement, and applied for the entire move of the Spacecraft that Turn. If you activate a thruster that brings your net thrust to zero or less, you may only *coast* **(H2b)**. Use a Rocket Figure to mark the base thrust along the top of your playmat and then sequentially apply modifiers in the following order to obtain your net thrust:

a. Megawatt (MW) Afterburn. If the thrust triangle has an *afterburn icon* and the thruster is Operational, you may expend **(F3b)** the indicated number of fuel steps to increase net thrust by one. This can only be done once per movement. Afterburning increases net thrust by one no matter how many steps are expended.

- ♢ **Open-Cycle Cooling.** Afterburns also generate one Therm of cooling **(♢J4d)** that applies for cards that were in the thruster's support chain **(♢J1c)** at the time of the afterburn.[23]

EXAMPLE [H3a]

The pebble bed fission support of your monatomic plug nozzle thruster needs one Therm of cooling, but you have no radiator. You can make your thruster Operational by afterburning. This simulates dumping heated coolant into the exhaust which increases thrust and gets rid of the heat the coolant had absorbed, although at a great expense to fuel economy.



b. Weight Class Modifier. Increase or decrease net thrust by the amount shown in the colored band above your Spacecraft's Wet Mass Chit. These weight classes are named *wisp* (+2), *probe* (+1), *scout* (+0), *transport* (-1), and *tug* (-2).

- **Timing.** This is calculated after any Fuel is spent to *afterburn* (previous bullet).

EXAMPLE [H3b] **A Rocket with a Dry Mass of 7 and a Wet Mass of 8½ is transport class (Wet Mass thrust modifier of -1). If its thruster has a base thrust of 1, its net thrust is 1 - 1 = 0. It can only coast with zero thrust, so it jettisons one step of Fuel to bring it to scout class (Wet Mass 8). This class has a Wet Mass modifier of 0, allowing it to move.**

c. Solar-Power Modifier. If the thruster or any card in its support chain has the solar-powered icon **(♢J5b)**, increase or decrease the net thrust depending on which Heliocentric Zone it's in *(-5 to +2, as indicated on the map)*.

- **Multiple Solar Modifiers.** This modifier only applies once regardless of the amount of solar icons in the support chain.
- **Neptune Solar.** Solar-Powered Cards are non-operational in the Neptune ♆ Heliocentric Zone **(B7g)**, unless they get a push (next bullet). If so, thrust has a -6 modifier.

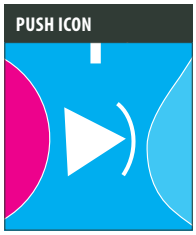
EXAMPLE [H3c] **Your Rocket has a mass driver (4•3) activated, which is powered by a solar-powered generator (flywheel compulsator). Around Mercury, the thrust is boosted to 6, but around Ceres, it drops to 2. Around Pluto, it stops altogether.**

TIP: Use a rocket token in the top track of the Fuel Strip to keep track of your net thrust. Use of this track is optional. [H3]

TIP: A high net thrust helps protect your Spacecraft if it enters a radiation belt (H10). Thematically this limits exposure by traversing the radiation quickly. [H3]

MISSION PLANNING TIP: A typical Crew thruster, when lifting off a large Site, will need to carry at least 8 steps of Fuel to enter the lander burn. This much Fuel puts them into a heavier weight class, forcing them to afterburn or carry less payload in order to maintain a thrust greater than the Site Size. [H3b]

23 OPEN-CYCLE COOLING is dumping water coolant into your nozzle. It has three advantages: (1) It increases thermal efficiency, which increases the percentage of power available for thrust. This is because the coolant captures power that would have been lost as waste heat. (2) Not only is thrust power increased, but the additional Mass flow also increases the thrust. Doubling the kg/sec out the nozzle doubles the thrust (+1 thrust in *High Frontier* scale). (3) Less waste heat means fewer radiators are needed to cool the rocket. The downside is that your specific impulse goes way down, a fancy way of saying that instead of expelling a white-hot trickle, you are shoveling out a lukewarm waterfall. Since Mass is often far more precious to a rocket than energy, you don't want to do this often. Furthermore, water coolant just can't intercept the types of energy emitted by some reactions. For a matter-antimatter reaction for instance, you need tungsten coolant instead of water.



d. Beamed-Power Modifier. If your activated *thrust triangle* has the "push" icon, either you or any *negotiation* partner **(N4a)** with the Powersat Ability/faction privilege, or with a Factory on a Site with the push icon,[24] (as marked on the map with the push icon ▶)) can add a +1 modifier. The Powersat modifier works at any range.[25]
- **No Double Push.** This modifier only applies once regardless of the number of Powersats.

e. ♢**Thrust-Modifying Supports.** If the *support chain* **(**♢**J1c)** of the thrust triangle contains any thrust modifiers, then adjust the thrust accordingly **(**♢**J5a** & **J5d)**. *Fuel consumption* may also be affected.[26]

EXAMPLE [H3e] **You create an electric rocket using a thrust-modifying support to generate its electricity. The base thrust of its hall effect thruster is 3, but its radioisotope stirling generator subtracts 2, for a net thrust of 1.**

H4. Movement Procedure

A Spacecraft may move any distance along the lines of the map, restrained only by a maximum number of Burns **(H5c)** equal to its ***net thrust* (H3),** and by its Fuel. Spend Fuel equal to ***fuel consumption*** for each Burn Space entered **(H5a).**

a. Directional Freedom. If the Space started in has multiple exits, the Spacecraft may choose any of them.

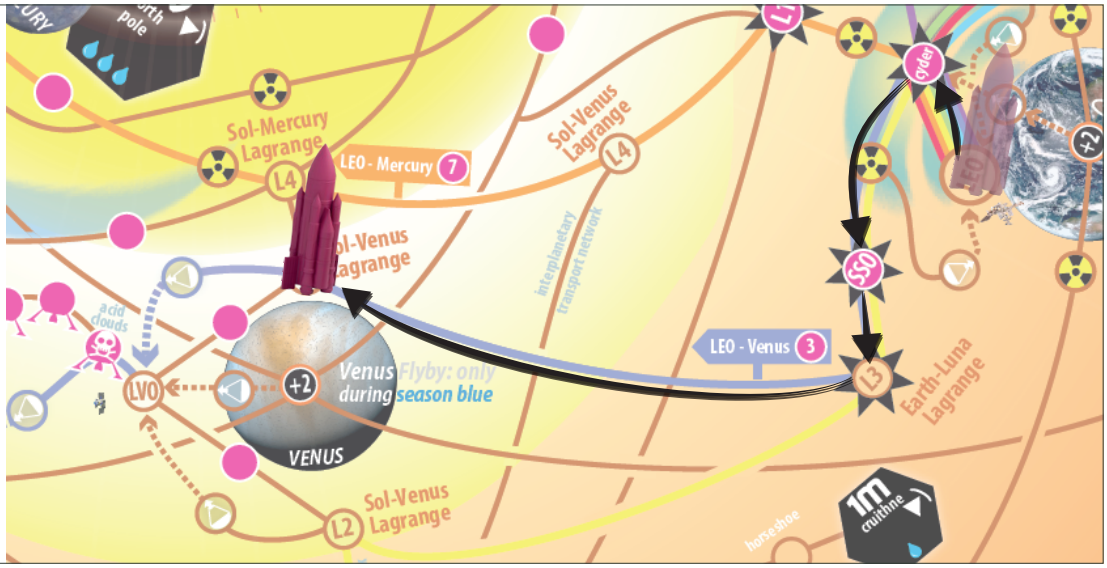
b. Stopping. Except for *lander burns* **(H5e)**, a Spacecraft may stop on any Space **(B7)**. Moving into a Site triggers a *landing* **(H6)** and ends movement.

c. Pivot. A change in direction during a move at a *Hohmann* **(B7b)** is called a **Pivot**. If a Spacecraft performs a Pivot, it must perform two Burns.[27]
- **Loiter.** However, if a Rocket instead stops on the intersection, and waits until the next Turn to move in the new direction, it is not a Pivot and does not expend Fuel **(H4a)**.
- **Unwavering.** Moving straight through a Hohmann without turning does not require a Pivot.
- ♢ **Ballerina Icon** indicates a Bonus Pivot (see glossary).

d. Free Turns. You may change direction during a move at any intersection marked with an icon, e.g. a lander (or half-lander), Lagrange Points, Burns, any Hazard, etc.

EXAMPLE [H4d]

Your Rocket takes route blue to Venus. From LEO you pass through 2 magenta-colored Spaces labeled cycler and SSO. Both are Burns, and cost Fuel to enter. Both are Lagrange Points, so changing direction does not cost Fuel.



e. No U-Turn. Upon entering a Space, a Spacecraft cannot immediately exit that Space using the route it entered by. However, if you halt on a Space, you may move in any direction on your next Turn *(loitering,* **H4c***)*.

f. Aerobrake Arrow. You can follow any route, except for an aerobrake path **(B7e)** against its arrowhead.

g. Coasting. This can extend your movement per **H2b.**

---

24 POWERSAT on Io obtains its energy from Jupiter (using an electrodynamic tether) rather than from Sol.

25 POWERSAT RANGE is the distance that its 60 MW laser beam can be focused. A good quality diffraction-limited Gaussian beam has a range of (πwD)/2λ, where w is the beam waist diameter (narrowest diameter at the focal point), D is the diameter of the beaming optics, and λ is the laser wavelength. This assumes a filled aperture (i.e. beaming optic is effectively a single lens or mirror), or a phased array of orbiting mirrors with the same total area. Suppose the beaming optic is a 500m diameter mirror, using an exotic UV laser with λ = 50 nm. Suppose also the waist diameter is 50 meters, equal to the receiving filled-aperture optic on the target spacecraft. Transmission efficiency is over 50% out to about 5AU (maximum distance to where a 500m optic can focus to a 50m spot), and beyond 5AU, power drops as the square of the distance. The orbital radius of Jupiter is 5.2 AU. Longer ranges are possible by using heliocentric midway collimators, or using mass beams instead of laser beams. —Ruslan Belikov, NASA Ames, personal communication, 2020.

26 AN ELECTRIC ROCKET enjoys a high fuel economy but suffers from a low acceleration especially if loaded with a massive powerplant and generator. If it instead receives its energy from a laser beam, it is much more nimble. Such a beamed-power system would need: (a) the high efficiency production of megawatt laser beams, (b) adaptive optics with handshake feedback over light-minutes of range, (c) a receiving Fresnel lens (actually a series of thin lenses, as a normal lens would be far too heavy), and finally (d) a blackbody cavity or photovoltaics to convert the beam energy into useful electricity or thrust. ***High Frontier*** assumes a 60 MW beam; currently only gas lasers provide such powers. The output wavelength for a CO_2 laser is 10.6 μm (infrared), which is not great because the longer the wavelength, the wider the beam spread due to diffraction and the less energy carried per photon. What is needed is a solid state or disk laser with blue or green light output, however so far solid media cannot withstand the high fluences for a continuous cw or pulsed run. —Dr. Andrew V. Pakhomov and Dr. Leik Myrabo, personal communications, 2010.

27 PIVOTS. 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.

H5. Burns

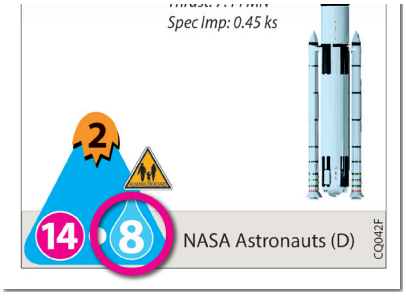
Performing a **Burn** expends a number of fuel steps (not tanks) equal to the ***fuel consumption*** **(B2d)** of the activated ***thrust triangle***. A Spacecraft performs a Burn in two instances: when it enters a Burn Space, either Lagrange or lander, or wishes to Pivot at a Hohmann **(H4c)** and continue moving. For each Burn Space entered, the Spacecraft must expend Fuel for one Burn; for each Pivot made **(H4c)**, the Spacecraft must perform two Burns.[28]

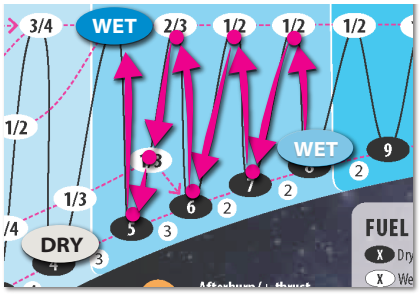
EXAMPLE [H5] **Your mission is to take a Mass 3 refinery from LEO to Mercury. You use a 12•8 crew thruster, a 0•0 sail card, and 4 tanks of water as lander Fuel to make a Rocket Stack with a Dry Mass of 4 and a Wet Mass of 8. But this is transport class, so your sailing net thrust is less than 1 and you can't move other than coasting. So you add 11 more tanks of water, bringing the Wet Mass to 19. During movement, first activate the 12•8 thruster to get through the first 2 Burn Spaces in the orange signpost route. This lowers the Wet Mass Chit 16 steps to 7, and the Rocket is now in the Mercury Heliocentric Zone, which gives a +2 thrust to Sails. The Rocket is scout class, and after activating the Sail has a net thrust of 2. The sailing net thrust is 2, enough to move. Now you can switch your thruster to the Sail, and over the next 2 years sail to L1 just outside the lander burn of Mercury. Finally switch to your Crew thruster again, and expend your last 8 steps of Fuel to land. See diagram on page 16.**

a. Expend Fuel/Adjust Wet Mass. For each Burn performed, move the Spacecraft's Wet Mass Chit a number of steps left along the Fuel Strip (following the black line) equal to the ***fuel consumption*** of the ***activated thrust triangle*** **(H2)**, possibly modified by ***supports*** **(◊ H3e)**.

EXAMPLE [H5a]

The NASA Crew has a (terrible) fuel consumption of 8, representing its SSME chemical engines. It must move its Wet Mass Chit 8 steps to enter each Burn Space!

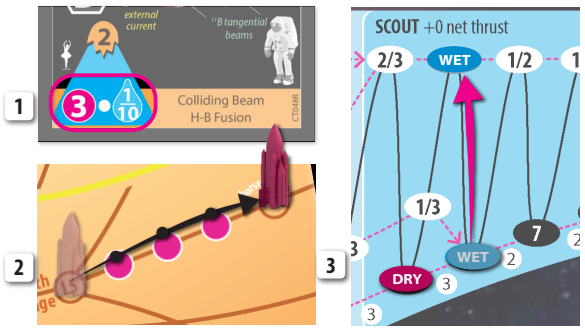




b. Fractional Fuel Use. Some thrusters consume a fractional amount of fuel steps per Burn. Move the Wet Mass Chit partially along the black line to show this. As you progress through Burns, you may place the chit between two spots to indicate partial fuel expenditure. At the end of movement, the total number of steps used is rounded up (move the marker left along the black line to the next numbered spot).

EXAMPLE [H5b]

Example: A colliding beam H-B fusion thruster (3•1/10) expends a tenth of a step for each Burn Space entered (1). If it enters 3 Burn Spaces in a Turn (2), it expends 0.3 steps of Fuel, which is rounded up to one step to the left (3).



EASILY MISSED: Losing Dry Mass after movement begins does not change the Dry Mass Chit until after movement is finished. [H5b]

c. Burn Limit. The total amount of Burns you may use during a movement (not including *Bonus Burns* **H8b**) may not exceed the Spacecraft's ***net thrust***, as calculated at the start of each movement **(H3)**.

EXAMPLE [H5c]

EXAMPLE: An ion drive thruster (2•½) is tug class, so it has a weight class modifier of -2. Its net thrust is accordingly zero, and it can enter zero Burn Spaces. It may coast (H2b) for its move.

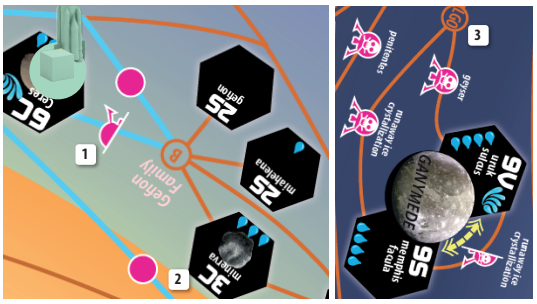


28 BURN SPACE is 2.5 km/sec of delta-v. It takes 9.5 km/sec to get to LEO, and another 3.4 km/sec to get to any of the Earth-Luna Lagrange Points. The solar system escape velocity is 42 km/sec, but since you are already going 30 km/sec (the Earth's orbital speed), this leaves just 12 km/sec more to travel to the stars (neglecting Oberth Effect). The first half of your trip to anywhere is in a steep gravity field, where you need high thrust engines, launch loops, or space elevators to get your Bernals built. The second half will be with high specific impulse interplanetary engines. *"Once you are in Low Earth Orbit, you're halfway to anywhere."* —Bob Heinlein.

d. **Insufficient Fuel.** A Spacecraft may not enter a Burn if it does not have enough Fuel to pay for it (the Wet Mass Chit may never pass the Dry Mass Chit).

e. **Lander Burns** are a special type of Burn Space abstracting the delta-v required for a Spacecraft to land or takeoff from a Site. They have the following special rules:
- **No Stopping.** You may not end movement on a lander burn. You may not enter a lander burn if you cannot continue moving through it, including enough thrust and Fuel for any Burns or Site landings later in the same move.
- **Bonus Burns (H8b)** cannot be used to enter lander burns.
- **Factory-Assisted Landings/Liftoffs (H6c)** cannot be used to enter lander burns (exceptions for Atmospheric Sites **(H6c)** and some Abilities).
- **Half-Burns.** Some lander burn spaces depict only half of a lander vehicle. These still count as one full Burn (for all purposes, including *burn limits* **H5c**) but only use half as many fuel steps (do not round until movement ends).

EXAMPLE [H5e]



EXAMPLE: Your Rocket on Ceres cannot use the Factory for factory-assist, because the entry route has a lander half-burn (1). [H5e]

EXAMPLE: Your Rocket has two thrusters, one with fuel consumption of 2 and another with 8. You attempt to enter the Ceres half-burn, but have only 3 fuel steps remaining. If you activate the high efficiency thruster, you expend only 1 fuel step but the thrust would be less than the Ceres Size of 6. If you activate your low efficiency thruster, you have enough thrust, but not enough Fuel. Since either thruster choice would result in making a new crater on Ceres, you cannot land there. Fortunately, the asteroid minerva is nearby, which you can land on (2). Then you can ISRU refuel an extra tank to make a landing on Ceres. [H5e]

EXAMPLE: You are moving to Ganymede (uruk sulcus) with a photon sail. Your Sail is not allowed to enter the "geyser" lander burn because it has insufficient thrust for a soft landing. If you stop in the LGO immediately before this Burn Space, and on your next Turn activate an afterburning Crew with net thrust = 10, you may make a powered landing (3).

f. ◊ **Fuel Grade Requirement.** *Thrust triangles* are color-coded with a *fuel grade* **(F4b)**. The Fuel expended when a Burn is used must be the same grade of Fuel or better (e.g., a dirt thruster can use any type of Fuel whilst a water Rocket may only use water or isotope Fuel).

g. **Fuel-Modifying Supports.** *Fuel consumption* can be modified per **(◊J5c)**.[29]

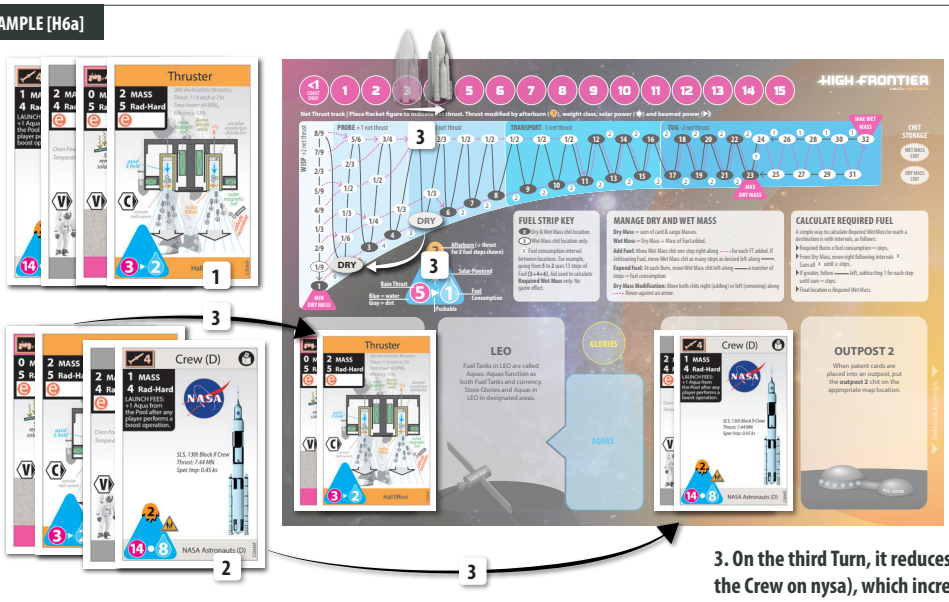
MISSION PLANNING TIP:
To help remember that you need a thrust greater than the Size, think of the Size number as the intensity of the gravity well, and you must have more thrust than weight to escape. [H6]

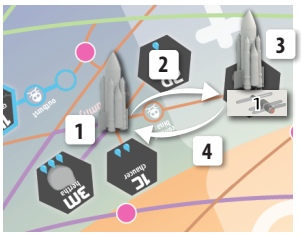
H6. Site Landing & Liftoff

Landing on a **Site** *(hexagonal Space)* ends a Spacecraft's movement; liftoff does not. You must follow one of three methods (powered, aerobrake, or factory-assist) in order to land or liftoff from a Site:

a. **Powered Landing/Liftoff.** To use this method, the activated thruster must have a net thrust **(H3)** greater than the Site Size *(large number on Site)* in order to enter or leave it. This does not expend Fuel.
- **Synodic Comets** have limited accessibility **(B7h)**.

EXAMPLE [H6a]





1. A crewed scout class Rocket moves with a 3•2 thruster to nysa (Size 3).

2. Since its thrust is too low to land, it halts and on its second Turn activates its Crew thruster, obtaining a net thrust greater than 3 and makes a powered landing.

3. On the third Turn, it reduces its Dry Mass (by dropping off a refinery and the Crew on nysa), which increases its 3•2 thruster's net thrust to 4.

4. It can blastoff without burning Fuel, using a powered liftoff.

29 FUEL MODIFYING REACTORS employ the science of thermodynamics to convert energy from one form to another. The reactor converts nuclear energy into radiation, either neutral charged plasma, or exotic, whereupon a generator may further convert this radiation into electricity, either impulsive or DC. An electric thruster converts electricity into thrust. The Second Law of Thermodynamics tells how much energy is available for useful thrust or electricity, and how much must be rejected as waste heat. Thermal efficiency is far more important in space than on Earth. In space, things are easy to heat up, but can only be cooled down by radiation. (Space has no convenient river or atmosphere with which to reject heat by conduction convection). The heat engines applicable in space, along with their thermal efficiencies, are: Thermionic 15%, Brayton 19%, Stirling 20%, Rankine 41%, AMTEC 45%, JTEC 66%, & MHD (open-cycle) 90%.

