

High Frontier- Alive & Complete

Vol. 1 - Basic Game

A game of exoglobalization for 1 - 5 players.

2nd Edition Living Rules: Updated **June 23, 2014**

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Rewritten for ease of learning. It includes Basic (Vol. 1), Colonization (Vol. 2), Interstellar (Vol. 3) and Colonization Variants (Vol. 4).

Volume II found here:

<https://docs.google.com/document/d/1pW4M9F93nrOKyQQtZyE3gYzcSmmKrzyCe379W253VFE>

WARNING: contains some (minor) rule changes from the published 2nd edition, as marked in **red**. Some terms changed: net thrust (was modified thrust), inspiration (was exotropy),

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Additional materials in the files section of the HighFrontier Yahoo Group <http://games.groups.yahoo.com/group/HighFrontier/>

Also see the download section of www.sierramadregames.com

Vassal Version (courtesy Sam Williams and Derek): <https://www.dropbox.com/sh/cj7o0ahdn0i9m0u/qamsuWTaR7>

Requirements: Vassal version 4.2.6 or later. **Compatibility:** Saved games from 40.3.x to 40.5.0 will only be compatible if the VP2 file is active instead of VP4. (Only load one of other file.)

NOTE: You may wish to purchase a “High Frontier Colonization Poster-Map” from Zazzle that combines the basic and expanded maps. Go to Zazzle of the nation you live in, and search “High Frontier Colonization”. The USA Zazzle is at: <http://www.zazzle.com/my/products/public?sr=250301154736367410>

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A. BASIC GAME OVERVIEW

Players, representing the space-faring 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. Once fueled with *water tanks* (WTs), these rockets fly to promising industrial and science *sites* (planets, asteroids, etc.). If *prospecting* succeeds, a claim is made. A claim can be upgraded into a *factory* to *produce* useful new technologies. By extracting water from a site, a rocket can refuel (WTs are used both as rocket propellant and as currency.) The winner is determined by the number of his off-world claims and factories, the resource value of his industrialized sites, and his exploration **achievements** (*ventures* and *glories*).

NOTE: Terms being defined are listed in **bold**, or *italicized* if defined elsewhere. Terms defined in the glossary are underlined. **Easily missed rules are listed white on black.**

A1. THIRD EDITION COMPONENTS

This rulebook.

2 Maps (inner & outer solar system)

2 Placeholder Sheets

1 Sol Sunspot, Events, Government Sheet

5 Player Mats

52 Clear blue disks (water tanks, or WT's).

45 Opaque disks (in 5 colors) for claims.

18 Black disks for busted mines and futures.

10 Yellow disks for outposts.

30 Cubes (in 5 colors) for factories & mobile factories.

5 Big Cubes (in 5 colors) for freighters.

10 Rockets (in 5 colors) for rocket's location & fuel.

10 Hemispheres (in 5 colors) for Bernal Sphere Tokens.

84 Cards for patents, colonists, and achievements. Also 5 crew cards.

1 six-sided die (1d6) for prospecting and hazards.

B. COMPONENT DESCRIPTIONS

B1. PATENT CARDS

There are three types of Patent cards: Thruster (used to move Rocket Stacks), Robonaut (used to prospect, refuel, and construct factories), and Refinery (used to build factories).

- White and Black Sides. The white side of a patent shows a product built on Earth; the black side shows an improved product built in space.
- Mass. The mass of a card for the basic game is shown in the upper white box to the left, and for Colonization in the upper red box to the right.
- The information in the red box is only used in the Colonization advanced game (**Part K**).
- ISRU. Some cards have an In Situ Resource Utilization rating, which is used to ISRU *refuel* (**H5**) and *Prospect* (**H6**).
- Thrust Triangle. Cards capable of moving stacks have a *thrust triangle* (**F1**).
- Product Letter. The letter shown on the black side of a patent (**C, D, M, S, V**) indicates what type of factory can build them (**H8**).

TIP: Patent cards represent unbuilt ideas (if held in your hand) or hardware in space (in locations marked by tokens on the map).

TIP: Until you build your first space factory, you will only be using the white side of the patent cards.

B2. STARTING CARD AND PIECES

You start with the following:

- Your **crew card**, a starting card identifying your color and faction privilege. This card follows all the rules of patent cards.

TIP: Three of the crew cards have a thruster triangle (**F1**), so they can be used as the thruster for your Rocket Stack. With enough fuel (18 steps), they can even fly alone to an aerobrake landing on Mars!

- Nine disks of your color to mark claims **and futures**, **plus two yellow disks to show your outposts**.
- Six cubes of your color to mark factories.
- **One big (10mm) cube of your color to indicate your freighter**.
- Two rocket markers, one to track the position of your rocket on the map, the other to track the mass and fuel of that rocket on your playmat.

IMPORTANT: You are limited to this number of cubes, disks, and rockets, see [logistics](#).

B3. PLAYMAT AND PLACEHOLDER SHEET

Each player starts with a **Playmat**, used to store his cards (in stacks if in play, or in your hand if on Earth), and his WTs (water tanks, used for money and fueling). It contains a Rocket Diagram and Acceleration Track (used to keep track of the fuel and net thrust of his Rocket Stack).

- The **Placeholder Sheet** contains the **five Exploitation Tracks (C, S, M, V, and D)**, and tables used in the Advanced Game (Sunspot Cycle, Event Table, Futures Stars, and Space Government).

TIP: The Depot is an area on your playmat where you can store your water tanks, representing an orbital storage station in Low Earth Orbit ([LEO](#)).