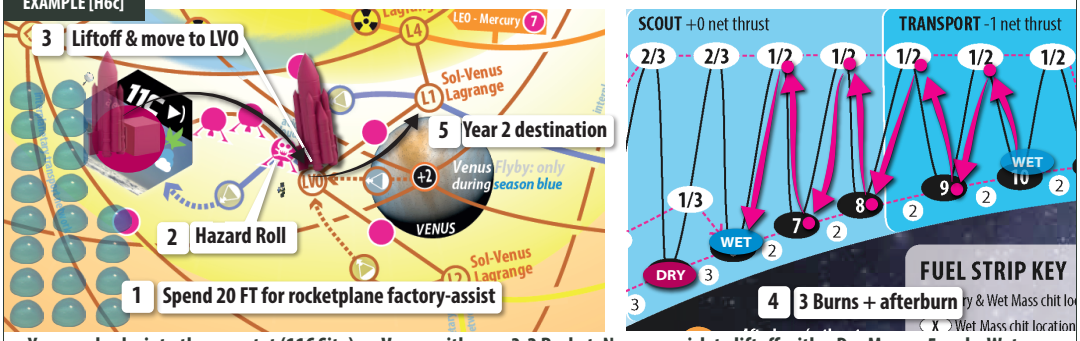
b. Aerobrake Landing. Entering a Site by following an *aerobrake path* **(B7e)** allows a Spacecraft to land there without any requirements for thrust, Fuel, or activated *thrust triangle* (you don't need a thruster to fall down). Entering an Aerobrake Hazard forces a *Hazard Roll* **(H7)**.

- **Aerobrake Burnup.** Decommission Sail cards immediately upon entering an Aerobrake Hazard, regardless if activated or not.

c. Factory-Assist Landing/Liftoff. 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.[30]

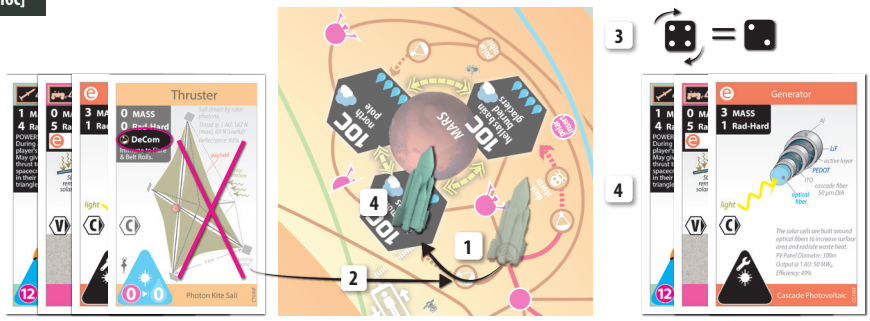
- **Crash Hazard.** If the Space first moved into with a factory-assist liftoff is a Hazard, ignore the Hazard. Using factory-assist incurs a *Hazard Roll* **(H7)** unless it is colonized or you have Powersat.
- **Factory Permission.** You may use an opponent's Factory for factory-assist with their permission.
- **Factory Hijack.** If you can commit a Felony 😎 (which requires that the Space contains your Humans but no defending Humans, see glossary), factory-assist may be performed without permission.
- **High Gravity Limit.** A Spacecraft may not use factory-assist to move into or out of a *lander burn* space **(H5e)** with the exception of acetylene rocketplanes (next bullet).
- **Acetylene Rocketplane Liftoff.** A Spacecraft may use factory-assist to enter one *lander burn* (paying the lander burn cost) from an Atmospheric Site without needing a thrust greater than the Site Size by expending a special water cost using FTs at the Site. This water cost, which is expended without adding to the Spacecraft's Wet or Dry Mass, is equal to a number of blue FTs equal to twice the initial Wet Mass of the Spacecraft. Then continue movement, treating lander burns as burns that you cannot halt on. This represents winged boosters using fuels manufactured directly from the atmosphere.[31]

EXAMPLE [H6c]



You aerobrake into the aerostat (11C Site) on Venus with your 3•2 Rocket. Now you wish to liftoff with a Dry Mass = 5 and a Wet Mass = 10 and reach the Sol-Venus Lagrange L1. This is 4 Burn Spaces away, and so you will need 4 x 2 = 8 steps (not tanks) of water. Normally you would need a net thrust greater than the Venusian Size of 11 to liftoff, impossible for your low thrust engines. But using acetylene boosters, you only need a net thrust of 3. Why 3? Because there are 3 lander burns to cross to reach LVO (Low Venus Orbit), and you are not allowed to halt on a lander burn. So your Rocket can't reach orbit around Venus unless its net thrust is at least 3. Because of its weight class (transport), afterburning is required to reach this net thrust, costing 2 extra steps of water. Spend your on-site water cost for acetylene: 2 x 10 = 20 FTs (1). Then roll your Hazard for acid clouds (no Hazard for factory-assist because of your Push Factory on Venus) (2). You survive, and then move the 3 Burns allowed by your net thrust, ending in LVO (Low Venus Orbit) (3). Including afterburn, this lowers your Wet Mass by 8 steps, from 10 to 6 (4). You have 3 steps of water remaining, enough to cross another Burn and reach L1 on your next Turn (5).

EXAMPLE [H6c]



A Sail coasts to LMO (Low Mars Orbit) and then to the left Aerobrake Hazard (1). The restriction listed on the Sail card states that it is Decommissioned if it enters an Aerobrake Hazard (2), but the rest of the Stack parachutes onto the arsia mons caves. The Hazard Roll is a '2', (3) which means the Stack lands safely (4).

MISSION PLANNING TIP: **Worlds 6 or larger have automatic success in prospecting, but you will not be able to liftoff any Factory products off such worlds unless you can attain a thrust higher than the Size. For Size 6 subplanets, you will need a thrust of 7 or more. For Size 9 worlds (Mercury and the largest moons), in the early game only Crew capable of thrust 10 or more will be able to land or blastoff. [H6a]**

EASILY MISSED: **If your industrialized world is size 5 or smaller, it won't have lander burns and factory-assist can be used to lift product off. This is ideal. In other words, if you have IRSU 3, an ideal destination would have 3 or 4 drops, be reasonably close, and be between Sizes 3 and 5. Only about 5 asteroids fit these criteria. [H6c]**

EASILY MISSED: **The minimum Dry Mass of a Spacecraft (including Freighters) is one, even if all its cards are mass zero (see "Dry Mass Chit" in glossary). This means that a rocketplane must always expend at least 2 FTs. [H6c]**

SUBORBITAL HOPPING: **The rules allow Spacecraft to use lander burns to travel on planets and moons with multiple Sites such as Mars. Since this is a *powered liftoff/landing* (H6a), the net thrust must be greater than the Site Size. [Example H6c]**

30 FACTORY-ASSIST LIFTOFFS use a fast monorail car as the launch vehicle. The rail provides traction as the car reaches orbital velocity and releases its payload into space. This follows the aerospace principle that if you have a choice to use a rocket or something else, always use something else.

31 ACETYLENE ROCKETPLANES. Atmospheres rich in CO_2 are found on Mars and Venus, and provide a fail-safe source of chemical booster fuel, for instance methane (CH_4), acetylene (C_2H_2), or carbon monoxide (CO). Each of these can be burned in oxygen to provide both energy and propellant. Acetylene is assumed in this game for two reasons: in a water-based economy, the use of hydrogen is to be minimized (ruling out methane or H_2-O_2 chemical boosters), and the exit velocity must be economical (if carbon monoxide boosters are used, fuel expenditure would be 5X the payload instead of 2X). Acetylene can be derived by a combination of the Sabatier and Sachsse processes, with hydrogen recycling. It can attain an Isp of 0.42 ks, but is dangerously explosive to store and has a higher flame temperature than most nozzles can handle.
—Hepp, Landis, Kubiak, *Carbon Dioxide Utilization on Mars,* 1993.

H7. Hazard Rolls

Certain Spaces are hazardous and if your Spacecraft enters one, immediately roll one die (1d6). If you roll a '1', each card and FT in its Stack suffers involuntary Decommission/Discard. A Hazard Roll is made for the following:

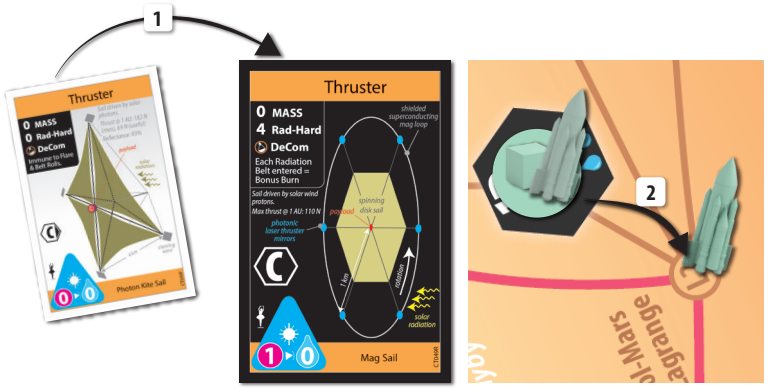
a. **Crash Hazard (B7d).** See glossary.[32]
b. **Aerobrake Hazard (B7e).** See glossary.
c. **Factory-assist.** A Hazard Roll is also made if you make this sort of liftoff or landing **(H6c)**.
d. **Epic Hazard.** See **1A6a**.
e. **FINAO Exception.** Before rolling, you may spend 4 Aquas for "Failure Is Not An Option" to avoid this roll. This represents paying Earth-based programmers for a fail-safe operation.

EASILY MISSED: If you have years invested in a mission, don't be stingy and fail to pay the programmers. It's not worth it. [H7e]

EXAMPLE [H7e]

You manufacture a Sail on deimos (1), and use factory assist to launch it to Sol-Mars L2. (2)

In order to not risk failure, back at Earth you pay 4 Aquas as FINA0 to the programmers.



H8. Flybys

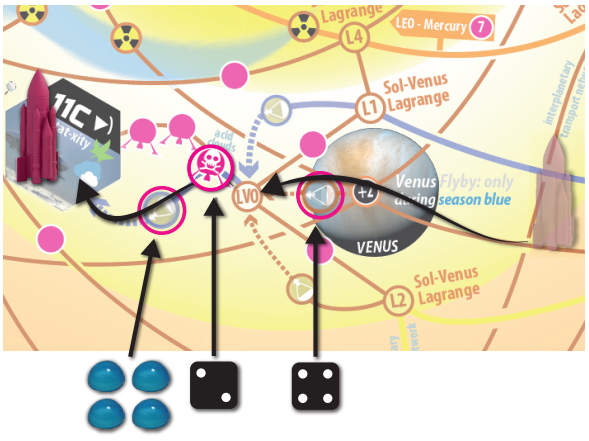
EASILY MISSED: The lunar flyby on route purple is an easy access to valuable sites such as the 4 Galilean moons of Jupiter or the 2 W-class "wet metallic" asteroids (Lutetia and Hertha). [H8]

Entering a Space with a flyby grants the Spacecraft a number of Bonus Burns equal to the number printed on the flyby.[33]

a. **Operational Thruster.** The Spacecraft is granted these Bonus Burns if it has an *Operational* and *activated* thrust triangle **(♢ J3)**, including coasting.
b. **Bonus Burns.** They do not count towards your *burn limit* **(H5c)**, require no Fuel, and can be spent any time you'd normally require a Burn other than *lander burns* **(H5e)**.
c. **♦ Venus Flyby.** The flyby bonus on the planet Venus can be used only if the Sunspot Cube is season blue.[34]

EXAMPLE [H8c]

During season blue, your Rocket makes a flyby of Venus, gaining 2 Bonus Burns. After making an aerobrake, you enter LVO (Low Venus Orbit). Attempting a landing, you enter the lander burn, and then aerobrake for the final descent. Note that you must spend Fuel at the lander burn, since Bonus Burns cannot be used for these. Thematically you are not parachuting to the surface, which is volcano-hot, but deploying an aerostat to remain floating at a pleasant (Earth normal) altitude. In total, you passed through 2 aerobrakes and one Crash Hazard (acid clouds). You decide to roll the Hazard Roll for the first two, and pay FINA0 for the final parachute.



32 CRASH HAZARD is greater on some asteroids due to rapid spin, instability, and chaotic rotation. An elongated asteroid that spins rapidly (with a day < 5.5 hr) has a rotational velocity that varies from spot to spot, and gravity is also deviated from the surface normal vector. Some asteroids are unstable "rubble piles": originally monolithic bodies that have been shattered and coalesced under the influence of gravity. Others are dumbbell-shaped contact binaries, formed when two smaller bodies come into gentle (but unstable) contact.

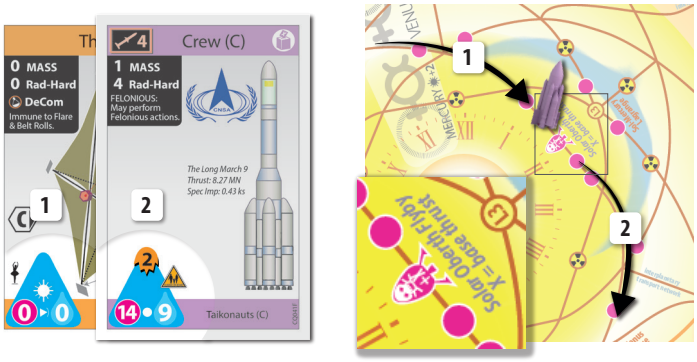
33 FLYBY. Suppose your rocket, bound for Mars from Earth, goes the opposite direction to Venus. If you fly past the "trailing" side of Venus (as it orbits Sol), its gravity will accelerate you (in both direction and magnitude) with respect to Sol. This "flyby slingshot" can be used to decrease the delta-v (by up to 10 km/sec) for the trip to Mars (or to other places in orbits superior to Earth's orbit). Conversely, passing in "front" of Venus will slow you down (again with respect to Sol). Consider a ship returning to Earth. A grazing (180 km altitude) flyby in front of Luna can slow the rocket (with respect to Earth) by up to 1.85 km/sec, allowing it to be captured by Earth. However, a flyby of Luna cannot speed you up or slow you down with respect to Luna (or places in lunar orbit). Likewise, a solar flyby cannot help you reach anything in solar orbit (ignoring the Oberth Effect).

34 VENUS FLYBY. The Hohmann route to Mars is possible when Mars and Earth are in **opposition,** which is when the two planets are at their farthest distance from each other (400 million kilometers) (Counterintuitively, the cheapest route to Mars is exactly when it's the farthest away from us.) This semi-ellipse is shown in the Appendix (**W3.Q5**). This trip lasts 8 months, and is represented on the map by the red route. An alternative route to Mars is the **conjunction** route, which debarks when Earth and Mars are near their closest point. This trajectory uses a gravitational flyby of Venus, which is a year longer than the Hohmann, but costs less fuel (both in the game, and in reality). Once at Mars, robonaut landers are used for dirtside operations, while humans remain in orbit. This avoids the 10-40 min. lag needed for robonautic teleoperation from Earth. Teleoperation takes place from Phobos in the NASA plan, and from the Sol-Mars L1 point in the Zubrin Athena plan. A typical nuclear-electric manned mission to Mars (Boeing STCAEM NEP 1991 opposition study) has a dry mass of 8 (for reactor, generator, radiator, crew, lander, & electric thrusters), plus 4 tanks of fuel. It takes 14 months for a round trip, including a month on the surface. Flybys at Luna and Mars are used.

d. **Multiple Flybys.** A Spacecraft may benefit from multiple flybys during a movement.
e. **Solar Oberth Flyby** *(☿ Heliocentric Zone)* grants a number of Bonus Burns equal to the ***base thrust*** (not ***net thrust***) of the Spacecraft's activated ***thrust triangle*** **(B2d)**.
   - **No Repeats.** As an exception to **H8d,** a Spacecraft gains Bonus Burns from the solar oberth only the first time in a move it enters it.
   - **The Lander Burn Space** is the flyby. Pay its Fuel cost and make its Hazard Roll upon entry before gaining its Bonus Burns.
   - **Afterburn.** If a Spacecraft performs an ***afterburn*** **(H3a)** on the solar oberth flyby, it gains one extra Bonus Burn. For a GW/TW rocket (Module 1), afterburning gains a number of Bonus Burns equal to the thruster's afterburn bonus **(1C2)**.

EXAMPLE [H8e]

1. Your Sail halts on the Burn Space immediately before the Solar Oberth.
2. On your next Turn, you activate your 14•9 crew thruster, so as to enter the Oberth with a base thrust of 14 rather than zero. You gain 14 Bonus Burns at a cost of 9 fuel steps. (The Oberth effect is known as a thrust multiplier, so it doesn't work on a Spacecraft without thrust).



f. ◊ **Mag Sail.** If this thruster is activated, then each ***radiation belt*** **(H10)** entered confers *Bonus Burns* **(H8b)** in the same manner as a flyby. Like the ***solar oberth flyby*** (previous bullet), these Bonus Burns are gained only the first time a Spacecraft enters a particular radiation belt in a move.
g. ◊ **Glitch Trigger.** Entering a flyby is a Glitch Trigger.[35]

H9. Buggy Roads

a. **Buggy Roads** are relevant for ***prospecting*** **(I6)** and Adjacency *(see glossary)*.
b. **The Martian.** With an Operational card with a ***buggy*** platform **(I6b)**, as a once-per-turn free action you can move your Crew or Colonist to a new Site along any buggy road, creating an Outpost. The buggy itself does not move, except that Crew or Colonists with a buggy platform can alternatively transport themselves.

H10. ◊ Radiation Belts & Belt Rolls

Entering a **Radiation Belt** (space with a radiation icon) incurs a **Belt Roll:** roll one die (1d6) and subtract your Spacecraft's ***net thrust*** **(H3)**. Do not subtract a negative net thrust. Compare the result to the rad-hardness of each card in the Spacecraft's Stack (listed in the upper-left). Any card with a rad-hardness **less than** the result is involuntarily decommissioned.[36]

a. **Failure Is An Option.** You may not pay Aquas to avoid a Belt Roll.
b. **Season Red Radiation.** If the Sunspot Cube is season red **(◊ K1),** then all Belt Rolls are made with a +2 penalty.[37]

EASILY MISSED: This penalty does not apply to flares, which involve CME Rolls rather than Belt Rolls. [H10b]

EXAMPLE [H10]

1. A Rocket with a net thrust of 2 moves from LEO to GEO, crossing the Van Allen Belt.
2. The season is not red. A 4 is rolled, so the radiation level is 4 – 2 = 2. The Rocket's solar panels (rad-hardness = 1) are Decommissioned.
3. Without power, its electric thrusters stop working. Having failed to reach GEO, the Stack may coast and be left as an Outpost, or else entirely Decommissioned.



35 GLITCH FLYBY. In 2007, the ESA Rosetta Spacecraft was well underway to a mission to land on Comet Churyumov–Gerasimenko, when mission control discovered that a course correction was required. An unscheduled Mars Flyby was decided. This was risky, passing in the martian shadow would shut down its solar panels for 15 minutes, causing a dangerous shortage of power. The craft was therefore put into standby mode, with no possibility to communicate, flying on batteries that were originally not designed for this task. This flyby maneuver, ultimately successful, was therefore nicknamed "The Billion Euro Gamble".

36 RADIATION BELT is a torus of charged particles trapped in a magnetic field. Such magnetospheres provide protection against solar storms.

37 AURORAL BRIGHTNESS is a good measure of the intensity of radiation flowing along field lines of a planetary radiation belt, and is strongly driven by the solar wind interaction with the magnetosphere. In planets such as Earth, Jupiter, and Saturn, the auroras are brighter in solar active years.

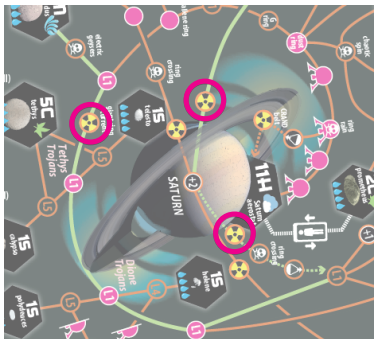
c. **Heavy Radiators.** If a heavy radiator fails its Belt Roll, rotate it to its light Orientation.
d. **Solar Flare Protection.** A Stack on a non-Sol Radiation Belt is shielded against *solar flare events* **(◊ K2d)**.
e. **Mag Sails.** If a mag sail thruster enters a Radiation Belt, see ◊ **H8f**.

EXAMPLE [H10e]

The green route to Enceladus passes through 8 Radiation Belts.







TIP: There are better ways than income to get money, for instance researching then selling cards in the free market. Even better is researching then letting other players win the auction, because then you don't bloat your Hand and don't have to spend Operations clearing your Hand of excess cards later. Nevertheless these are situational, as there is no cookbook way to make the most income. [I1]

TIP: If you want to initiate an auction but exceed the academia hand limit, you may Discard cards as a free action (G6) before performing the research. But because you can only perform free actions during your own Turn, you may not Discard cards during another player's Turn in order to bid in an auction the other player initiates. [I2a]

EASILY MISSED: If the initiator loses an auction, the winning bid is paid to the initiator. [I2d]

I. Operations

You may perform one Operation each Turn.

I1. Income Operation

Receive 1 Aqua from the Pool, added to your LEO Stack/Bank on your playmat.

I2. Research Auction Operation

Choose one of the patent decks **(B2)** and auction off the top card.

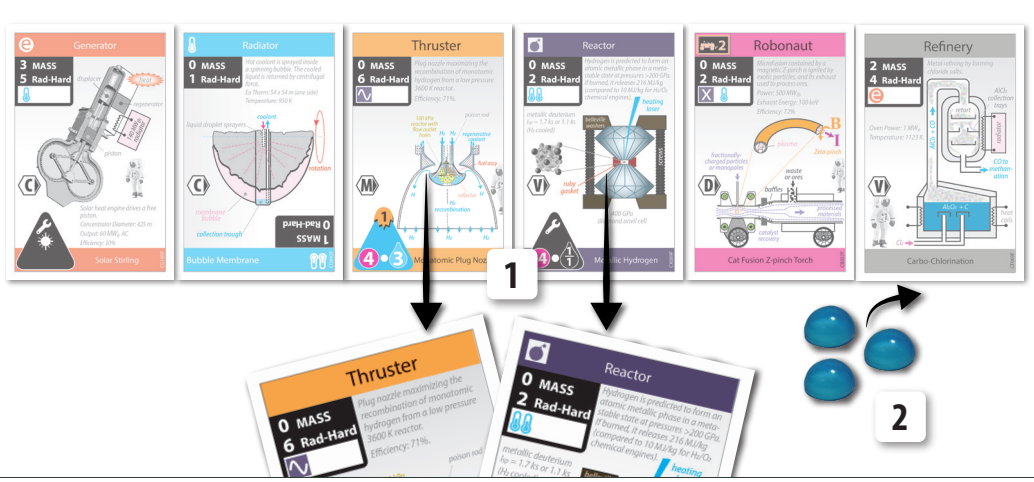
a. **Academia Hand Limit.** A player with four or more cards in Hand may not initiate or bid in an auction.
b. **Auction Procedure.** As the **initiator**, you must make the first bid (minimum of 0). Then, in any order, other players (who do not exceed the *academia hand limit*) may bid. Continue until no player wishes to raise their bid.
c. **Bid Currency.** Bids are made in Aquas (FTs in other locations can never be used as money).
d. **Win Procedure.** If you win, as the initiator, you pay your bid to the Pool. If somebody else wins an auction you initiate, then they pay their bid to you. The winner adds the card to their Hand.
e. **Ties.** As the initiator, you win a tied bid you are involved in. If you are not involved, you choose which of the tied players wins.

EXAMPLE [I2e] **You initiate an auction, with a bid of zero. Another player bids one, and you match their bid. That player then bids two, and a third player also bids two. You are unwilling to bid higher, so you choose one of these players to be the winner of the auction. The winner adds the card to their Hand and pays two Aquas to you.**

f. **Information.** The front side of the top card of each deck is visible and open to inspection at all times. As soon as you announce that a card is up for auction, any player may pick it up to examine its backside. This reveals the front side of the next card in the deck.
g. **Bonus Supports.** If the card requires *supports* **(◊ J)**, the auction winner also takes the top card of the corresponding patent deck for each required support into their Hand.
   • You do not get additional cards to support the bonus supports, only for the initially auctioned card.
   • You get the top support of the required type (reactor, generator, or radiator), regardless if it is the correct subtype to support the card purchased **(◊ J1a)**.
   • Extra supports are not moved from their deck until the auction is won.

EXAMPLE [I2g]

On Turn 13, your bid wins the monatomic plug nozzle thruster in an auction. This card lists a support: a reactor ~. You take the top reactor card. Unfortunately, this is a bomb reactor, which doesn't support the plug nozzle. So next Turn you sell the reactor on the free market.



I3. Free Market Operation

Obtain Aquas by selling one card that is either (a) a Hand card or (b) a Black-Side card in a Stack in your Bank:

a. Selling Hand Card. Return a card from your Hand to the bottom of its corresponding patent deck. Receive 3 Aquas from the Pool.[38]

EXAMPLE [I3a] **Your LEO stack has 3 cards. But all 3 are on their white-side, so you cannot sell them per I3b. But you can Decommission one into your Hand (free action), and then perform a free market to sell it for 3 Aquas.**

b. Selling Black-Side Card From LEO Stack. Discard a Black-Side card located in your Bank (see glossary) to your Hand. Receive Aquas equal to the factory stock price listed on the Exploitation Track **(B5)** for that card's Spectral Type (letter on the card: **C, S, M, V, D,** or **H**). Thus, a Black-Side card could be worth 4, 5, or 8 Aquas. If there are no Factories of a Spectral Type (e.g. the last cube is retired per **I7f**), then it is worth 10 Aquas.

- **Radiators** are sold for the same price regardless of Orientation (see glossary).
- **Any.** Cards that are of Spectral Type "ANY" can be ET produced at any Factory but cannot be sold.

EXAMPLE [I3b] **You have ET produced a Black-Side card of Spectral Type C. You can move it to LEO and sell it to your Hand for 4 to 8 Aquas, or you can Decommission it and sell it from your Hand for 3 Aquas. Since Spectral Type C is currently at value 8, you choose to move it and sell it at LEO.**

EASILY MISSED: Cards in your Hand are not considered White- or Black-Side. [I3a]

I4. Boost Operation

Bring one or more Hand cards into the LEO Stack/Home Orbit by spending Aquas equal to the combined Mass of the card(s).

a. White-Side Only. You can never boost cards on their Black-Side, since Black-Side cards are only produced in space by the *ET production operation* **(I8)**.

b. No Movement Restriction. A card may move in the same Turn it enters LEO.

c. Radiator Orientation. Radiators **(◊ J1d)** have both a heavy and light Orientation. Choose the card's Orientation as it is boosted (and pay the appropriate amount of Aquas for its mass).

I5. ♦ Site Refuel Operations

The following three operations produce FTs at a Site, and each one is a Glitch Trigger:

a. ISRU Refuel Op. An Operational card with an ISRU platform produces a number of water FTs equal to one plus the Site's Hydration minus the card's ISRU rating. Place these FTs in a Colocated Stack, or create an outpost **(E6c)**.

- **Busted Sites.** A Site with a red disk **(I6.5)** can still be used to ISRU refuel.
- **Foreign Factories & ISRU.** The presence of an opponent's Claim, Factory or Bernal on a Site has no effect on ISRU refueling.
- **♦ Dirt Refueling.** Except for Crew dirt thrusters, this is a *free action*, see **G1c**.

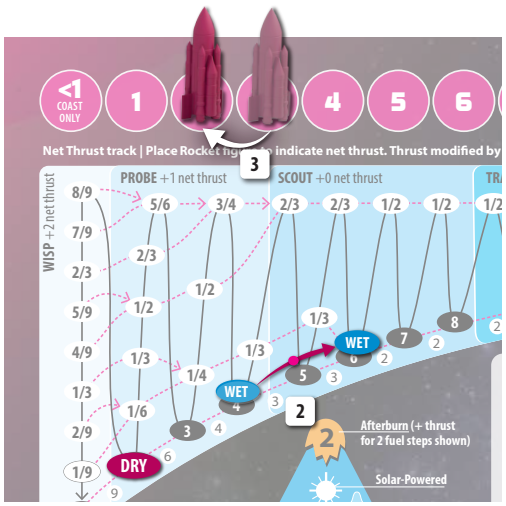
EXAMPLE [I5a]

1. An unfueled Rocket Stack sits on the north pole of Mercury (Hydration = 3) and has an ISRU = 2.

2. By performing an ISRU refuel operation, it gains 1 + 3 – 2 = 2 water fuel tanks, which moves its Wet Mass Chit from 4 to 6.

3. This increases the Rocket's weight class, which lowers its net thrust by one. If instead factory-refuel is used (i5b), it gains up to 7 tanks, moving the chit to 11 and lowering its net thrust by two.





EASILY MISSED: FTs may always be used to freely and immediately refuel a Spacecraft with cargo transfer (G1b) or internal tankage (G2). Either one makes a mass adjustment (F3b,c). If you are planning on immediately fueling your Spacecraft, feel free to move directly to wet mass adjustment (see examples). [I5]

EASILY MISSED: If your ISRU rating is greater than a Site's Hydration, you will produce no FTs or Fuel. [I5a]

FORMULA: Fuel Tanks gained from ISRU refueling = 1 + Hydration - ISRU. [I5a]

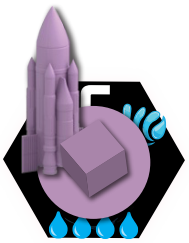
38 FREE MARKET. There are no unique raw materials waiting for us in space (possible exception of 3He). There are a lot of hydrocarbons on Titan, but because of delta-v costs, it will always be cheaper to derive them from marginal locations on Earth, like oil shales or biofuels. Even if a platinum-rich asteroid were found, platinum would be obtained cheaper by re-opening a depleted low grade mine on Earth. If extraterrestrial raw imports will never be economical, is there anything left to drive exoglobalization? Increasingly, processes rather than raw materials are most important for industry. Space processes can control the gravity, vacuum, radiation, temperature, and energy density to degrees impossible on Earth. These characteristics, the forgotten resources of space, can produce high-strength membranes using surface tension effects, long whiskers and gigantic laser crystals grown in microgravity, nano-engineering using ultrapure vapor deposition, strong glassy materials produced by exploiting a steep temperature gradient, and alloys mixed by diffusion alone. Relatively small machinofactured and nano-produced objects, including pharmaceuticals and bio-tech, will be the first space imports to Earth.

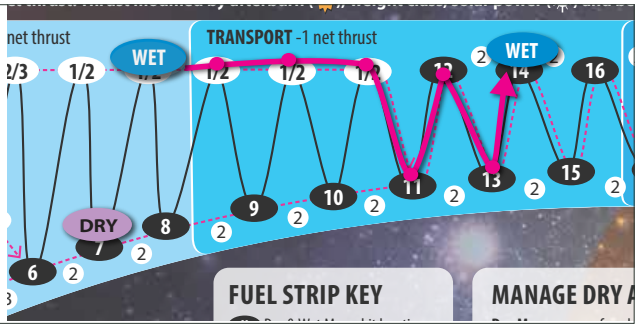
b. Factory-Refuel Op. A Factory on a Site can produce either 7 blue FTs (water fuel) or 1 gold FT (isotope fuel). Place these FTs in a Colocated Stack, or create an outpost **(E6c)**.[39]

- **Using Opponents' Factories.** You may use an opponent's Factory with their permission. You do not need their permission to land or ISRU refuel there.
- **Factory Hijack.** This can also be done without permission if you can commit a Felony 😎 (see glossary).

EXAMPLE [I5b]

Your blue Wet Mass Chit is on the 7-½ position, and you perform a factory-refuel. This moves the Wet Mass Chit 7 steps to the right, ending on the "14" spot.





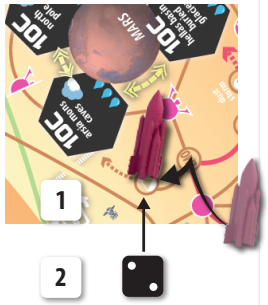
REMEMBER: Fuel tanks gained from Air-eater = Five minus fuel consumption. [I5c]

MAGNETOSHELL: The Ability on this card protects you from all Aerobrake Hazards. [I5c]

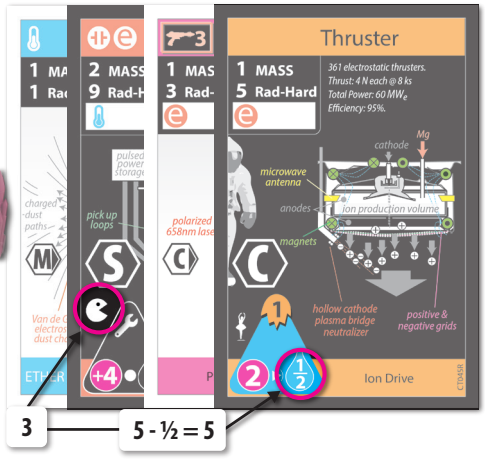
c. Air-Eater Refuel Op. At the end of its movement, a Spacecraft on an Aerobrake Hazard may gain fuel by "scooping" the planet's atmosphere. This moves its gray or blue Wet Mass Chit (following the dashed red line) a number of tanks equal to 5 minus its activated *fuel consumption* **(B2d)**, dropping fractions from fuel consumption before subtracting.[40] To gain Fuel this way requires the following:

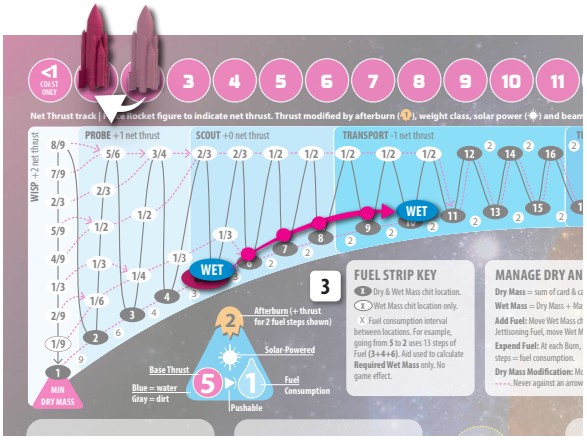
- **Pac-Man.** The Stack must contain an Operational card with the air-eater icon and an Activated thruster.[41] This card may (but does not have to) share supports with the thruster *support chain* **(J1c)**.
- **Diver Orbit.** The Spacecraft may remain on an Aerobrake Hazard to refuel several Turns. Each Turn you remain and refuel counts as a Hazard requiring either a Hazard Roll or FINAO.

EXAMPLE [I5c]



EASILY MISSED: After you enter an Aerobrake Hazard, you can remain there on subsequent Turns, but must make a Hazard Roll if you refuel by air-eating. [I5c]





Your ion drive rocket (fuel consumption = ½) has a dry mass of 5 and no fuel. Thus, its wet mass is also 5. In its support chain it has an air-eater generator (3) (optoelectric nuclear battery). It ends its move in a martian aerobrake and performs an air-eater, surviving its Hazard Roll (2). Its Wet Mass Chit is moved ½ tank to the left (zero after dropping fraction), then 5 tanks to the right, ending on 10.

39 FACTORY WATER PRODUCTION. The martian soil is perhaps 1% water by weight. To extract this, a caterpillar-tracked robonaut on Mars periodically scoops soil and fills a dump tank, which is cooked by an oven to 500 C. The dry soil is dumped as waste by a conveyor belt. 37 MJ of energy per kilo of dirt is required for the ovens, and less than 1 MJ to run the belts and robonaut. About a MW of power would be required to collect 7 tanks of water in a year. Alternatively, although the martian atmosphere is only 0.03% water by volume, by adiabatic expansion or isothermal compression a Factory could produce a kilogram of water per million cubic meters of atmosphere processed.

40 ATMOSPHERIC SCOOPING. A spacecraft in a highly elliptical orbit around an atmospheric planet periodically dips into its atmosphere if its periapsis is low enough. Some of the propellant liquified must be expended for thrust in order to overcome drag as it scoops the air. If the exhaust velocity of the rocket engine is less than the orbital velocity of the air being scooped, the rocket will need to expend more propellant than it collects. But if the exhaust velocity is greater, then it could collect many tonnes per year. The break-even exhaust velocity is around 10 km/sec, corresponding to a game fuel consumption of 4.

41 AIR LIQUEFACTION. Most of the "scoop" cards are generators, because a few kW electrical power is needed to liquify the gases scooped. The scoop itself is a lightweight membrane since the drag forces are in the mN/m² range.

I6. ♦Prospect Operation

A successful prospect operation allows you to place a Claim of your color on a Site that is unclaimed and not Busted.[42] Performing a prospect is a Glitch Trigger. Attempting to prospect a Site is a five-step process:

1. **Operational Requirement.** You must have a Stack containing an Operational card with an ISRU rating on the Site (with certain exceptions for *rayguns* and *buggy roads*).
   - **Assaying Smelters.** If Colocated and Operational, some Abilities (e.g. Von Neumann Santa Claus Machine and, if pushed, Magbeam) modify the ISRU rating of the card used to prospect. However, an ISRU rating can never go negative.
   - **Multiple Platforms.** If a Stack or card has multiple ISRU platforms, choose one of them to use as the prospecting ISRU.
   - **Luna.** Unless you Claim Jump, prospecting either Site of Luna requires the *permission* of the 1st Player **(N4e)**.
2. **Hydration Requirement.** That card's ISRU rating must be equal to or less than the Site's Hydration *(number of water droplets)*.
3. **Size Roll.** Roll a die *(1d6).* A result equal to or less than the Site Size (large number on site) is successful.
   - **Fully Baked.** Prospecting the kreutz sungrazer is always successful (see Glossary, Synodic Comet).

EXAMPLE [I63] **You land on Ceres (Size 6) and prospect. A size roll is unnecessary, since at this Size it will be automatically successful.**

MISSION PLANNING TIP: **Look at the IRSU of your Crew or robonaut. This number is the minimum number of drops of Hydration of the world you want to prospect. [I62]**

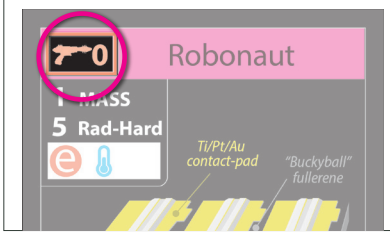
4. **If Successful:** place a Claim on the Site. If you have no more disks, then you may remove one from one of your unindustrialized claimed Sites.
   - The vacated Site may be prospected again by any player.
5. **If Unsuccessful:** place a translucent red disk on the Site, which means it is **Busted** (contains nothing of interest). It cannot be prospected again by any player, but can still be landed on and used to *ISRU refuel* **(I5a).**

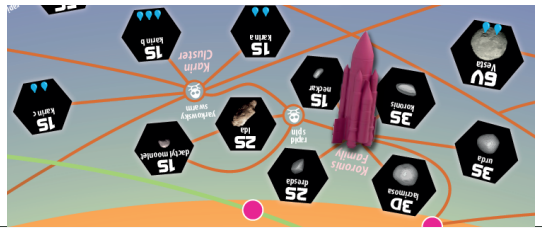
There are 3 Types of prospecting, depending upon the card's *platform icon* **(B2c)**:

a. **Raygun Prospecting.** If the card used has a *raygun icon* with its ISRU rating it may prospect multiple Sites with a single Operation and may prospect at range. Choose any number of Sites with high enough Hydration located at and/or Adjacent (see glossary) to the card's Stack. Resolve each roll separately in the order of your choice.[43]

EASILY MISSED: **Hazard and lander Spaces are ignored when determining Adjacency. [I6a]**

EXAMPLE [I6a]

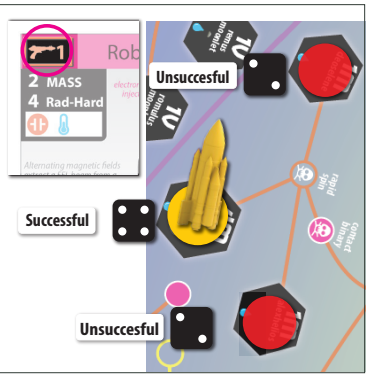




Because Hazard Spaces are ignored, a raygun with ISRU = 0 on the HEO for the koronis family may prospect 10 asteroids in one operation! This includes the asteroids in the karin cluster. Roll separately for each prospect.

EXAMPLE [I6a]

A raygun (ISRU = 1) on the surface of kleopatra can prospect kleopatra and both of its moonlets in one Operation, since they are joined by a Crash Hazard Space.



EXAMPLE [I6a]

Your Rocket with a raygun ends in the G ring "dust ring" near Saturn. This is Adjacent to epimetheus and janus. Because the Spaces "chaotic rotation" and "F ring spokes"are Hazards, they do not count towards Adjacency and so your Rocket is also Adjacent to pandora and prometheus. Your prospect operation makes a size roll for each of the 4 moons.



42 PROSPECTING. As it was in the development of the New World in the 16th century, manpower is the biggest limiting asset in space. Hazardous or high radiation work will be done by robonauts, remotely controlled by humans. However, the speed of light time delay limits how distant the humans can teleoperate these machines. Hohmanns on the map are 500 light-seconds distant from each other. Assessing a body for mineral or volatile resources may be done three ways: (a) Raygun robonauts fire an energy beam at the surface from orbit. Of special interest is the 3μm spectrophotometric signature that indicates water. (b) Buggy rovers scavenge and beneficiate regolith which has been enriched by solar wind "space weathering". (c) Missile robonauts assay metals and silicates by melting them with thruster plasmas. Metals must be cut or melted at high temperature, or reacted at low temperature using gaseous carbonyls (see the CVD Molding - Carbonyl Volatilization card). Silicates from the inner belt are completely hydrated, having marinated in contact with liquid water for millions of years. These ices are released by vaporization. In the outer belt, the silicates of icy asteroids remain anhydrous, because the asteroid has never thawed.

43 ASTEROID FAMILIES. The formation of the asteroid belt left shattered clusters in similar orbits. Such clusters are called Hirayama Families, the most important of which are depicted on the map. Another type of asteroid family is the trojans: worlds that accumulate at planetary Lagrange Points. The most numerous are the jovian trojans, which precede and trail Jupiter by about 60°. They may outnumber the main belt asteroids. The "Greek camp" of Trojans corresponds to the preceding Sol-Jupiter L4 point, and the "trojan camp" corresponds to the trailing Sol-Jupiter L5 point. Asteroids in both camps are likely captured centaurs, and are mainly spectral type **C** or **D**. Also on the map is the martian trojan Eureka, and the pseudo-terrestrial trojan Cruithne (Earth's second moon).

- **Before Rolling.** All desired Sites must be chosen before making any *size rolls* **(I6.3)**.
- **Opaque Atmospheres.** A raygun may not prospect at a range greater than zero at an Atmospheric Site (see glossary).
- **One Re-roll** per *prospect operation* is allowed if using the Ability listed on the Lorentz-propelled microprobe raygun. Make all desired rolls first, then choose a single failure to reroll.

b. Buggy Prospecting. If the card used to prospect has a buggy icon next to its ISRU rating, if you fail your *size roll* **(I6.3)** for a prospecting attempt, you are allowed a single re-roll.[44]

EASILY MISSED:
The re-roll for buggy prospecting raises chances of success on a comet from 16.7% to 30.6%. [I6b]

EXAMPLE [I6b] **A buggy prospects dresda. The size roll is a 3, which fails because dresda is Size 2. But the second roll of 2 succeeds and places a Claim.**

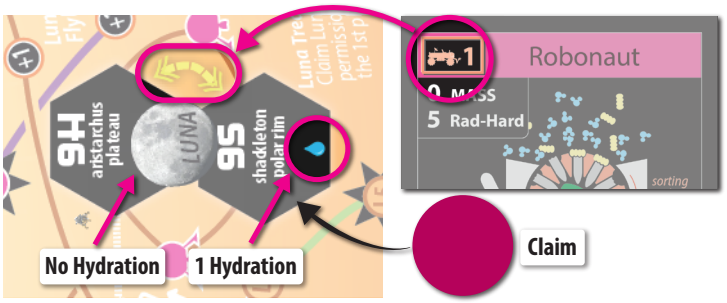
- **Buggy Roads.** By prospecting one Site, a buggy simultaneously prospects all other Sites with a high enough Hydration **(I6.2)** connected by a *buggy road* (yellow dashed line) with a single Operation.

c. Missile Prospecting. This has no special rules.

MISSION PLANNING TIP:
A missile robonaut and its supports is perhaps the fastest way to Claim the valuable mid-sized asteroids and moons. [I6b]

EXAMPLE [I6b]

You land on the lunar polar rim with an ISRU = 1 buggy and prospect. Because the lunar size is 9, prospecting is automatically successful. The Site is connected to another lunar site by a buggy road. Because this Site is bone dry (Hydration = 0), your buggy has insufficient ISRU to prospect or claim it.



I7. ♦ Industrialize Operation

This Operation allows you to build a Factory at a Site where you already have an unindustrialized Claim. Decommission an Operational robonaut and refinery card, along with their required *support chains* **(◊ J1c)**. This places a small cube on top of the Claim, and this combination is your new Factory. Performing this operation is a Glitch Trigger. A Factory on a Site with the push icon ▶) yields the Powersat Ability.

a. ◊ Overlapping Support Chains. The cards that are Decommissioned can share a support (see **◊ J1b, ◊ J1c**).

b. Stacking Limit. There may only be one Factory on each Site.

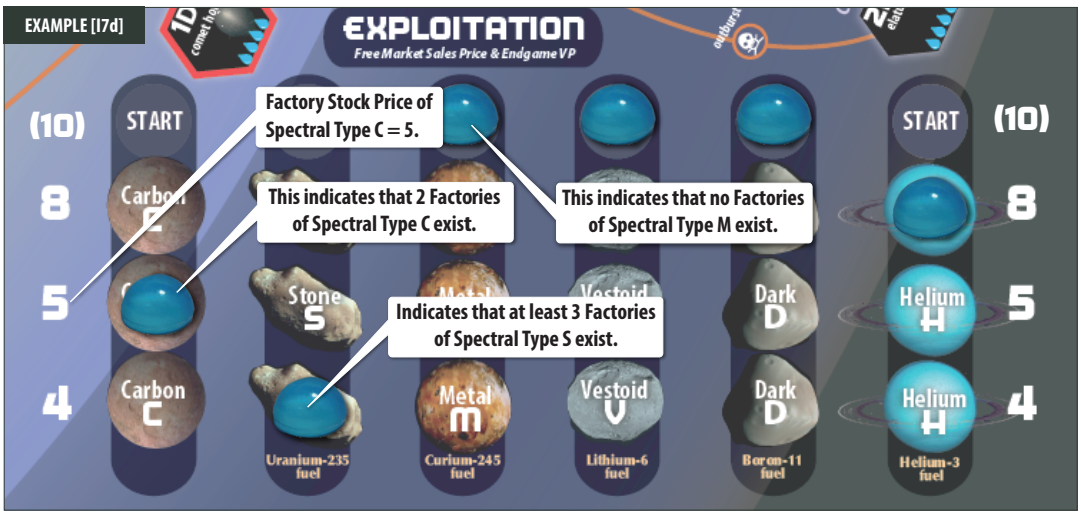
c. Spectral Type. The Spectral Type (letter) of a Factory becomes the Spectral Type of the Site it is on, and determines which cards it can *ET produce* **(I8)**. The Spectral Type of the cards Decommissioned do not matter.

d. Exploitation Track. Adjust the blue bead on the Exploitation Track as necessary to keep track of the total number of Factories in play for each Spectral Type. This will be used for stock prices during *free market* sales and *final scoring*. If there are 3 or more Factories of a Spectral Type, the bead stays in the lowermost row.

e. Colonies. A Colony can be built on a Factory as a *free action* **(G3)**. Colonies are *permanent* **(G6b)**.

EASILY MISSED:
Industrialization always requires the Decommission of a robonaut, and neither Crew nor Colonists can be substituted. [I7e]

EXAMPLE [I7d]

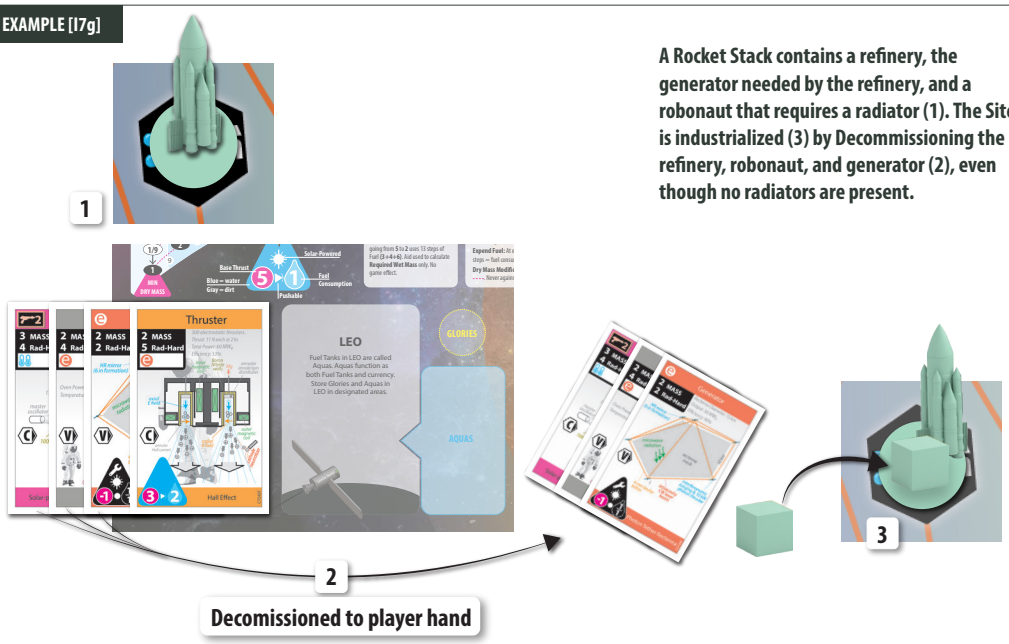


44 BUGGY REGOLITH SCAVENGING. The stream of solar wind causes space weathering, a deposition of wind particles directly into the veneer of rock dust, called regolith, common on asteroids and moons. The atoms are implanted at a shallow depth (<100 μm) and the finest material is the richest in solar wind gases. Wind-enriched particles contain traces of hydrogen, helium, carbon, nitrogen, and other low Z elements rare in space. These volatiles can be recovered by scavenging: scooping regolith over wide areas with robonautic buggies, processing it to recover the volatiles, and dumping the remains overboard. The concentrations of volatiles in lunar maria regolith is a few hundred ppm of each type. Other valuable materials, magnetically or electrophoretically separable from maria regolith, include iron fines, uranium (2-6 ppm), and ice crystals (in permanently shadowed regions). The helium fraction includes 5 to 100 parts per billion of the rare isotope 3He, valued because it is rare on Earth, and can be used as a fusion fuel, using the 3He-D "clean" (aneutronic) fusion reaction.

f. Cube Limit. Your Reserve of cubes is limited to 7. To place a Factory, Sunspot Cube, or delegate when you have no remaining cubes, you may Discard another cube as a ***free action*** **(G6)**. You cannot Discard a Sunspot Cube, colonized Factory, or a ***Dirtside*** **(2Ba).** You cannot become the ***1st Player*** **(O6b)** if you have no discardable cube to use for the Sunspot Cube.

g. ◊ Radiator & Cooling Exception. It is not required to Decommission or even have a radiator support **(◊ J4)** in order to industrialize. Any card that requires cooling has its requirements met for this purpose (because the nightside of the world provides all the cooling you need for industrialization).
- **Industrial Use Only.** This does not apply to other operations.

EXAMPLE [I7g]



A Rocket Stack contains a refinery, the generator needed by the refinery, and a robonaut that requires a radiator (1). The Site is industrialized (3) by Decommissioning the refinery, robonaut, and generator (2), even though no radiators are present.

I8. ET Production Operation

Bring a single card from your Hand into play, Black-Side up, at one of your Factories.[45] Place the card in an Outpost Stack **(G1d)** at the location.

a. Spectral Type. The Spectral Type (letter) of the card must match the Spectral Type (letter) of the Factory Site **(I7c)**.

b. Black Cards Only. An ET production operation can only produce cards on their Black-Side. A card without a Black-Side (e.g. Crew) cannot be ET produced.

SPECTRAL TYPES [I8a]



EXAMPLE [I8b]

You have a lunar factory on Crater Shackleton (1). By taking an ET production, place an Outpost Figure (3) on Crater Shackleton, and an S Black-Side card into your Outpost #1 slot (2).



MISSION PLANNING TIP: Once you finally get a Factory going, you need something to build! Be sure to have cards ready of the proper Spectral Type.

c. Movement Timing. A card may move in the same Turn it enters play.

d. Martial Law. You may ***negotiate*** **(N6)** or use a ***Felony*** 😎 **(N6a)** to use an opponent's Factory for ET production.

e. ◊ Radiator Orientation. Choose the Orientation (see glossary) of any radiators produced.

45 ET PRODUCTION. The ancient manufacturing style of engineering handles atoms and molecules in bulk. "Manufactories" have produced everything from flint chips to computer chips. As contrasted to "nanofactories", which handle individual atoms and molecules in zero-gee. It constructs objects using sequences of chemical reactions directed by nonbiological molecular machinery. The fullerene C_{60} nanotubes, nicknamed "Buckytubes", will be the most important nanofacturing product. The space production of carbon nanotubes doesn't introduce catalyst impurities and isn't restricted in length, as it is on Earth. Depending on their structure, diameter, and chirality, nanotubes with diameters in the nanometer range have either metallic or semiconducting properties. Kevlar-coated nanotube composites and nanotube-reinforced plastics exhibit ultrahigh tensile strength and stiffness. Nanotubes can form the backbone structures of molecular machinery, or can be used as fine flexible fibers woven to fifty times the strength of an equivalent mass of aluminum. —Courtesy K. Eric Drexler.

I9. ♦Delivery Operation

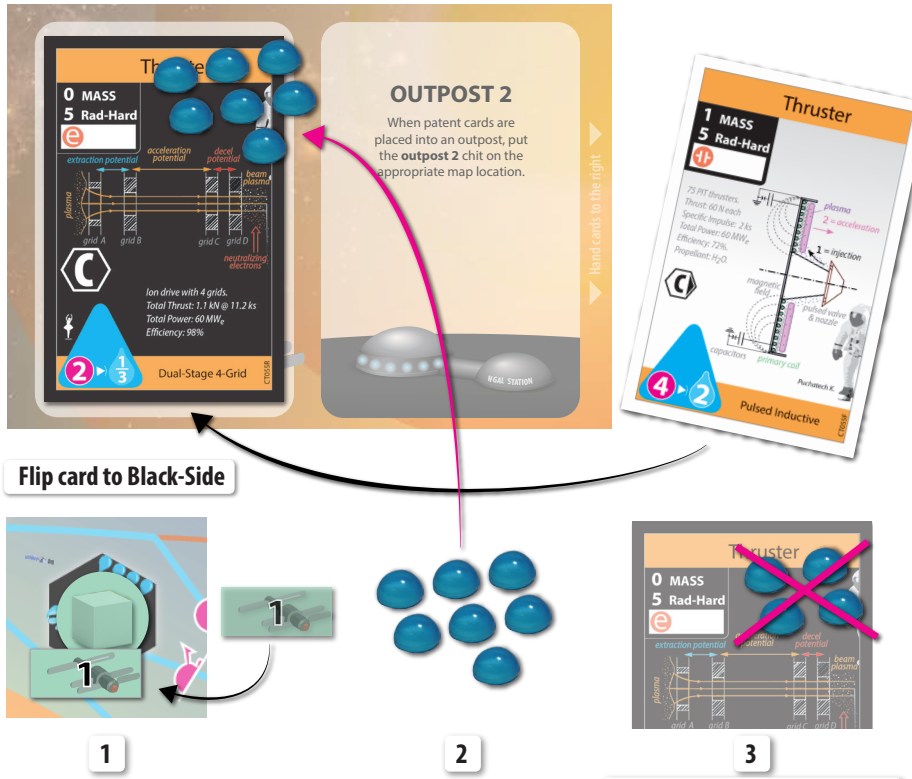
EASILY MISSED:
Deliveries from the Earth Heliocentric Zone cost zero FT (+1 for Luna since it is over Size 6). [I9]

If you have a Stack at a Factory that contains both a Black-Side card and the specified FTs, you may move the card to LEO by expending FTs from that Stack equal to <u>twice</u> the number of Heliocentric Zones the Factory is from LEO, plus 1 FT if the Size of the Site is 7 or more. This operation is a Glitch Trigger.

a. Freighters. This Operation is not available if using Module 1.

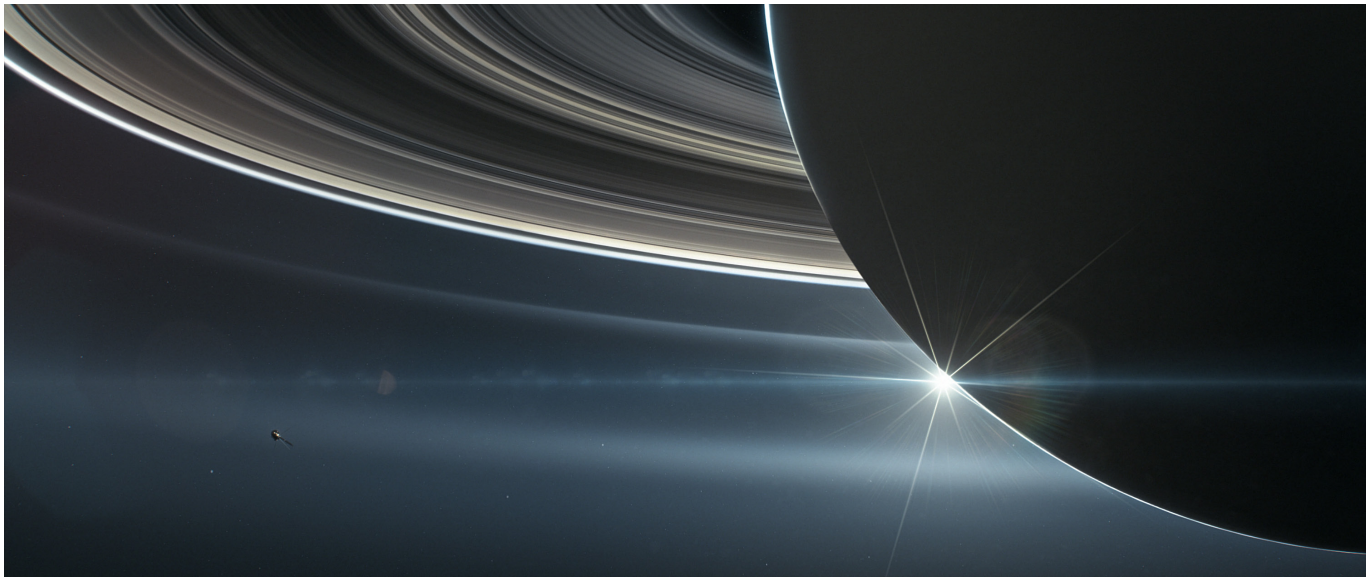
EASILY MISSED:
A delivery operation moves one Black-Side card only. White-Side cards cannot be delivered, since only space-built products have a resale market at Earth. [I9]

EXAMPLE [I9]



You spend one Turn to ET produce a Black-Side thruster at your Factory in your Outpost 1 at Ceres (1), and a second Turn to factory-refuel 7 FTs (2) into the same Outpost (I5b). Since the Ceres Heliocentric Zone is two zones from Earth, on the 3rd Turn you deliver the Black-Side thruster to LEO by Discarding 4 FT from the Outpost (3).

Saturn from the Cassini spacecraft. Picture NASA.



J. ♢ Supports

There are 3 **types** of support cards: generators, reactors, and radiators. These are used to support other patent cards in a stack (such as thrusters, robonauts, refineries, and other support cards). A single support can make multiple cards Operational.

MISSION PLANNING TIP: Among generators, ⓔ is common and ⓟ is uncommon. Among reactors, Ⓧ is the least common. [J]

J1. ♢ Using Supports

If a card lists supports in its white field to the left **(B2h)**, in order to be *Operational* **(J3)**, it needs the indicated type and subtype of support card to be Operational and in the same stack.

a. **Support Subtypes.** The generator and reactor support types are subdivided into **subtypes**. Cards that need generator or reactor supports list the particular subtype they need to be Operational. The icons for the subtypes are:
   - **2 Generator Subtypes:** ⓔ or ⓟ
   - **3 Reactor Subtypes:** 💣, ∿, or Ⓧ [46]

b. **Sharing Supports.** A single support can be used to satisfy all other cards in its stack that require that type of support. However you must choose no more than one support card for each requirement. Radiators and their *cooling therms* behave slightly differently **(J1d, J4)**.

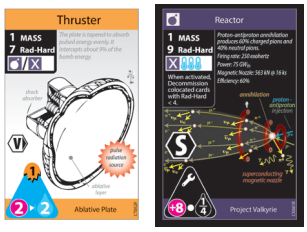
MISSION PLANNING TIP: If you need a generator for your thruster, it can be used for your robonaut and refinery as well. [J1b]

EXAMPLE [J1b] **In your Rocket, you have two cards requiring generators and three generators. In your Turn, you can designate one generator to service both cards, or designate each card to have its own generator. You cannot designate a card to be serviced by 2 generators when it only requires one. This is relevant if both generators are movement-modifying supports (J5).**

c. **Support Chains.** The card itself, the supports required by the card, the supports of those supports, etc. are all part of the card's **support chain**. You must specify the entire support chain used for movement **(H2)**.

VALKYRIE: This reactor has the limitation that, if activated per H2, it decommissions cards in that Rocket Stack (including opponent's cards) with Rad-Hard <4 at the start of the Rocket's move. This is a Felony if it decommissions Humans. [J1c]

EXAMPLE [J1c]



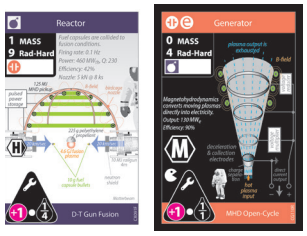
You have an ablative plate thruster which requires a 💣/Ⓧ type of reactor. (The "/" = "or"). You equip it with the project valkyrie 💣 (burst) reactor, which in turn requires an Ⓧ (exotic) reactor. Although the Ⓧ reactor could be used to support the ablative plate and make the project valkyrie unnecessary, you are not forced to do so.

d. **Radiators** provide all or part of their *Therms* as part of the support chain **(♢ J4)**. A card's cooling requirements can come from multiple radiators.

e. **Pulsed Generators** can simultaneously act to support, and be supported by, a reactor. This is because its function includes capacitive energy storage, serving both as the reactor's initiator and outputting reactor power as pulsed electricity.

SUPPORT ICONS: If your support reads: 💣/Ⓧ🌡️🌡️, read this as needing either a pulse reactor or an exotic reactor, but in either case needing 2 therms of cooling. [J1d]

EXAMPLE [J1e]



You have an D-T gun fusion reactor which uses a MHD open-cycle generator as its ⓟ (pulsed electric) support. This generator in turn needs the reactor as its 💣 (burst) support. The generator can be used to support other equipment, using its +1 thrust modifier.

J2. ♢ Non-Operational Consequences

A card needs to be Operational **(♢ J3)** to be activated for thrust, prospecting, refueling, and industrializing, or for any printed Ability whilst the card is in a stack. This does not apply to hand cards, cards that are free-marketed, or otherwise not in a stack.

a. **Thrust Triangle Activation.** A non-operational *thrust triangle* cannot be activated to move a Spacecraft stack.

b. **ISRU Refueling & Prospecting.** Except for *factory dirt refuel* **(♢ G1c)**, a stack cannot perform these operations **(I5a, I6)** without an Operational card with an ISRU value.

c. **Air-Eater.** This refuel cannot be performed without an Operational card with the pac-man icon **(I5c)**.

d. **Industrialize.** Both a robonaut and a refinery needs to have all its support requirements met, other than Therm requirements **(I7g)**, or else they cannot be industrialized into a Factory.

e. **Abilities & Restrictions** become inactive if its card is not Operational **(B2g)**. With the exception of *movement modifying supports* **(J5)**, a card does not need to be part of the support chain for its Ability to be active (e.g. magnetoshell or air-eater).

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46 REACTORS represented in the core game usually generate a few hundred megawatts of thermal power, enough to power a MW rocket. For GW and TW thrusters (Module 1), these reactors are used not as power sources but as initiators for the primary nuclear power chain (often fusion). The ratio of nuclear power to initiator power is called the **Q factor**.

J3. ♢ Operational Cards

A card becomes *non-operational* **(J2)** the moment one of these requirements is violated:

a. Solar-Power. If the card has a sunburst icon ✹ then it is non-operational in the Neptune ♆ Heliocentric Zone *(labeled "NO SOLAR POWER")*, unless given a push by a Powersat.

EXAMPLE [J3a] **Your Rocket with a Solar-powered support moves into the Neptune Heliocentric Zone. From here on, it is allowed coasting for the rest of that Turn (H2b) but cannot perform Burns or use flyby bonuses.**

b. ♢Supported. All of its required supports are in its stack.

c. ♢Support Chain Operational. All of its required supports are Operational **(♢J1c)**.

d. ♢Cooling. The card's stack contains enough Therms to meet its cooling needs **(♢J4)**.

e. ♢Option. You may choose to make a card non-operational.

J4. ♢ Cooling Therms

All cards that list one or more 🌡 icons in its support field require a number of "Therms" of cooling equal to the number of icons. To be Operational, these Therms must be supplied by radiators and/or *afterburn cooling*.[47]

EASILY MISSED: A Therm is supplied to a single colocated card for the entire Turn (movement, operations, combat). However, the Therm from afterburn cooling can only be applied to the activated thruster during movement. [J4b]

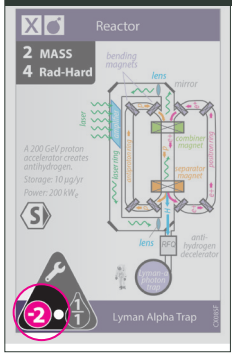
a. Therm Production. Each Therm can be supplied to a single Colocated card in a movement or Operation.

b. Therm Assignment. Each time a card that requires cooling is used **(♢J3)**, there must be sufficient Therms available for the card and its entire support chain. For example:
- **A robonaut or refinery** (and its supports) must satisfy their combined Therm requirements each time it is used during an Operation other than *industrialization* **(♢J2d)**.
- **Activation Prerequisite.** A thruster (and its supports) must satisfy its Therm requirements to be *activated* **(H2)**.
- **Ability Prerequisite.** A card's Ability **(B2g)** is locked unless the Therm requirements of itself and its supports are satisfied.
- **Circular Support Chains.** If a radiator needs a support (e.g. magnetocaloric refrigerator), its Therms can be used to cool its own supports.

c. Therms Reuse. The total Therms produced are not exhausted by any individual Movement, Operation or Action that Turn. Therms produced in a stack may be reused to cool any or all *support chains* **(♢J1c)** needed during a single Turn. Reuse applies only to Therms produced by radiators, not *afterburning* **(♢J4d)**.

EXAMPLE [J4c] **A thruster used for movement needs 3 Therms, and a robonaut in the same Stack used to prospect needs 2 Therms, then 3 Therms total are needed that Turn. If the robonaut is used both for movement and prospecting, 2 Therms total are needed.**

EXAMPLE J5a



d. Afterburn Cooling. If the activated thrust triangle *afterburns* **(H3a)** during movement, it produces one Therm of cooling as if it were a radiator.
- **Timing.** This Therm only lasts during the current movement, and must be used to cool the activated thruster and its *support chain*.
- **Non-Operational Cooling.** A non-operational thruster may afterburn if the single Therm provided is enough to make it Operational (i.e., it is only one Therm short of being Operational).

e. Radiator Orientation. The mass and number of Therms of a radiator depends upon its *Orientation*, see glossary.

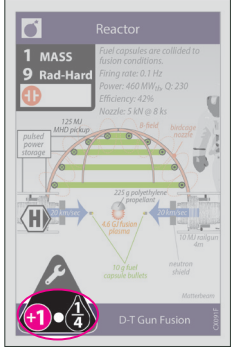
J5. ♢ Movement-Modifying Supports

A movement-modifying support, as indicated by a *black triangle* with the *wrench icon* **(B2i)**, will (if Operational) increase or decrease the net thrust and/or *fuel consumption* **(B2d)** of its Spacecraft. This gain or loss only occurs if the movement-modifying support is chosen to be in the *support chain* **(J1c)** of its activated thrust triangle, as determined during *thrust triangle activation* **(H2)**.

Follow the standard order of operations for these modifiers: multiplication and division, then addition and subtraction, and rounding fractions up at the end of the move **(H5b).** There are 3 types:

EASILY MISSED: Movement-modifying supports are <u>not</u> applied if the active thruster (e.g. a Sail) does not need them as support, or the support is for an exception (e.g. magnetocaloric refrigerator or D-T gun fusion) listed in [J5d]

EXAMPLE J5d



a. Thrust-Modifying Support contains a positive or negative thrust modifier in its black triangle**.** When calculating a Spacecraft's *net thrust* **(H3e)**, add or subtract this number.

b. Solar Thrust-Modifying Support contains the *Solar-Powered icon* ✹ **(B2e)** in its black triangle. If there is at least one Solar-Powered support in a thruster's support chain, modify its thrust by the amount of the Spacecraft's Heliocentric Zone (-5 to +2). This is only applied once, not once per Solar-Powered support.

c. Fuel-Modifying Support is indicated by a black triangle and the wrench icon. When a Spacecraft performs a *Burn* **(H5a)**, multiply its *fuel consumption* (right number in the *thrust triangle*) by this amount. To indicate a fractional fuel consumption after a Burn, you may place the Wet Mass Chit between two spots. At the end of movement, round any fractional fuel consumption up to the next highest integer. If it indicates "1/1", this means the fuel consumption is unchanged.

d. Exceptions. Ignore all movement-modifiers for supports needed only for radiators, reactors, Freighters, or GW thrusters. Solar-Power supports can never be used in the Neptune ♆ Heliocentric Zone unless getting a push from a Powersat (-6 thrust). Movement-modifiers do not affect *afterburning* **(H3a, 1C2)**.

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47 RADIATORS. For any space-based activity, all waste heat must ultimately be directly radiated to space. For a rocket with megawatts of power and closed-cycle cooling, radiator mass dominates total mass. The Stefan-Boltzmann Law states that the watts radiated per square meter of radiator equals (5.7 X 10^{-8} W/m^2) (e) (T^4), where e is the emissivity (typically 0.9) and T is the temperature at which the heat is radiated. This temperature, varying as the 4th power, depends on the thermodynamic cycle. In this game, radiators reject heat at around 990 K for earth designs and 1150 K for space designs. Therefore, a 990 K design rejecting one Therm (120 MW) requires a square panel 35 meters on a side, radiating both sides. Each millimeter of aluminum armor on both sides of such a panel would add 6.6 tonnes! Radiators suffer from diseconomies of scale, working fluid evaporation, vulnerability to meteoroids and hostile action, as well as dormancy and restart problems.

K.♢Sunspot Cycle Events

As the last step in a year, the 1st Player advances the Sunspot Cube one spot clockwise. If it passes an Event threshold, an Event Roll is made and applied to all players.

K1. ♢ Colors Of The Seasons

The Sunspot Cycle diagram is divided into three colored **seasons:** red, blue, and yellow. The season the Sunspot Cube is in determines the accessibility of *Synodic Comet Sites* **(B7h)**, the Venus flyby **(H8c)**, and the *event* **(♢K2)**.

K2. ♢ Event Roll

When the Sunspot Cube passes an "event" threshold on the Sunspot Cycle diagram, immediately roll one dice *(1d6)* and resolve the event: 1 or 2 = Inspiration, 3 = Glitch, 4 = pad explosion/space debris, 5 or 6 = a season-dependent event.

a. **Inspiration Event ('1' or '2').** Put the topmost card of each patent deck and the Colonist queue on the bottom of that deck.
b. **Glitch Event ('3').** Each player places a Glitch (red disk) on their stack with the most cards that have neither a Glitch nor Colocated Humans. Choose if stacks are tied.
   - **Glitch Roll.** If later in the game a glitched stack performs a Glitch Trigger (see glossary), a Glitch Roll is made.
   - **Glitch Repair.** A Glitch is harmlessly removed by a free action using a Human **(G7)**.

EXAMPLE [K2b] **Your Rocket has 5 cards, with rad-hardnesses 1, 3, 3, 5, and 6. It suffers a Glitch. Years later, your Rocket enters a Glitch Trigger (flyby) and you roll a "3" in your Glitch Roll. Both cards with rad-hardness 3 are Decommissioned.**

c. **Pad Explosion/Space Debris Event ('4').** Each player Decommissions their card with the highest Mass in LEO, choosing one if tied. However, Crew, Black-Side, Purple-Side, Colonist, and Bernal cards are immune.
d. **Solar Flare Event ('5' or '6', Sunspot Cube in season red).** Make a CME Roll to determine overall flare **severity**: roll one die *(1d6)* and apply the result to every card in all non-LEO stacks *(but see shieldings below)*. For each card, first add or subtract the modifier printed next to the Heliocentric Zone its located in *(-5 to +2)* from the die result, then compare the result to the *rad-hardness* **(B2j)** of that card. Any card with a rad-hardness less than the result suffers involuntary decommission unless shielded:
   - **Van Allen Shielding.** Cards located in the LEO or cycler Space are immune to this event.
   - **Magnetic Field Shielding.** Cards located on a *Radiation Belt* **(H10)**, with the exception of the 14 belts surrounding Sol, are immune to this event.
   - **Bunker Shielding.** Cards on Sites are immune to this event.

EXAMPLE [K2d] **The event roll is a 6 during season red, so a CME Roll is made: severity ="3". An outpost in the Jupiter zone is safe because its modifier brings the severity to zero. A Rocket in the Earth zone has a thruster with a rad-hardness of 1, and this is Decommissioned.**

e. **Anarchy Event ('5' or '6', Sunspot Cube in season blue).**[48] Until the Sunspot Cube exits season blue, each player's listed *faction privilege* **(B6a)** is replaced by an Ability equivalent to the Felonious faction privilege.
   - **Lawlessness** (Module 0). Additionally, the Law indicated by the Active Law is inactivated but it can still move and all Laws may still be lobbied.
   - **Purge Roll** (Module 0). Additionally, roll a dice and consult the dice numbers printed on the assembly. Discard (if possible) one delegate of each player color in this Ideology. If so, this generates a *vote tally* (**O3a**).
f. **Budget Cuts Event ('5' or '6', Sunspot Cube in season yellow).** Each player Discards a card of their choice from their Hand (if they have any) to the bottom of the corresponding patent deck.
g. **Event Order:** If an event instructs multiple players to do something, they resolve it beginning with the 1st Player and going clockwise.

EASILY MISSED: Crew are "invisible" to pad explosions. [K2c]

TIP: It is dangerous to be flying during season red. [K2d]

THEORY: Faction privileges (but not Bernal privileges) are shutdown during anarchy because of nationalization/seizure of LEO facilities. [K2e]



48 ANARCHY. If the police, judiciary, and standing army in your city or country were to disband, what would happen in your neighborhood? Would suppressed hate erupt into looting and pogroms? Would foreigners invade? Would new local governments emerge, such as neighborhood gangs or the Mafia? Would anyone with a mining laser or nuclear device find himself empowered? Without lawful regulation on the use of force, only cultural traditions prevail, and it is difficult to predict the outcome.

L. Glories

The *glory chits* start in the Heliocentric Zone indicators on the map **(B3, C7)**. When you land a Human onto any Site in a zone with its glory chit not yet taken, you may take it and place it on the Human's card with the chit's lowest VP side up. Each Crew or Colonist can carry a maximum of one glory chit. However, no glory can be obtained from a Site that a Human has previously landed on.

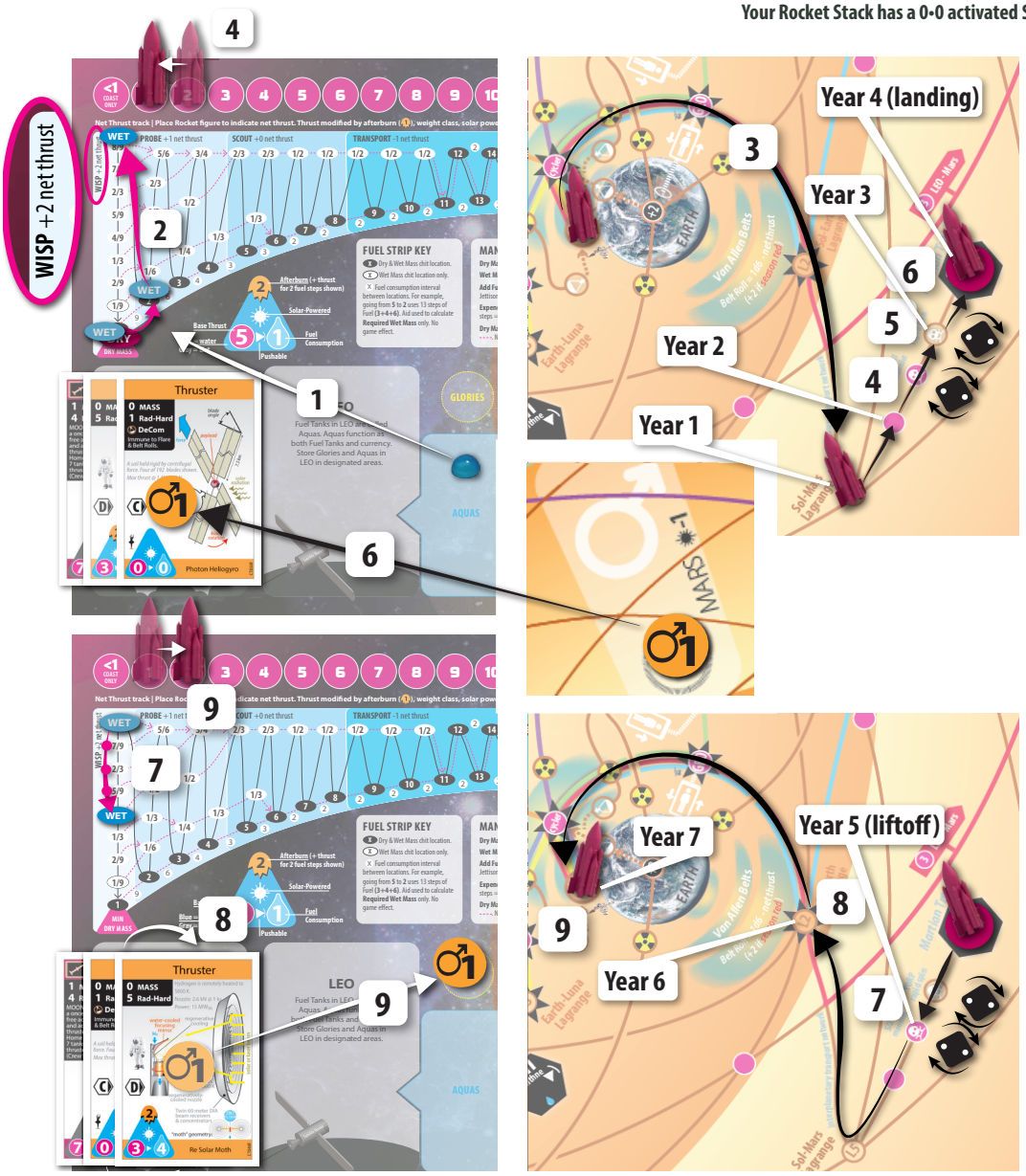
a. Ticker Tape Parade! If a Human returns back to your Bank with a glory chit on its card, this chit goes into your playmat (in the space labeled "Glory"), with its highest VP side up.

b. Tragedy. If a Human has a glory chit on its card when it is Decommissioned (e.g. death or colonization), this chit goes into the Glory space on your playmat, but remains on its lowest VP side up.

c. Heroism. These 4 chits start on the map's *heroism spots* **(C7)**. They are only used in games with 3 or more players. The map contains a description of what accomplishment each heroism chit can be awarded for. At any time before the last year of the game, any player can nominate another player, or himself, to be awarded this victory chit. Players vote beginning with the 1st player, and the chit is permanently awarded if the majority agrees (with the 1st Player breaking ties).

EXAMPLE [La]

Your Rocket Stack has a 0•0 activated Sail, 3•4 Re solar moth, and Crew.



1. You load one tank of Fuel.

2. Then you Jettison one step in order to enter the +2 wisp class.

3. Your wisp, with a Dry Mass = 1 and Wet Mass = 1 ⅘, embarks from LEO bound for eureka to claim the glory chit in the Mars zone. The net thrust is 2 which is the base thrust of 0 plus 2 for being wisp class. This gets it to the Sol-Mars Lagrange L5 after the first year of travel.

4. This is in the Mars zone, and the extra distance from Sol reduces its net thrust down to 1.

5 & 6. For years 2 and 3 it advances from 1 burn to the next, rolling a risk for each Hazard entered.

6. At the beginning of year 4, it activates the Re solar moth to land on eureka, and load the Mars zone glory chit.

7. On year 5 it uses the same thruster to liftoff, and, because it is in a hurry, spends 4 steps of Fuel to enter the Hazard Burn.

8. Activating its Sail on year 6, it enters the fit enters the final burn before Sol-Mars Lagrange L5 and coasts to Sol-Earth Lagrange L2.

9. On year 7 it flies through the last 2 Burns to LEO, for the ticker tape parade.

M. Game End & Scoring

M1. Core Endgame

The end of the game is triggered when 48 years (four solar cycles) have been completed. This happens when the Sunspot Cube crosses the seniority threshold, as the last Seniority Disk is removed.

a. Endgame with Modules 1 and/or 2 is 5 solar cycles, and with Futures is 7 solar cycles.

M2. Scoring

The player with the most ***victory points*** (VP) at the end of the game is the winner. Resolve ties by most Aqua. If still tied, share the victory or position. VP are awarded for each Token of their color, plus bonus and politics VP:

Endgame Victory Points (VP)	
a. Token VP	• 1 VP for each wooden or plastic Token (e.g. Rockets, Claims, Factories) in a player color on the map and (Module 0) on the Assembly.
b. Bonus VP (depending on the location of the token):	• Factory Stock Price. +8 / +5 / +4 VP per Factory according to its Exploitation Track (2VP regardless of track if game ends in War), (doubled if linked to a Space Elevator). • Colony Dome Location. +1 VP (Astrobiology) / +2 VP (Submarine, Bernal). • Glory & Heroism Chits. As listed on its faceup side. • Dirtside Hydration (Module 2). VP = Dirtside Hydration (Home Bernal = 6 VP). • Future Stars (Modules 0, 1, & 2). VP as listed on each completed Future.
c. Politics VP (Module 0): Increase the Token VP for all players according to final position of Active Law (skip if Anarchy/War):	**Freedom =** +1 VP per Factory cube. **Honor =** + 1 VP per glory chit. **Unity =** +1 VP for each Ideology you have a delegate in. **Authority =** +1 VP per Claim disk. **Equality =** +1 VP per Colony dome (including on Bernals). **Individuality =** +1 VP per wood/plastic Token on Sites with Hazardous lander burns.
d. Bernal VP (Module 2): Score VP for specific Anchored / Promoted Bernals:	**Promoted Cancer Hospital Bernal** = +1 VP per Colony dome. **Promoted Climate Control Bernal** = +2 VP per Dirtside for this Bernal. **SSO Diplomatic Bernal** (Module 0) = Your delegates in the Ideology of your player color are +1 VP each. **Promoted Diplomatic Bernal** (Module 0) = Your delegates in the assembly are +1 VP each. **Tourism Cycler** = +2 VP per Dirtside for this Bernal.

TIP: Always form a Rocket Stack on your last turn for its Token VP. Outpost are cardboard and are not worth any Token VP. [M2a]

N. Negotiation

At any time, even on an opponent's Turn, you may negotiate mutually-desirable deals with the other players. A deal can involve promises and/or the transfer of certain items ***(see below)***, but any deals that cannot be carried out in the Turn the deal is made are non-binding.

a. Timing. Deals can be made at any time and on any player's Turn, but transfer of items (cards, FT other than Aquas, Figures) cannot be done during ***movement,*** an ***Operation,*** or a ***free action.***

b. Transferable Items & Services. See **N1** – **N8** for a list of what is transferable. In particular, you cannot transfer ***glories,*** Futures, Anchored Bernals, or any promoted card (except unemancipated Robots may be transferred).

TIP: Don't be afraid to make deals. How often have you desperately needed your ship to have one more thrust for the Turn? Are you missing an exotic reactor or pulsed generator? Need cash for that software upload? [N]

N1. Negotiated Aquas

Players may transfer Aquas directly to and from each other without restriction.

EXAMPLE [N1] **During an auction for a patent plus its support, your opponent agrees not to bid against you in return for selling them the support for 1 Aqua.**

N2. Negotiated Transfer of Hand Cards

A player may transfer cards from his Hand to other players' Hands.

a. Academia Restriction. A card that has been traded from a Hand cannot be traded from its new Hand again until the start of its original owner's next Turn.

N3. Negotiated Transfer of Stacks & Figures

If a Stack, Claim, Factory, or Colony changes ownership, one player removes its Figure from the map and the other replaces it with a corresponding one of their own. If you trade Stack cards to an opponent, transfer the cards and FTs to his playmat. He is allowed to create an outpost or other Stack to accommodate them.

a. Stacked Tokens. See **G6a**.

b. Component Limits. Keep in mind limits for Stacks **(E3)**, disks **(G4a)**, and cubes **(I7f)**.

EXAMPLE [N3b] **If you acquire a third outpost, you must be down to your limit of two outposts by the end of your Turn. [N3b]**

c. **Free Actions.** Only the active player may perform free actions **(G)** on their Turn (e.g, their opponents may not withdraw components to comply with the previous two bullets).
d. **Crew.** Your Crew/Colonist may be moved into an opponent's Stack (e.g. in a rescue mission) but it is still under your control and provides no benefits to the opponent other than being Human (e.g. *glitch repair* **G7**) and *thrust triangle activation* **(H2)**. Either player may Jettison **(G1g)** the Crew/Colonist as a *free action* (this can be a Felony) and it is returned to your LEO Stack (or Bank) if Decommissioned.

N4. Negotiated Faction Privileges

a. **Powersat.** With this Ability/faction privilege (see glossary) you may negotiate in order to add to the thrust of any pushable Spacecraft *(marked with the push icon ▶))* **(H3d)**.
b. **Felonious.** With this Faction privilege, you may allow an opponent to commit Felonies on his Turn (thematically using corrupt bureaucrats or double agents).
c. **Mooncable.**[49] You may, as a once-per-turn free action, dirt refuel another player's Rocket at LEO/Home Orbit, either 1 tank (if it is a Crew), or 7 tanks (if it is non-crew).
d. **Scrum Troubleshooters**. You may negotiate Glitch repair of any Stack, which cannot be after the Glitch Roll.
e. **1st Player.** You may negotiate prospecting Luna **(I6.1)**. You may negotiate placement of the seniority disks as *legacy votes* (Module 0, **O6**).

N5. Negotiated Factory-Assist

You may perform a *factory-assisted landing/liftoff* using a consenting opponent's Factory **(H6c)**.
a. **Felonious.** This can also be done without consent if you can commit a Felony 😎 (see glossary).

N6. Negotiated On-Site Operation

You may use an opponent's Claim, Factory, Crew, Colony, Bernal, or Colonist to perform an On-Site Operation (e.g. site refuel, prospect, industrialize, and ET production).
a. **Felonious.** If you have Humans present and your opponent does not, these can also be done without consent if you can commit a Felony 😎 (see glossary).
b. **Lunar Mines.** If you are the *1st Player* **(C8a),** you may negotiate permission to prospect Luna.

EXAMPLE [N6]

You pay Player Green 3 Aquas to factory-assist land at his factory, use factory-refuel operation (I5b), and factory-assist liftoff. Because Player Green has Powersat, there is no factory-assist risk during landing or liftoff. Per H6c, the rapid spin Hazard is ignored during liftoff.



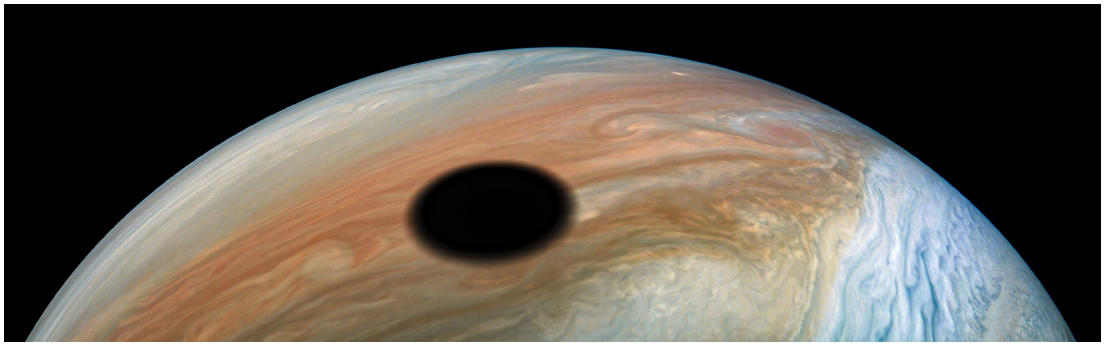
2 To Player Green
3 Factory-refuel, gain 7 FT
4 Factory-assist liftoff

N7. Negotiated Abilities

You may share an Ability listed on a Stack card or Colonist *specialty* **(2C1)** with an opponent's Colocated Stack.

N8. ♢ Negotiated Glitch Repair

A Glitch on an opponent's stack Colocated with one of your Humans is always automatically removed, regardless if you or your opponent performs the *glitch repair free action* **(G7)**.



Jupiter with shadow of Io. Picture NASA.

49 MOONCABLE. A stone on Luna has potential energy that can be released if dropped to the Earth. It must first be elevated out of the lunar gravity well, past Earth-Luna L1. If a cable, balanced at L1 so as to be orbiting both Earth and Luna, contains buckets of stones at both ends, the bucket falling towards Earth could lift the bucket on Luna. Then the cycle repeats. The mooncable itself is made of lunar silicon, grown around a "seed filament" brought from Earth. The initial fiberglass-producing plant would be between the size of Surveyor and Apollo. Both net energy, recovered from electromagnetic braking, and lunar dirt are exported to Earth orbit.
—JED Cline, *The Mooncable: A Profitable Space Transportation System*, 1972.

O. Module 0 – Politics (by Justin Grey & Brad Smith)

Welcome to your first Module, a body of rules which you can add to your ***High Frontier*** experience. In this Module, Factions elect representatives from their population as ***delegates*** into 7 different ***Ideologies***, each with its own Law. [50]

a. **The Assembly** is the hexagonal area on the placard where Factions use elected delegates to manipulate policy and gain advantages in the political arena through ***Laws.***
b. **Ideologies** include the freedom, honor, unity, authority, equality, individuality, and (in the center) centrist areas of the assembly.[51]
c. **Economic vs. Political Pull.** You gain delegate cubes by fundraising, building Colonies, or *exomigration* **(2A6)**. You are limited to 7 cubes, which can be used either as Factories or as delegates. Thus, the more you use for Factories means the fewer you can use for delegates. If you run out of cubes for delegates, you may remove a Factory per **I7f** and vice-versa.
d. **Active Law.** A gold star on the assembly indicates which Law is **active.**
e. **Anarchy**. Delegates can be killed by the *anarchy event* **(K2e)**.

EXAMPLE [0e]

1. Anarchy occurs and the Purge Roll = 2.

2. This kills delegates in honor. You have 2 delegates in honor, and your opponent has 1 delegate in honor. You each lose one delegate there.



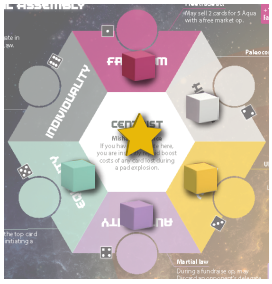
O1. Political Assembly Setup

In addition to *core setup* **(C),** find the assembly placard and set up the assembly as follows:

a. **Active Law** (gold star) is placed into the starting centrist ideology. [52]
b. **Starting Delegate.** Each player adds one cube into the Ideology of their player color.

EXAMPLE [01b]

A 5-player setup of the assembly.



NOTE: if continuing a game of "Bios:Origins 2" in a grand campaign, the Active Law starts depending upon the end condition of the game: if it ends in pacifist or unity it starts in unity, if it ends in agnostic or equality it starts in equality, if it ends in abolitionist or freedom it starts in freedom, and if it ends in the middle it starts in centrist. [01a]

50 POLITICS defines the principles of a proper social system: how people should productively get along. Especially important is the principles regarding the use of physical force.

51 IDEOLOGY is a set of principles establishing a particular social system. It makes fundamental a particular social collective called the **BSU** (Base Societal Unit), the independent sovereign entity that the society's political rights are based upon, to the exclusion of other collectives. In the game's political spectrum, individuality is based upon individual rights, equality is based upon majority rights, unity is based upon national rights, and centrist is based upon human rights. The game's ideologies are in three dichotomies:
- Freedom-Authority. Political liberties to protest, speak out, or transact as desired, versus heavy government where all these are under bureaucratic regulation.
- Honor-Equality. BSU family, in which meritorious behavior is respected, versus BSU democratic majority and left wing socialist unions, where members are treated identically, without favoritism or merit.
- Individuality-Unity. BSU libertarian individualism where diverse ideas and beliefs are accommodated, versus BSU right wing socialism and nationalism, where unity in race, ideas, and creed is sought.

52 CENTRIST. If an extremist is one who stoutly defends a principle, a centrist is the opposite, one who holds no principles or scruples, and instead follows the philosophy of pragmatism: do whatever seems to work, without regard to scruples or morals. Most democratic politicians fall into this camp, taking an opinion poll to choose the "stand" they take for the moment.

O2. Delegates & Fundraise Operation

EASILY MISSED: **When playing this Module, the income operation in the Core game is no longer available. [02]**

The new **fundraise operation** gives you 1 Aqua, adds 1 cube into the assembly, and moves one cube in the assembly.

a. **Delegates** are any cube of a player color in the assembly. You are component-limited to 7 cubes **(I7f)**. You cannot use your big cube as a delegate (Module 1).
b. **Fundraise Operation** replaces the *income operation* **(I1)**. It is performed in 3 steps:
   - Receive 1 Aqua as income.
   - You may **elect** (add) a delegate from your Reserve into your *faction ideology* **(B6b)** or an Ideology where you already have a delegate.
   - You may move any one of your delegates to an adjacent Ideology.
c. **Representation.** If you build a Colony **(G3c)** or *exomigrate* **(2A6c)**, you may immediately place one of your cubes as a delegate into the Ideology as indicated by the politics of the Crew or Colonist used. See **I7f** if your Reserves are empty.

O3. Law Activation

After an Operation, free action, or other game effect that places, removes, or moves a delegate is finished, perform a *vote tally* then *activation*:

a. **Vote Tally.** Check to see if any Ideologies have equal to or more delegates than the Active Law (the active player chooses if tied). If so, the active player must move the Active Law into an Ideology with the most delegates. If tied with the current Ideology, the Active Law may stay.
b. **Activation**. Immediately following the vote tally that moves the Active Law into a new Ideology, the Law associated with that Ideology becomes **active** and may be used by any Faction on their Turn.

EXAMPLE [03]

In a 2-player game, the Active Law is in centrist along with 2 delegates, 1 of yours and 1 of your opponent's. You build a Colony and add a delegate into unity (1), where your opponent also has 2 delegates. Since unity now has the majority, move the Active Law (2) into unity and activate its Law (UN general assembly).



O4. Lobby (new free action)

EASILY MISSED: **In peacetime, you must pay 1 Aqua to lobby. [04]**

As a once-per-turn *free action*, pay 1 Aqua and Decommission 1 of your delegates in an inactive Ideology to use its Law throughout your Turn.

a. **Centrist Law (O5g)** is exceptional in that it may be lobbied only during the *pad explosion/space debris event* **(K2c)**.
b. **Anarchy/War.** Laws may be lobbied during *Anarchy* **(K2e)** or War. Payment is waived during War.

O5. Laws

EASILY MISSED: **Under paleoconservative directive, if you have no glory, you gain no income from fundraising. [05b]**

EASILY MISSED: **All of the Laws modify existing operations. So you're still doing a free market op, a research op, etc., but you're modifying it with the active law. If lobbying, as a free action you can expend a delegate to treat another law as the active law. [05]**

Every Ideology has an associated Law, which if *activated* **(O3)** modifies rules for all players:

a. **Free Trade Act** (freedom). You may sell two cards for 5 Aqua total with a *free market operation* **(I3)**.
b. **Paleoconservative Directive** (honor). During a *fundraise operation*, your *income* **(O2b)** gained is equal to the number of glory chits that you hold anywhere.
c. **UN General Assembly** (unity). Every other Ideology with 2+ delegates also has its Law *activated* **(O3b)**, but no player may lobby any Laws.
d. **Martial Law** (authority). Once per Turn right after completing the *vote tally* **(O3a)** of a *fundraise operation*, you may additionally Discard an opponent's delegate. Thus, the player moving the Active Law into authority via a fundraise can remove one delegate that same Turn. Martial law prevents changing the 1st Player at the end of each cycle **(O6b)**.
e. **Research Grants** (equality). When initiating a *research auction operation* **(I2),** you must skip the auction and instead pay 1 Aqua to take the top card of any patent deck without *bonus supports* **(I2g)** or *academia hand limit* **(I2a).**
f. **Freedom To Roam Treaty** (individuality). You may treat an opponent's Factory or Bernal as your own for the purposes of On-Site Operations, factory-assist, Promotions, or Space Elevators without needing the owner's permission.[53] Other uses of a Factory or Bernal, such as Powersat, are unchanged by this treaty.

EXAMPLE [05f] **Freedom to roam is the Active Law and there is no Anarchy/War. You ET produce your thruster M Hand Card at an opponent's M Factory and use factory-assist to move it.**

53 PRODUCTIVITY IN SPACE will likely be bottlenecked by manpower rather than energy or materials. Accordingly, an influx of foreign workers would be a win-win for both parties.

g. **Mishap Insurance** (centrist). During a *pad explosion/space debris event* **(K2c)**, any Faction with a delegate here gains Aquas equal to the Mass of his decommissioned card. A player may lobby this to gain the insurance (outside of his Turn beginning with 1st Player) after the *Event Roll* **(K2).**

EXAMPLE [O5g] **Mishap insurance is the Active Law and there is no Anarchy or War. You suffer a pad explosion event, and although there are 2 delegates in centrist, neither of them are yours so you are unfortunately not insured.**

O6. 12-Year Legacy

Whenever a *seniority disk* is removed, the 1st Player adds it to an Ideology of their choice in the circular spot. This will count as a **legacy vote** only during the *final vote* and has no other purpose. They cannot be moved or removed.

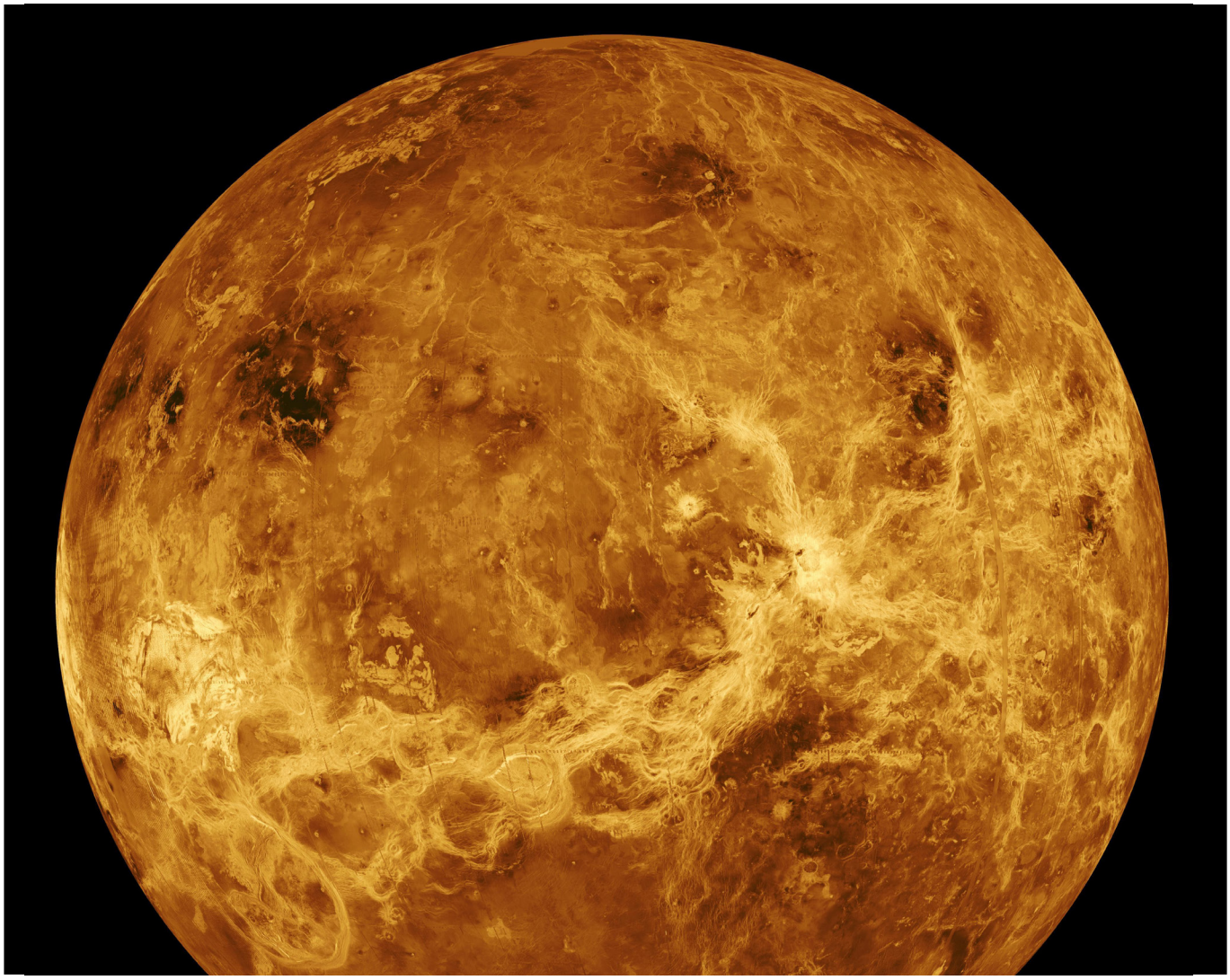
a. **Final Vote.** Placing the final *seniority disk* into the assembly ends the game. The final 1st Player performs a *vote tally* **(O3a)**, counting both delegates and *legacy votes*. The final Active Law affects scoring per **O7**.
b. **Term Limits Baton Pass.** Except during active *martial law* **(O5d)**, and assuming the game has not ended per the previous bullet, the 1st Player must then assign another player to be the 1st Player.
   - **Cube Swap.** A new 1st Player with no available cubes **(I7f)** must discard a valid cube immediately. If this is not possible that player cannot be chosen as 1st Player.
   - **Big Cube.** You cannot use your big cube for the Sunspot Cube (Module 1).

O7. Political Scoring

After the *final vote* **(O6a),** if there is no current Anarchy/War calculate *endgame scoring* **(M2c)** as follows:

a. **Freedom.** +1 VP per Factory cube.
b. **Honor.** + 1 VP per glory chit (in your Spacecraft Stack or playmat).
c. **Unity.** +1 VP for each Ideology you have a delegate in.
d. **Authority.** +1 VP per Claim disk.
e. **Equality.** +1 VP per Colony dome (including on Bernals).
f. **Individuality.** +1 VP per wood/plastic Token on Sites with Hazardous lander burns.
g. **Centrist.** No VP changes.

Magellan synthetic aperture radar mosaics from the first cycle of Magellan mapping are mapped onto a computer-simulated globe to create this image of Venus. Picture JPL/NASA.



Glossary

Definitions of capitalized terms in the Core rules and Modules are found here. These are the game's most fundamental concepts.

1st Player. The player who owns the Sunspot Cube, and thereby becomes the Sol secretary-general. He starts each *player turn phase* **(D1)** after events and completes the *sunspot cycle phase* **(D2)** at the end of each year. The 1st Player is determined during setup by the Crew with the best *clout* **(C8).** Prospecting Luna requires the permission of the 1st Player.

Ability is printed in the colored band of certain cards **(J2e)**. It includes restrictions. It applies only if the card is *Operational* **(J3)**. You can declare a card non-operational for the Turn if you wish to shut down its ability. A Factory on a Site with the push icon yields the Powersat Ability. If a card is *promoted* **(2A3)**, any abilities on the unpromoted side are lost. Abilities on unpromoted Bernals require the Bernal to be *Anchored* **(2A5).**

Active Law. In Module 0, as soon as the gold star token enters an Ideology, it makes the Law associated with that Ideology *active* **(O3)** while there is no Anarchy/War.

Active Thrust Triangle. In a moving Spacecraft stack, one Operational card with a *thrust triangle* is chosen to provide thrust for its move **(H2)**. It is suggested that this card go on top of the stack.

Adjacent. A Space is adjacent to another Space if you can trace a route from one to the other (along the lines of the map) without passing through another Space. Ignore any Space with a Crash Hazard (including Crash Hazard Burns but not including Aerobrakes) and *lander burn* Spaces when determining adjacency (since these represent abstractions, not distance). Adjacency is relevant for e.g. rayguns and Dirtsides.

a. **Buggy Roads.** Spaces connected by yellow dashed lines are never adjacent to each other (since the horizon blocks line-of-sight).





Aerobrake Hazard. A Space marked with the parachute icon. Entering it represents flying into the atmosphere to decelerate for landing, orbital adjustment, or scooping.

a. **Aerobrake Hazard Roll.** When entering an aerobrake hazard, make a Hazard Roll unless using *FINAO* **(H7e)**. The Ability of certain cards, if Operational, allows the stack they are in to forgo this roll.
b. **Air-Eater Operation (I5c)** is performed on an aerobrake hazard if you have an Operational card with the pac-man icon. Each Turn of refuel requires either a Hazard Roll or FINAO.
c. **One Way.** A Spacecraft cannot move against the arrow's direction on an *aerobrake path* **(B7e)**.
d. **Ballistic Re-entry.** You may use *coasting* **(H2b)** to follow an *aerobrake path* **(B7e)**.
e. **Solar Sails** (photon heliogyro, electric sail, photon kite sail, mag sail, etc.) are involuntarily decommissioned if their stack enters an aerobrake hazard, even if they are not activated.

Anarchy can happen during season blue, as an event **(K2e).** Because this danger is periodic, think of it as representing a divisive election year. During anarchy, all players lose their listed *faction privileges* **(B6a),** but gain the Felonious faction privilege. (Module 0) Anarchy has 2 additional effects: it inactivates the effects of the Active Law (which can still be lobbied), and also makes a 1d6 Purge Roll, which removes one delegate of each Faction in the Ideology of the number rolled. Anarchy ends when the Sunspot Cube exits season blue.

Anchored indicates a Bernal that has undergone the *anchoring operation* **(2A5)**, meaning local materials have been employed to provide it with a habitable atmosphere and radiation shields. Place a dome on the Bernal Figure to indicate that it is now an anchored orbiting colony. Anchoring has special requirements **(2A5a,b,c,d)** and special effects **(2A5e,f,g,h,i)**. Anchoring in a Home Orbit also has special effects **(2B3, 2B4)**.



Aqua is the name given to blue beads (water FTs) stored in your Bank. Each represents an orbiting 40-tonne water tank used as currency for auctions, paying off programmers, etc. They may also be used as Water FTs for fueling.

Astrobiology Site is a Site with the *green leaf* icon. Because this Site may contain the original condensate from the protostellar nebula in "cosmic" abundances, a Colony here is worth an additional victory point **(M2b)**.

Atmospheric Site is one in which the cloud icon appears in the Site hex. This is relevant in *liftoffs* **(H6c)**, in *raygun prospecting* **(I6a)** and *air-eater refueling* **(I5c).** It is also relevant in some Futures. All atmospheric sites have nearby Aerobrake Hazards. Except for Mars, all Atmospheric Sites have aerostats. Atmospheric Sites include:

- **Venus:** Venus aerostat-xity.[54]
- **Mars:** Arsia mons caves[55], north pole, hellas basin buried glaciers.
- **Jupiter:** Although atmospheric, Jupiter's gravity well is too steep and too radioactive to have a Site.
- **Saturn:** Saturn aerostat.
- **Titan** (Moon of Saturn)**:** Titan aerostat, ontario lacus, kraken mare.
- **Uranus:** Uranus aerostat.
- **Neptune:** Neptune aerostat.
- **Triton & Pluto** are not atmospheric sites, although their deep thin vapors allow aerobraking where indicated.

NEPTUNE ATMOSPHERIC



Bank (3A3j). The single Space on the map where your Aquas are considered to be stored, which is normally LEO. Your Bank shifts to your *Home Bernal* **(2B3a)**, or your *ET Home Bernal* **(3F)**, whichever is furthest from Earth.

Belt Roll (H10). This roll is made if entering a Radiation Belt, and is not made if suffering a *flare* **(K2d)**. Roll one die (1d6) and subtract your Spacecraft's *net thrust* **(H3)**. Add 2 if the Sunspot is in season red. Compare the result to the rad-hardness of each card in the Spacecraft's Stack **(B2j)**. Any card with a rad-hardness less than the result is involuntarily decommissioned.

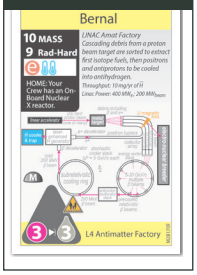
Bernal. A large orbital habitat, boosted from Earth and delivered as an empty shell to its destination, where its atmosphere and radiation shielding, constituting the vast majority of its mass, are added using local materials. Each player can have up to two. Its purpose is to maintain an Earth normal environment, either in a Home Orbit to service Earth, or at a distant world so workers can tele-operate mining activities from orbit. It is represented by a Token in your player color which designates the location of your Bernal and your Bernal Stack.

a. **As a Spacecraft,** if Operational it can activate its *thrust triangle* and use the gray Fuel Strip with its own Wet and Dry Mass Chits. It can also be carried by a Rocket.
b. **Once Anchored** by the *anchoring operation* **(2A5)**, a Bernal becomes immobile, Human, and converts all Adjacent Factories into Dirtsides. You instantly gain a Colonist by *exomigration* **(2A6)**. Dirtside factory fuel **(2A7d),** and ET products **(2A7e)** can be delivered there. Place a Colony dome on top of the Bernal Figure to indicate that it is Anchored.
c. **If Anchored In Any Home Orbit,** your *faction privilege* **(B6a)** is unlocked, you gain 1 Aqua per Turn profit, all your Aquas are stored there, cards stored there are immune to events, and you may boost cards from Earth directly to the Bernal, at double the normal boost costs **(2B3e)**. Home Orbits are indicated by 7-pointed stars.
d. **If Anchored At Its Promotion Colony (1A5a),** a Bernal card can be promoted to its Purple-Side, which activates its *Abilities* **(2B4)** and makes it into a *Lab* **(1A5b)**.

BERNAL TOKENS



BERNAL CARD



Black-Side Card. A *patent card* **(B2)** built in space, see **B2a**. It cannot ever be boosted **(I4a)**.

Blink Telescope. With this *faction privilege* **(B6a),** for each prospecting attempt using a raygun platform, you are allowed a single re-roll for the first Site prospected in the Operation if you fail its *size roll* **(I6.3)**.

Bonus Burn is a Burn which a Spacecraft can use without spending fuel and without counting towards the Spacecraft's *burn limit* **(H5c)**. A Spacecraft gains them during *flybys* **(H8)**. A bonus burn can be used anytime a Spacecraft would normally require a Burn other than *afterburning* **(H3a)** and *lander burns* **(H5e)**. If you have both bonus burns and non-bonus burns remaining, you may choose the order you use them in. They cannot be saved for the next Turn, however.

Bonus Pivot is indicated by the *ballerina* icon. Each ballerina on an activated thruster or other card indicates an extra Pivot a Spacecraft can make in a single move without spending fuel and without counting towards its *burn limit* **(H5c)**. Bonus pivots are listed on Sails, some promoted thrusters, and on certain Freighters **(1B4a)** and one bonus pivot is conferred to pushable Spacecraft ▶) by the collimator Bernal, a *Bernal Ability* **(2B4d)**.

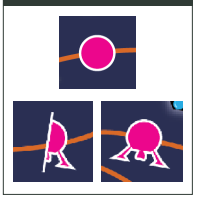
BONUS PIVOT



Burn is spending a number of fuel steps on the Fuel Strip, following the black line, equal to a Spacecraft's *fuel consumption* **(B2d)**. This can occur either by entering a Burn Space on the map or by making a Pivot.

Burn Space is a magenta-colored Space, either Lagrange burn or lander burn **(H5)**. Normally, entering counts against your *burn limit* **(H5c)**, and expends a number of fuel steps equal to Spacecraft's *fuel consumption* **(B2d)**. You may not halt on a *lander burn* **(H5e)**.

BURN SPACE



Busted. A Site covered by a translucent red disk, to indicate that there is no chance of placing Claims or Factories there. It still may be used for *ISRU refueling* **(I5a)**. Busting can occur during a failed *size roll* **(I6.5)**.

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54 XITY is the name of a bubble settlement that is buoyed by its O_2/N_2 mixture of breathable terrestrial gases. Xities are possible on Venus, Titan, and the gas giants. Hat tip to Peter Kokh of the Moon Society.

55 MARTIAN CAVES may contain considerable ice deposits, retained since the days of martian oceans. In latitudes from the equator to 40°, because daytime temperatures exceed the water frost point, any water down to a depth of 100 meters is expected to have dessicated into the dry thin atmosphere. Closer to the poles than 40°, a vast inventory of permafrost water is assumed on Mars. Ice retrieval would be easiest in sands, gravels, and fractured basalts where the principal energy required is melting the ice. The polar caps, at least in the northern summer, are water ice on the surface and are likely 15 to 30 meters deep. —Baker, Gulick, & Kargel, ***Water Resources and Hydrogeology of Mars,*** 1993.

Cargo. Cards, FTs, Freighter cubes, Mobile Factories, and Bernals carried in a Spacecraft Stack. Their combined Mass is called Dry Mass. If Operational, their Abilities are active.

Claim. A disk of a player's color on a Site showing that they have successfully prospected and mined it. Each claim is worth 1 VP.

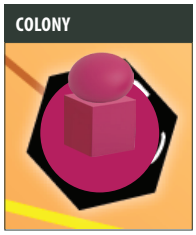
Claim Jump. See **G4, 1B9b, 1D1c.**

CME Roll. Abbreviation of "coronal mass ejection". This is a single 1d6 roll made if a ***flare event occurs* (K2d)**. This roll can't be avoided by FINAO, and indicates the flare's severity which is compared to the rad-hardness of every unshielded Stack Card on the map. This severity, ranging from 1 (a meek L1 flare) to 6 (Carrington X95 flare), is modified according to the Heliocentric Zone modifier each Stack Card is in. Any card with a ***rad-hardness* (B2j)** less than the result suffers involuntarily decommission unless shielded:

a. **Van Allen Shielding.** Cards located in the LEO or Cycler Spaces are immune to this event.
b. **Magnetic Field Shielding.** Cards located on a *Radiation Belt* **(H10)**, with the exception of the 14 belts surrounding Sol, are immune to this event.
c. **Bunker Shielding.** Cards on Sites and Anchored Bernals are immune to this event.

Colocated. Occupying the same Space. A Space, all Figures/outpost chits on that Space, and cards in stacks represented by those Figures/outpost chits are all colocated.

Colonist is a type of non-patent card **(2C)** introduced to the game via ***exomigration* (2A6)**. It can either be Human or Robot. You normally have as many colonists as you have Anchored Bernals. If carried to a Site, a colonist does work for you according to its ***Profession* (2C1)**.



Colony is an industrialized Claim or Bernal with its cube topped with a dome, with a maximum of one dome per Factory or Bernal. In the core game, the dome is added as a free action by Decommissioning a Human at a Factory **(G3)**. A colony dome can also be added to an industrialized claim by ***homesteading* (2A4)**. In either case, a non-Bernal colony is ***permanent* (G6b),** always contains Humans, and is worth endgame VP **(M2c)**. Colonies can be ***Promotion Colonies* (1A5a)**, Submarines, or Dirtsides.

Component Limits. See **G4a** (disks), **I7f** (cubes).

Core. Refers to these rules, and the components that come in the box, which form the basis for tutorials, Modules, and grand campaigns.



Crash Hazard. A Space marked with the white skull icon. When entering a crash hazard, make a Hazard Roll unless using *FINAO* **(H7e)**.

Crew. This card has Mass, ***ISRU platform, rad-hardness,*** and usually a ***thrust triangle***. It is Human, and so is useful to defend against Felonies and fix Glitches. It cannot be traded, sold, or Discarded, and always occupies a Stack, never going into your Hand. Except during ***Anarchy* (K2e)** (or your Home Bernal if using Module 2), its listed ***faction privileges* (B6a)** are active, regardless of the crew's location. If Decommissioned, crew goes into LEO (or your Bank if using Module 2).

TIP: To a normal person, "decommission" means filling out some forms. In a Phil Eklund game, this means watching your 3 hours of meticulous gameplay planning vaporize in an instant with no more consolation than having the new crater named after you. —Phirax

Decommission returns a card to your Hand **(E7)**, Crew to LEO/Bank **(B6a)**, FTs to the Pool, and Colonists to the bottom of the queue **(2C2,** but see Murder/Suicide for an exception). If a decommissioned Human was carrying a glory chit, move it to your playmat with the lowest VP side up. Decommissions can either be voluntary: Murder/Suicide, ***jettison* (G1g)**, ***Phileas Fogg* (G2c), *build colony* (G3), *and industrialize* (I7)**, or involuntary: Glitch Rolls, ***Hazard Rolls* (H7)**, Belt Rolls, CME Rolls, or ***pad explosions* (K2c).** Decommission is special for heavy radiators (see Orientation). Crew or Colonists can only be voluntarily decommissioned in the following instances:

a. **Founding Settlement**. To build a Colony **(G3)** or **(2A4b, 2A7b).**
b. **Crew Only.** If you have the Felonious ***faction privilege*** allowing Murder/Suicide.
c. **Colonist Only.** See ***homesteading* (2A4)**, ***unanchoring* (2B6),** and ***Murder/Suicide* (2C2a).**

Dharma Refuel. With this ***faction privilege* (B6a),** your Crew enjoys double yield from site refuel when carrying a glory chit.

Dirtside (2Ba) is a Factory Adjacent to an Anchored Bernal (see Adjacent in the glossary). The Hydration of its Site counts towards your ***dirtside hydration* (2B5)** for endgame scoring. Your Factory Adjacent to an opponent's Bernal counts towards their dirtside hydration. You may specify ***dirt refuel* (G1c),** ***factory-refueled FTs* (I5b, 2A7e)** or ***ET factory products* (I8, 2A7f)** built at a Dirtside to appear at the Bernal instead.

Discard. Return a ***patent card* (B2)** from your Hand to the bottom of its corresponding patent deck, or return a token to the Pool or Reserves.

a. **Cards** can be discarded as a ***free action* (G6)**, ***free market operation* (I3b)**, or the ***budget cuts event* (K2f)**.
b. **Loyalty.** Your Crew or non-robotic Colonists may never be discarded. Discard Robots to the colonist deck.
c. **Tokens** can be discarded when a Stack is disbanded **(E2e)**, or ***glitch repair* (G7)**.
d. **Discarding a Card** (goes to the bottom of its patent deck) is distinct from Decommissioning a card (goes to your Hand, or into your Bank if Crew).

Dry Mass is your Spacecraft Mass assuming its fuel tanks are "dry" (empty). Thus it includes just the mass of its FTs, cards, and Mobile Factories. It is indicated on the Fuel Strip with a Dry Mass Chit.

Dry Mass Chit. The token on the Fuel Strip indicating the mass of a Spacecraft, not counting its fuel. Find the Dry Mass by adding the masses of all the Cargo (i.e. cards, FT, and cubes) in the Rocket or Bernal Stack. You have 2 Dry Mass Chits, one for your Rocket and one for your Bernal. If it changes, see **F2**.

a. **Min & Max.** The minimum Dry Mass of a Spacecraft is one. If the mass of the cards is less than one, treat it as one. The maximum Dry Mass allowed is 23.

Epic Hazard Roll (1A6a). When building a *Space Elevator* **(1B9)** or attempting a *Future* **(1D1),** either pay FINAO or roll 1d6. If a "1" is rolled, the attempt fails and the Freighter or Human involved suffers involuntary Decommission.



ET. Short for extraterrestrial, meaning "not from the Earth".

Event Roll (1d6) occurs each time the Sunspot Cube is moved across a threshold labeled "event":
1 or 2 = inspiration, 3 = Glitch, 4 = pad explosion/space debris, 5 or 6 = a season-dependent event **(K2)**.

Exoglobalization. The elimination of government-enforced restrictions on exchanges across the Earth and extended to extraterrestrial resources and facilities, creating an interglobal marketplace.

Exploitation Tracks record the *factory stock price* **(M2b)** of each Spectral Type, considering how many Factories of each type exist. The more of a particular type, the lower its stock price. Update this as Factories (totaling all players) are created *(through industrialization or moving a Mobile Factory onto a Claim)* or destroyed *(through Decommission or moving a Mobile Factory off of a Claim)*. The maximum stock price is 10 and the minimum stock price is 4. Stock prices are used during a *free market operation* **(I3b)** and *endgame scoring* **(M2b)**.

Faction. One of the 5 player colors. Each represents a "basal societal unit" (BSU): global regulation (yellow), national government (white), socialist regime (purple), worker union (green), or private entrepreneur (red). Each faction has a *faction privilege* **(B6a)**.

Factory is a cube sitting on a Claim. This indicates the Site is industrialized, with the factory cube created by *the industrialize operation* **(I7)**. Factories provide VP and many other benefits. If you Promote a Freighter **(1Bc)**, all your Factory cubes become Mobile Factories. A Factory Adjacent to an Anchored Bernal is called a *Dirtside* **(2Ba)**. A Factory on a Site with the push icon ▶) grants the Powersat Ability **(H3d)**.



Factory-Assist Hazard. Using *factory-assist* **(H6c)** incurs a Hazard Roll unless it is colonized or you have Powersat.

Factory Hijack. A Felony 🥸 allowing you to use an opponent's Factory to perform a *factory-assisted landing/liftoff* **(H6c)**, *factory-refuel operation* **(I5b)**, *ET production operation* **(N6a)**, or *promotion* **(2A3)** without the owner's permission. Hijacking cannot be performed if an enemy Human is Colocated.

Factory Loading Only. A Freighter labeled as such may only receive Cargo when located at a Factory or your non-Home Anchored Bernal.

a. **Cargo Load/Unload**, It may never receive Cargo in LEO or at your Home Bernal. It may give Cargo anywhere.

Felonious. As free actions during your Turn, this *faction privilege* **(B6a)** allows you to perform Felonies: *Claim Jumping* **(G4)**, Murder/Suicide, and Factory Hijacking.

Felony is an activity which is prohibited except in season blue after an *anarchy event* **(K2e)** or for those with the Felonious faction privilege. Your Human must be Colocated to commit a felony. Felonies include Murder, Suicide, Claim Jump (including prospecting Luna without permission), and Factory Hijack.

Figure. Any component placed onto a Space on the map. In the core game these include Figures that represent a stack's location *(Rocket tokens or outpost chits)* as well as your Claims **(I6)**, Factories **(I7)**, and Colonies **(G3)**.



FINAO (Failure Is Not An Option). Before making a Hazard Roll, you may pay 4 Aquas before rolling to automatically succeed. This represents paying programmers for a fail-safe fix.

a. You may not use "FINAO" when making any other type of roll, such as Glitch, CME, or Belt Rolls.

Freighter. A stack of cards on your playmat extension, with a location indicated on the map with your big cube. You may only have one freighter at a time. See **(1B1a)** for production, and **(1B4)** for movement.

FT (Fuel Tank). 1 mass unit's worth of fuel, represented by a bead on the map or in a stack. Each FT has a mass of 1. In the core game, only water FTs are used.

a. **Creation.** FTs are created by the *internal tankage* free action **(G2)**, *income operation* **(I1)**, or *factory-refuel operation* **(I5b)**. Water FTs are also considered Aquas if residing in LEO/Bank.
b. **Colors.** FTs come in 2 colors: blue (water grade) and gold (isotope grade). Your gold FTs are always your domestic Spectral Type **(1C1c)**. These fuel grades are important in *mixing fuel* **(F4d)**, *internal tankage* **(G2b)**, and in *site refuel operations* **(I5)**.

Fuel. See Wet Mass Fuel. This technically represents, not fuel (which stores energy), but propellant (which stores reaction mass). In the core game, fuel can be either dirt or water.

Fuel Strip. The upper part of your playmat, which uses Wet and Dry Mass Chits to track Spacecraft and fuel mass.

Futures (1D) are optional quests **(1A2b)** that are available when you Promote a card to its Purple-Side. If you fulfill the listed requirements, you get extra VP as listed. You need a longer game if playing with futures, so place 7 Seniority Disks for an 84-year game.

Glitch is a red disk placed on a Stack if it suffers the *glitch event* **(K2b)**. As a result of this event, each player must glitch his stack with the most cards, not counting those with Humans (including LEO) or those already glitched. If a glitched stack performs a Glitch Trigger, then make a Glitch Roll.

a. **Glitch Removal.** A Glitch can be removed only through a *glitch repair free action* **(G7)**, or if the stack is Decommissioned or removed.

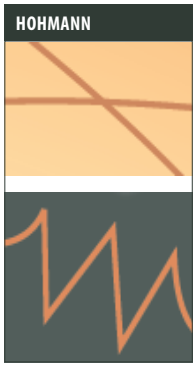
WHAT IF A GLITCH DISABLES YOUR ROCKET?: **You can create an Outpost Stack there and cargo transfer the cards into it (so you can make a new Rocket Stack to rescue them). You can voluntarily Decommission some or all of the cards to start over (but you can't do this to Crew unless you are allowed Felonies).**

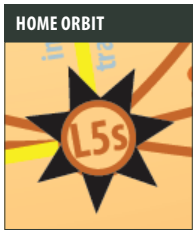
Glitch Roll. Roll one dice (1d6). All cards in your Stacks, which are colocated with your Glitch and which have a *rad-hardness* **(B2j)** exactly equal to the dice roll (if any), suffer involuntary decommission. If a heavy radiator is glitched, instead of Decommission rotate it to its light Orientation. Whatever the result, the Glitch is retained.

Glitch Triggers. Make a Glitch Roll immediately before a glitched stack performs any of the following. For **c** to **g** below, this still counts as your Turn's Operation even if you fail to complete it because of the Glitch:

a. **Enters A Flyby (H8).**
b. **Cargo Transfer Free Action (G1).**
c. **Site Refuel Operation (I5).**
d. **Prospect Operation (I6).**
e. **Industrialize Operation (I7).**
f. **Delivery Operation (I9).**
g. **Anchoring Operation (2A5).**

GW. Short for "gigawatt", or a billion watts. Thrusters are rated to approximately how many watts of power they are rated for. The core game uses megawatt thrusters, and Module 1 introduces gigawatt thrusters, which become starship-class terawatt (trillion watt) thrusters if Promoted.









Hand. A set of patent cards set to the right of your playmat. They are added during *research auctions* **(I2),** when cards (except Crew) are Decommissioned, and when Robot Colonists are exomigrated or Decommissioned. Cards are taken out of your Hand during the operations *free market* **(I3a)** or *boost* **(I4)**. There is no hand limit, however see **E1a.**

Hazard. A Space that forces a Hazard Roll when entered. See Aerobrake Hazard, Crash Hazard, Epic Hazard Op, and Factory-Assist Hazard.

Hazard Roll. Roll one dice (1d6) for the Spacecraft. If you roll a '1', each card, FT, and cube in its Stack is involuntarily decommissioned. You can avoid the risk if, before rolling, you pay for FINAO.

Heliocentric Zone is one of a series of concentric zones on the map centered on Sol identified by the astronomical symbols Mercury (☿), Venus (♀), Earth (⊕), Mars (♂), Ceres (⚳), Jupiter (♃), Saturn (♄), Uranus (♅), and Neptune (♆). Each has a positive or negative number that affects stacks within that zone, affecting both the thrust of activated *thrust triangles* that use Solar-Power **(J5b)** and the severity of *solar flares* **(K2d)**. In the Neptune heliocentric zone, which is furthest out from Sol, Solar-Powered cards become non-operational **(J3a)** unless pushed by a Powersat.

Hohmann. A Space where two routes either intersect or make a corner, unmarked by a circle or other icon **(B7b)**. Changing direction mid-move in a Hohmann requires a *Pivot* **(H4c)**. If routes cross without touching, this is not a Space and Pivots are not allowed.

Home Orbits are Spaces near Earth marked with a 7-pointed star, see **2Bb.**

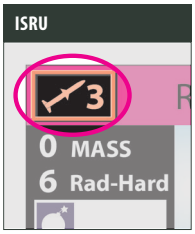
Home Bernal is a Bernal anchored in a Home Orbit **(2B3, 2B4)**.

Human. Cards that contain humans (or conscious transhumans), as signified by the orange "humans on board" triangle *(e.g. Crew & Colonist cards)*. Colonies (domes), cards in LEO, Anchored Bernal Figures are also human. If the *uplift future* **(1D5n)** is completed by anybody, Robots become Human. Humans can prevent or cause Felonies, and can repair Glitches **(G7)**.

Hydration. Water availability on a Site, as denoted by the number of waterdrops listed (between zero and four, see **(B7a)**). If the number of waterdrops is less than the ISRU rating of a robonaut or Human card, then ISRU *refueling* **(I5a)** and *prospecting* **(I6.2)** operations are impossible. Dirtside hydration is used for victory points in Module 2 **(2B5)**.

Ideology. One of the 7 regions in the assembly (Module 0). Six of them are associated with player colors.

Isotope Fuel. GW Thrusters require special fuel, as represented by either gold FTs or a gold Wet Mass Chit. During *factory-refueling* **(I5b)**, the refueling rate for isotope fuel is limited to 1 isotope tank (gold bead) per site refuel operation. The Spectral Type of the Site where the fuel is obtained must match the Spectral Type of your GW thruster. Spectral Type **D** is boron-11 fusion fuel, **H** is helium-3 fusion fuel, **M** is curium-245 fission fuel, **S** is uranium-235 fission fuel, and **V** is lithium-6 fusion fuel.



ISRU. Cards able to prospect or dig for water have an "In Situ Resource Utilization" rating **(B2c)**, ranging from zero (the best) to four (the worst). In order for a unit to be able to ISRU *refuel* **(I5a)** or *prospect* **(I6)** at a Site, it must have an ISRU number less than, or equal to, the Hydration of the Site.

1) Check Site Hydration and robonaut/Human ISRU on the table below to see if prospecting is possible.
2) Roll less than or equal to Site Size on 1d6 to establish a Claim (Size > 5 = automatic success).

Prospect Operation	💧💧💧💧	💧💧💧	💧💧	💧	No Hydration
ISRU 4	Can prospect (1)	NO	NO	NO	NO
ISRU 3	Can prospect (2)	Can prospect (1)	NO	NO	NO
ISRU 2	Can prospect (3)	Can prospect (2)	Can prospect (1)	NO	NO
ISRU 1	Can prospect (4)	Can prospect (3)	Can prospect (2)	Can prospect (1)	NO
ISRU 0	Can prospect (5)	Can prospect (4)	Can prospect (3)	Can prospect (2)	Can prospect (1)
ISRU Refuel Operation: Refuel # of Water FT equal to number in parentheses above based on ISRU/Hydration.					

Jettison. As a *free action* **(G1g)**, you may Decommission unwanted stack cards to your Hand and or Discard unwanted FTs to the Pool. Make a *dry* and *wet mass adjustment* **(F2, F3)** on the Fuel Strip. If Wet Mass Fuel **(F1)** is *jettisoned* **(G1f)**, move its Wet Mass Chit to the left along the black line.

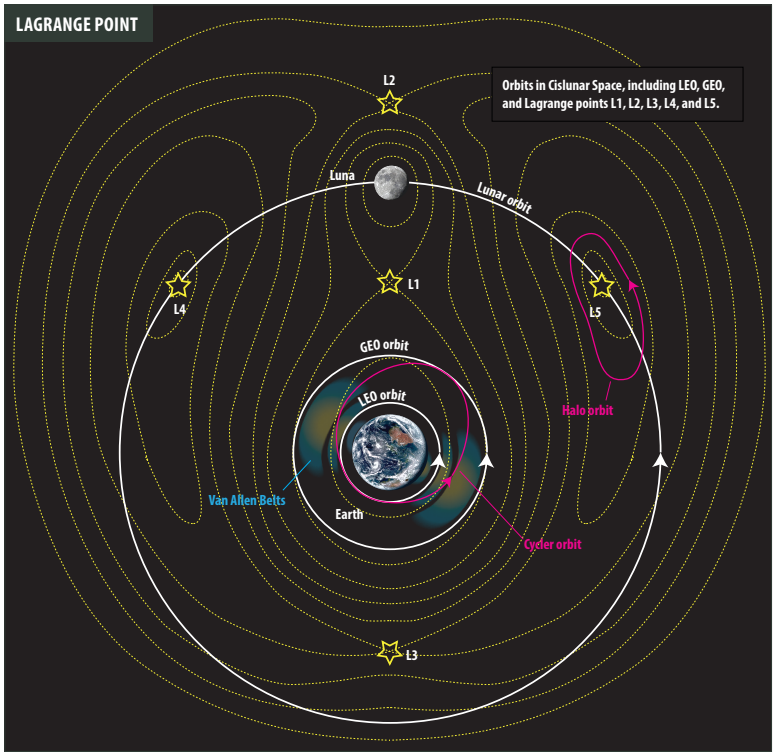
Lab is a Promoted and Anchored Bernal, where Colonist, Freighter, and GW thruster cards can be *promoted* **(2A3)** to their Purple-Side , regardless of their promotion colony type.

Lagrange Point. Any intersection marked with a circle, either filled (Lagrange Burn) or unfilled (Lagrange intersection), is a junction where you can turn for no movement or fuel cost. (In a Lagrange Point, the gravity gradient is flat due to the canceling gravitational effects of 2 massive bodies such as Sol or planets. This allows for effortless course corrections. Note however that many of the "Lagrange Points" in the game are not true Lagranges.)

Launch Fees. This *faction privilege* **(B6a)** gives you a 1 Aqua bonus from the Pool after any player (including yourself) boosts one or more cards.

Laws. See **O5**.

LEO. Low Earth Orbit, and the closest Space to Earth. Cards in your LEO Stack and your Aquas are located in LEO. Cards at LEO, including in your Rocket Stack and your LEO Stack, are vulnerable to *pad explosions/space debris* **(K2c)**. LEO always contains Humans. Cards can be added to the LEO stack by the *boost operation* **(I4)**, and Black-Side Cards in LEO can be sold by the *free market operation* **(I3)**.



Load Limit is a number listed on a Freighter card indicating how much Mass a Freighter can carry, adding together the Mass of all the cards, FTs, and cubes in the Freighter Stack other than the Freighter card itself **(1B3a)**.

Marketeer. With this *faction privilege* **(B6a)**, you always win *auction* ties **(I2e)**, even if you are not the initiator.

Mass. A number indicating how heavy cards and fuel are, where each mass is 40 tonnes. This number is found in the upper left corner of cards, and also is the number indicated on the Fuel Strip.

Mishap Insurance (O5g). During a *pad explosion/space debris event* **(K2c),** gain Aquas equal to the mass of your decommissioned card, if you have a centrist delegate.

Mobile Factory (1B6). Once you Promote your Freighter Card, all your Factory cubes become mobile factories, able to move with the same capacities as your promoted Freighter Card. This allows them to uproot and fly to new Claims. They are only considered a Factory while on a Claim, however.

Module. A set of rules that reference the core rules. You can add or subtract a module to tailor your High Frontier experience.

Mooncable. With this *faction privilege* **(B6a)**, as a once-per-turn free action you may refuel an activated dirt thruster at LEO/Home Orbit with 7 tanks (non-crew thruster) or 1 tank (Crew thruster).

Murder/Suicide. A Felony allowing you to voluntarily decommission Humans under your control, limited to once per Turn. Suicide is the same as murder except another Human does not need to be present. ***Build colony* (G3)**, and ***industrialize* (I7)** Decommission your Crew without being considered murder/suicide. If a Colonist is murdered/suicided, its card goes into LEO or your Bank (without generating *exomigration* **(2A6)**, in a similar manner to Decommissioned Crew).

MW. Short for "megawatt", or a million watts of power. The core game thrusters are in the MW range, while Module 1 introduces thrusters in the gigawatt range (see "GW" for comparison).

On-Board Nuclear Support. Certain Freighter and Colonist cards contain an "On-board Nuclear" icon, either reactor or generator **(1B5, 2C4)**. If reactor, it can act as a reactor support with a ***subtype* (J1a)** of stationary, burst plasma, or exotic, as specified. If generator, it can act as a generator support, either pulsed or electric, as specified.

On-Site Operation is any operation that is conducted on a Site, and includes ***site refuel* (I5),** ***prospect* (I6),** ***industrialize* (I7)**, ***ET production* (I8)**, *promotion* **(2A3),** and *anchoring* **(2A5).** This is important in ***negotiation* (N6)** and War.

Open Source FINAO. With this *faction privilege* **(B6a),** FINAO only costs 3 Aqua.

Operation. A game process. In the core game, you are allowed one operation per Turn, chosen from the 9 kinds **(I)**. Additional operation choices are introduced in Modules 0, 1, and 2: ***fundraise, promotion, homesteading, anchoring,*** and ***epic hazard operations.***

Operational. A *patent card* **(B2)** is optionally Operational if it is in the same stack as all of its required support cards (if any), which themselves are Operational. Solar-Powered Cards () are non-operational in the Neptune Ψ Heliocentric Zone or farther. You may declare an operational card to be non-operational.

Orientation. Radiator cards have two orientations: heavy or light as listed on the top and bottom half of the card. You must decide on the orientation when it enters a stack due to a boost or *ET production* operation. It may change orientation in 3 ways:

a. **Ablation.** If a heavy radiator is Decommissioned by a Hazard Roll, Glitch Trigger or bad ***Belt Roll,*** instead of Discarding it, reorient it into its light orientation. Other involuntary Decommissions discard the radiator entirely.
b. **Jettison.** You can convert a heavy radiator into its light orientation by using the ***jettison free action* (G1g)** or *Phileas Fogg* refueling **(G2c)**. This involves a ***dry*** and ***wet mass adjustment* (F2b, F3b)** equal to the difference in mass between the heavy and light orientation.
c. **Heatsink Fountain Radiators.** Both the White-Side and Black-Side of this radiator starts on its heavy orientation, but is reoriented to its light orientation the first time it provides a Therm of cooling (as it uses up its cooling salts). Thus the heavy side is not useful for thrusters or Bernals that need cooling for multiple Turns.

Outpost Stack. A Stack of cards located on the map where one of your two outpost chits (#1 or #2) is placed. It can be created by the ***cargo transfer free action* (G1d)**, the ***factory-refuel operation* (I5b)**, or the ***ET production operation* (I8)**.

a. **Limit.** You may only have two outpost stacks at the end of your Turn.
b. **Actions.** An outpost cannot move but it can be converted into a Spacecraft stack as a free action **(G1d,e)** or transfer any number of their cards to a Colocated Stack **(G1)**.
c. **Creation Methods & Locations.** See **E6.**

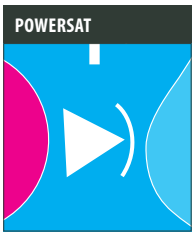
Phileas Fogg Refuel. Inspired by *"Around the World in 80 Days"* by Jules Verne. See **(G2c)**.

Pivot is a change in direction during a move at a ***Hohmann* (B7b)**. If a Spacecraft performs a pivot, it must make two Burns. A Pivot is a measure of distance, and each is 2 AU (16.7 light minutes).

Pool is the pile of Aqua, red disks, and other tokens not belonging to any player (i.e., the general supply).

Powersat is a ***faction privilege* (B6a)** or Ability used when calculating a Spacecraft's ***net thrust* (H3d)**. It only works on Spacecraft with the push icon ▶). It gives its "+1 push" at any range.

- **a. Single Push.** It has no effect if the Spacecraft is already being pushed **(H3d)**.
- **b. Negotiation.** A push can be *negotiated* outside of your Turn **(N4a)**.
- **c. Push Factory.** A Factory on a Site with the push icon yields the Powersat Ability.
- **d. Ability.** Some cards (e.g. ionosphere lasing refinery) allow you to permanently gain the Powersat Ability.
- **e. Safe Factory-Assist.** Allows *factory-assist* (**H6c**) without a Hazard Roll.
- **f. Freighters (Module 1)** can move 2 if pushed with a powersat.
- **g. Bernals (Module 2).** When anchoring a Bernal, Solar-Powered supports do not work in the Jupiter zone or beyond unless you get a push from a powersat.
- **h. Anarchy/War** cancels the Powersat faction privilege, but not the Powersat Ability conferred by cards or Push Factories/Colonies.



Profession. One of 4 jobs that each Colonist specializes in: miner, prospector, industrialist, or engineer. Each profession has a ***specialty* (2C1)**, that makes ***on-site refueling***, ***prospecting/promoting***, ***industrializing/anchoring/nanofacturing***, or ***ET production*** much faster.

Promote. This Operation is part of Module 1 **(1A5)** and Module 2 **(2A3)**. It permanently flips a card to its Purple-Side when the card is at its ***promotion colony* (1A5a)**, unlocking Abilities and optionally Futures.

Purple-Side Card. The Promoted side of certain ***patent* (B2)** and Colonist cards. The ***promote operation*** is part of Module 1 **(1A5)** and Module 2 **(2A3)**.

Purge Roll. (K2e).

Push Colony (1A5a) is a dome at a Site marked with the push icon ▶) (Io, plus most Sites within the Heliocentric Zones of Mercury (☿), Venus (♀), or Earth (⊕).

Radiation Belt (H10). A Spacecraft marked with the radiation icon. A Spacecraft that enters it must immediately make a Belt Roll for damage.

Reserves are the tokens of a player currently not in play, placed next to his playmat. The number of components in the reserve during setup is specified in **(C3)**. Token limits are as specified in **(B8)**.

Robot is a type of Colonist **(2C2a)**. It is not Human (and thus cannot repair Glitches, etc.) unless ***emancipated* (2A6b).** If in your Hand, it is treated as a ***patent card* (2C2b)**.



Rocket. A stack of cards on your playmat, with a location indicated on the map with your rocket figure. You may only have one Rocket at a time. See **(E5)** for creation, and **(H)** for movement.

Sails are thruster cards representing huge gossamer films propelled by Sol (solar photons, solar wind, or solar magnetic field). Although technically not rockets, they act as rocket ***thrust triangles*** with a fuel consumption of zero. Sails include: photon kite sail, mag sail, photon heliogyro, and electric sail. Certain Colonists are also sails: calypso-2 seed sail, and wet-nano seed sail.

- **a. Aerobrake Burnup.** Sails are Decommissioned immediately upon entering an aerobrake hazard, regardless if activated or not.
- **b. Bonus Pivot.** Sails enjoy one Bonus Pivot, as indicated by the ballerina icon.
- **c. Mag Sail Bonus.** If activated, the Mag Sail **(H8f)** receives one Bonus Burn in the same manner as a ***flyby* (H8b)** for each Radiation Belt entered. However, each Radiation Belt can boost a Sail only once per Turn, in the case where a Sail circles and re-enters the same point.

EXAMPLE **A Sail with a mass of 1 takes on Cargo with a mass of 6. Set both the Wet Mass Chit and the Dry Mass Chit on 7 (this indicates it is flying "dry" with no fuel).**

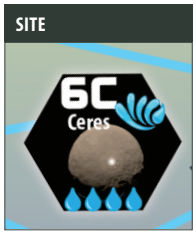
Scale.

a. **Every Round** of player Turns is one Earth year. Each year is half movement, half operations.
b. **Each Mass** is a quadecaton (40 tonnes, or 40,000 kg). A tonne is roughly equal to the US or UK ton.
c. **Each Human Mass** is a six-man crew with life-support.
d. **Fuel Consumption** is inversely proportional to a rocket's specific impulse (Isp) in seconds, as follows: 8 = 4.6 km/sec (0.46 ks Isp, where "ks" = 1000 seconds), 4 = 10 km/sec (1 ks Isp), 2 = 20 km/sec (2 ks Isp), 1 = 40 km/sec (4 ks Isp), ½ = 80 km/sec (8 ks Isp), ¼ = 160 km/sec (16 ks Isp), 0 ≥ 0.4% lightspeed (121,000 km/sec).
e. **A Thrust of one** is 0.75 kN (750 Newtons, or 169 lbs, the weight of the game designer on Earth!). Each additional point doubles this. For instance, a 100 kN thrust is a thrust of 8.
f. **A Net Thrust** (more accurately called ***acceleration***) of 0 is 0.3 milligees or 0.3 cm/sec^2, and each step more than doubles this. A net thrust of 0 can, in 6 months of continuous thrusting, move 2.4 AU, about 1 Pivot.
g. **Size One Worlds** have a surface gravity of 0.75 milligees, and each additional step doubles this. Size 1 worlds have the following diameters based upon density: comet nucleus 52 km (only Centaur comets approach this size), **S**-type asteroid 22 km, **M**-type asteroid 14 km.
h. **Hydration 4 Sites** are icy or permafrost bodies. Hydration 3 has small amounts of surface or subsurface ice. The Sahara Desert is Hydration 3. At Hydration 2, trace amounts of water can be extracted from kilotons of regolith. At Hydration 1, concrete would be considered a good source of water. At Hydration 0, oxides and hydrides are the only alternatives.
i. **Reactors** produce 650–2000 MW_{th} of thermal power, either in heat, neutrons, pions, or plasma jets. Assuming +0 net thrust, a generator converts this into 60 MW_e of electricity (Subscript e = electricity, th = thermal).
j. **Beamed Power** from a GEO solar-power satellite emits a laser beam of 60 MW or more. A push factory on Mercury, Venus, or Io emits a 450 MW laser or mass beam with a 500m filled aperture beaming optics.
k. **Each Radiator Therm** rejects 120 MW_{th} of heat at 1200 K when used to cool MW rockets, 240 MW_{th} at 1427 K when used to cool GW rockets, and 960 MW_{th} at 2000 K for TW rockets. These increases simulate the higher-temperature alloys and higher operating temperatures available to the higher-powered rockets.
l. **Each Lagrange Burn or Lander Burn** requires a delta-v (velocity change) of 2.5 km/sec. A half lander burn (found on worlds with a surface gravity around 24 milligees) is 1.25 km/sec. Each Pivot (brachistochrone maneuver) is 5 km/sec and a distance of about 2 AU (16.7 light minutes).
m. **A Solar Flare Event** with a die roll of 1 is an L1 flare with an X-ray power density of 10^{-5} Watts/m^2. Each point more is 4 times this amount. Thus, a die roll of 6 is a X95 (Carrington-class) flare with a power density of 10^{-2} Watts/m^2.
n. **Equipment with a Rad-Hardness of 1** can withstand a total ionizing dose of 4 X 10^{-7} rad (Si) without failing. Each additional point is 1000 times this amount. For example, equipment with a rad-hardness of 6 can survive 400 Mrad of dosage. This is the scale used by the industry. Note that 100 rad = 1 Gy.
o. **Solar Insolation** is 1.38 kW/m^2 at 1 AU (1 AU = Earth-Sol average distance). Maximum sailing thrust is 12.2 N/km^2 from photon pressure at 1 AU, or 0.002 N/km^2 (2 nPa) from solar wind dynamic pressure. These values are in the Earth zone. Each zone closer to Sol doubles them.
p. **Each Fuel Tank (FT)** of water is a 40-tonne bag with a diameter of 4.25 meters. For rockets that use hydrogen as propellant, 40-tonnes of LH_2 or slush hydrogen is held in a cryotank cylinder 7.5 meters in diameter and 16 meters long, including active refrigeration for zero boil-off (ZBO).
q. **The Boost Cost to LEO** is 2 million USD/tonne to LEO using the Falcon Heavy by SpaceX, or about $80 million USD/Mass.

Scrum Troubleshooters. With this *faction privilege* **(B6a),** repair any Glitch anywhere. This is *negotiable* **(N4d)**.

Secretary-General. With this *faction privilege* **(B6a),** start the game with two extra Aqua.

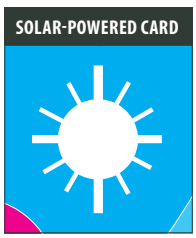
Seniority Disks (C1). Translucent red disks in the center of the Sunspot Cycle (over the Sol icon) count the game's Solar Cycles. One disk is removed each time the Sunspot Cube crosses the indicated seniority threshold, indicating the completion of one 12-year cycle. If there are no more disks to take, the game ends per **M1.**



Skunkworks. This *faction privilege* **(B6a)** allows you to ignore the *academia hand limit* **(I2a)**, so that you can participate in a *research auction operation* **(I2)** regardless of your hand size. It applies to both starting and bidding in auctions.

Site. These hexagonal Spaces are worlds where a Spacecraft can land. Sites have a Size *(the number)*, a Spectral Type *(the letter)*, an amount of Hydration *(0-4 water droplets)*, and sometimes other icons, see **B7a.**

Size. The first number on a Site represents the magnitude of its surface gravity. It is used for a *size roll* **(I6.3)** during prospecting and during *powered landing/liftoff* **(H6a)**.



Sol is the name of our star. Its gravity dominates the Heliocentric Zones, and most of the Spaces on the map are in a solar orbit. Its radiation provides energy for Solar-Powered cards and Sails (as well as terrestrial life). It has a 12-year Sunspot Cycle, and during season red it can give off dangerous flares.

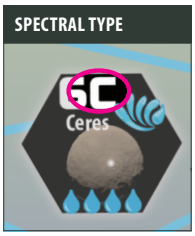
Solar-Powered Card is one with the solar icon ✷ **(B2e)**. If a thruster or thruster support is solar-powered, the thrust is modified per **H3c.** Solar-powered cards are non-operational in the Neptune ♆ Heliocentric Zone (labeled "NO SOLAR POWER") unless getting a push from a Powersat (-6 thrust). Solar-powered cards cannot be used in the Jupiter zone or beyond when ***anchoring*** a Bernal **(2A5)**, unless getting a push from a Powersat.

Space. A position on the map accessible along route lines, sometimes referred to as **"location".** Spaces include Hohmanns (both intersections and corners), Site hexes, Burn Spaces, Hazards of any sort, and any open circle with a symbol inside it. Some intersections are "bridged" as indicated by a gap in the route, and these are not Spaces.

Spacecraft. The Rocket, Freighter, Mobile Factory, and Bernal Figures, as defined by the cards, FTs, and cubes in their associated Stacks. They are capable of movement, and each can be moved once per Turn. Rockets and Bernals track fuel during movement, and thus use the Fuel Strip.

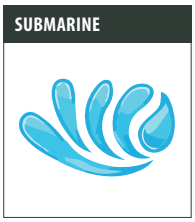
Space Elevator (1B9). A structure connecting 2 Spaces on the map as indicated by a special icon, allowing connected Factory owners to move Cargo or Humans. To build a space elevator, one of the Spaces must be industrialized, and you must have a cube (Factory, Freighter or Mobile Factory) at the other. Then you must perform an ***epic hazard operation*** **(1A6),** and if its roll is successful place a wooden elevator stick over the map icon. The Space Elevator at Earth is exceptional, and is automatically built by anchoring the GEO Elevator Home Bernal (Module 2, **2B4i**).

Spectral Type. Each Site has a letter indicating its resource type: **C** = carbon, **S** = stone, **M** = metal, **V** = vestoid, **D** = dark, and **H** = helium-3. Factories on a Site may only ET produce Black-Side Cards of the Site's Spectral Type.



Stack. A collection of cards and/or FTs that are tied to a particular location on the map. Normally this location is determined by a Figure, but for the LEO stack there is no Figure and the location is always the LEO Space on the map. With exceptions, cards can be moved between Colocated Stacks and even new stacks can be created using various free actions: *LEO* **(E4)**, *Rocket* **(E5)**, and *Outpost* **(E6)**.

Submarine is a Colony on a *waves icon* **(B7a)**. This indicates an underwater military and science base worth extra VP **(M2b)**.



Sunspot Cube. A cube in the color of the 1st player that tracks the Sunspot Cycle. It is advanced just before the 1st player starts his Turn **(D2)**.

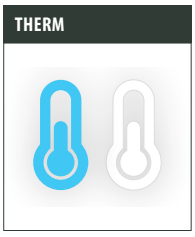
Sunspot Cycle. This diagram tracks the years, where each spot is one year, and the entire cycle is twelve years (about the solar sunspot cycle length). The Sunspot Cycle is divided into three **seasons:** red, blue, and yellow. Each time the Sunspot Cube crosses an indicated *event threshold*, roll for an *event* per **K2**. If it passes the indicated seniority threshold, remove a Seniority Disk from the center **(D2b)**.

Synodic Comet Site. A Site with a red, blue, or yellow border represents a comet whose extreme orbit causes it to become inaccessible during certain portions of the Sunspot Cycle. These Sites are subject to the following:

a. **Landing/Liftoff.** Both the site and Adjacent colored space(s) cannot be entered or exited **(H6)** by a Spacecraft unless the Sunspot Cube is in the matching-colored *season* **(◊ K1)**. Exception for Rockets with activated *TW thrusters* **(1C3b),** which can enter or exit in any season. Travel between a Synodic Comet and a similarly-colored Adjacent colored space or between colored spaces is allowed.
b. **Kreutz Sungrazer.** This is a special synodic comet in the Saturn Heliocentric Zone. Prospecting is automatically successful, however Decommission all cards, cubes, and FTs on this Site when the Sunspot Cube leaves *season yellow* **(◊ K1)** of the Sunspot Cycle. It is a Felony 😎 to establish a Colony on this Site.

Taxes. This *faction privilege* **(B6a)** gives you a 1 Aqua bonus from the Pool for each Claim or Factory established by any player (including yourself). No tax bonus for Claim Jumping.

Therm. A unit of cooling, either *supply* **(J4a)** or *demand* **(J4b)**, as denoted by the Thermometer icon.



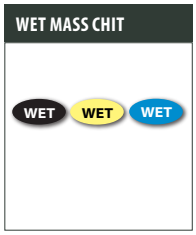
Token VP. Victory points obtained for having wood or plastic tokens of your color at the endgame. On the map, this includes disks, cubes, domes, Rockets, Freighters, Bernals **(M2a)**. Note that domes may be worth additional VP **(M2b)**. (Module 0) Token VP is also awarded for each ***delegate*** **(M2a)** in the assembly.

Turn. Each player takes a turn during the *player turn phase* **(D1)**. On your turn, you may perform one Operation, any number of free actions, and move each of your Spacecraft. Then go to the next player clockwise. Turns last one earth-year for that player.

War of Independence can occur as a result of certain Futures (Module 1) or during Module 3 (Conflict). This war is between the **Independents**, the space factions who want independence from Earth, and the **Loyalists**, those who want to remain national colonies dependent on Earth. Unless playing Module 3, players completing a ***casus belli future*** **(1D2c)** are automatically Independents and the other players are Loyalists. Unless playing with Module 3, War creates the following effects for all players:

a. **Home Bernals.** For the Independents, Home Bernals must unanchor at their first opportunity for the duration of the War. For the loyalists, Bernal *profits* **(2B3d)** are canceled.
b. **No Earth Operations.** Income/fundraising, research auctions, free market, boost, and delivery operations are not allowed. ***Exomigration*** **(2A6)** is allowed. ***Lobbying*** **(O4)** is allowed for Loyalists only. ***Homesteading*** **(2A4)** is allowed for Independents only.
c. **Research Auctions** are replaced by a new operation called **war grants**, in which a player takes the top card of any patent deck without ***bonus supports***. Since it can't be boosted, only the Black-Side is useful. On-Site Operations are allowed.

d. Glory. *Ticker tape parades* **(La)** are not allowed, although pre-war glory stored on your playmat still counts.
e. Felonies. All players lose their listed *faction privileges* **(B6a)**, but gain the Felonious faction privilege (similar to *Anarchy* **(K2e)**.
f. End Of War. Unless playing Module 3, war ends when the Sunspot Cube exits the current season (similar to *Anarchy* **(K2e)**). War can only happen once.
g. FINAO. Paying for FINAO is not allowed.
h. Scoring. Unless playing solo, if the game ends in War, *Factory stock prices* **(M2b)** are reduced to 2 each and *Politics VP* **(M2c)** doesn't score.



Wet Mass is your Spacecraft's total Mass, including its Dry Mass plus the mass of the fuel onboard **(F1a)**.

Wet Mass Chit is the token indicating the total mass of a Spacecraft including its fuel. The Wet Mass is the Dry Mass plus one for each fuel tank carried. The number of steps between the Wet Mass Chit position and the Dry Mass Chit position is the number of steps of fuel you have. The game provides 3 double-sided chits per player: blue/gray, blue/gray, and blue/gold, with the color indicating its *grade* **(F4b)**.

Wet Mass Fuel is tracked on your Fuel Strip using a Wet Mass Chit **(F1a)**. This chit is placed during *rocket stack creation* **(E5d)**, and adjusted via *cargo transfer* **(G1b)**, *internal tankage* **(G2)**, or *site refuel operations* **(I5)**. The chit's color indicates its *grade*: dirt (gray), water (blue), or isotope (gold).

White-Side Card. A patent card built on Earth, see **B2a.**



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Websites
This game is indebted to two of the best websites about near future space exploration:
http://www.projectrho.com/public_html/rocket/
by Winchell Chung "Nyrath the nearly wise".
"Phil and Winchell are like a superhero and his secret identity, which is why you never see them in the same place." – Neal Sofge, Project Coordinator.
http://toughsf.blogspot.com/
by Malik "Matterbeam", who boldly goes where no mind has been before.

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