B4. SOLAR SYSTEM MAP

The map shows the **spaces** (i.e. orbits in the Solar System where a rocket can “halt”), and the **routes** between the spaces. Some of the most useful routes are colored and labeled with a signpost (e.g. “Earth-Mars”). The various kinds of spaces are described below:

- Sites. The black hexes are **sites**, e.g. planets, moons and asteroids that can be landed on. Each site is characterized by a **size** (a number indicating the surface gravity, the larger the more likely prospecting will be successful and the more powerful your rocket has to be to take off and land there), **spectral type** (a letter - **C, D, M, S, V** – showing what can be mined there and thus the *product letter* of cards able to be factory-produced there), and **hydration** (a number of waterdrops indicating how easy it is to obtain water). A microscope icon indicates a science site or TNO science site. See [Site Anatomy](#).
- Intersections. The intersection between two routes is called a **Hohmann** if the two lines touch, and a **Lagrange Point** if it is marked by a hollow or filled circle. (If the lines don’t touch, they just pass by each other without intersecting). Turning requires a pivot in a Hohmann, but is free in a Lagrange Point. Each sharp turn, for instance the zig-zag routes in the outer solar system, also require a pivot.
- Burns. The filled magenta Lagrange Points, called **burns**, cost fuel for a rocket to enter, and the number of burns a rocket can enter in a turn is limited by its thrust.
- Spaces can be marked with the **hazard (F7)**, **flyby (K1)**, or **radiation (K2)** icons.
- Aerobrake and Buggy Routes. Routes along a dashed brown line have special *coasting* rules (**F8**), and you cannot move along the route against the arrowhead. The dashed yellow lines are **buggy roads**, used only for buggy prospecting, not movement.

- Heliocentric Zones. These divide the solar system into concentric zones to mark the decreasing solar energy as you move further away from the sun. Each zone is named after a planet (from Mercury to Neptune). These zones modify the thrust of solar-powered rockets and sails, see F4. Solar-powered cards or functions do not work in the outermost zone.

B5. WATER TANKS & INDICATOR DISKS

- Transparent disks simulate 40-ton water tanks (**WTs**) stored at LEO and are used both as “money” and as fuel for rockets at LEO. Clear (non-colored) disks represent 1 WT. Transparent red and blue disks are used to represent 5 WT and 10 WT denominations respectively. Store them in a central pool.
- Black disks are used to mark **busted sites** where *prospecting* has failed.
- Transparent blue disks are also used to track game information.

C. BASIC GAME SET-UP

1. Players choose or are given a faction and a *playmat*. Each gets the Crew Card specific to his faction, placed to the right of his playmat.
2. Faction Cubes, Disks, and Rockets. Put the **1 big cube**, 6 small cubes, 9 disks, and 2 rockets of your color anywhere on your playmat.
3. Water Tanks. Each player places 4 clear disks on his playmat. These disks are **WTs** (water tanks), used as both fuel and currency.
4. Patent cards are separated into types, shuffled and placed white side up alongside each other. Five blue tokens are placed on the starting positions of the resource exploitation tracks.
5. Busted Mines. If playing with 4 or fewer players, put a black “**busted**” disk on Luna **and the “subsurface ocean” site of Callisto near Jupiter** (indicating that they may not be prospected). If playing with 3 or fewer players, additionally put a black disk on all three sites of Mars.
6. Determine the **starting player** by any suitable means.

C1. OPTIONAL QUICK START, BASIC & COLONIZATION

This variant starts the players with a hand of patent cards, selected during special turns called **Idea Turns**.

- Players start with 3 WT.
- **Idea Turns**. The first few turns are used to build up each player’s hand. Starting with the first player, for his turn each may pay 1 WT and take the top card off one of the patent decks (including the colonist deck). *Exception: The first player pays 2 WT for his first card, to offset his advantage in drawing first.*
- **Ending Idea Turns**. If for your turn you decide to perform a standard operation instead of an Idea Turn, you become the new **first player** for the rest of the game. No further Idea Turns can be played.

COLONIZATION: Start with 1 WT per patent deck available instead of 1 WT. During Idea Turns, there is no hand limit and the Sunspot Cycle is not active. The card drawn comes alone, without supports.

D. BASIC GAME PLAY SEQUENCE

On your turn, you may move your spacecraft (**F**), perform *operations* (**H**), and perform *free actions* (**D1**). In the Basic Game, you are allowed two spacecraft (your rocket and your freighter), one operation, and any number of free actions. The advanced game will make additional spacecraft and operations available (see **Q**, **P**, and **R**).

- Moves and operations can be taken in any order. For instance, you may move your rocket, take an operation, and then move your freighter. When your turn is complete play passes to the next player clockwise.

D1. FREE ACTIONS

You may perform the following **free actions** without expending an operation. The first three can be done anytime in your turn except during movement. The last four can be done at any time in your turn.

- Cargo Transfer. Form a stack per **E5**, **E6**, or **E6** by transferring cargo from colocated stacks into the appropriate slot on your playmat. For instance, a Rocket Stack can be formed per **E5** transferring cards boosted to LEO. Except for Freighter Stacks, stack can have any number of cards. If you transfer cargo to your rocket or Bernal, perform a dry mass adjustment (**D2**).

Note (Colonization): You cannot transfer dedicated cards.

- Refuel in LEO (i.e. transfer WTs to your rocket in LEO as fuel tanks). Water is always added to a rocket in **tanks** (i.e. the jagged columnar stripes on the rocket diagram). These columns are labeled Tank #1, Tank #2, etc. Each water tank added moves the fuel figure to the next tank to the right of the current fuel figure.
- Liquidate Fuel. Convert tanks of fuel in your rocket in LEO into “cash on hand” (each full tank = 1 WT). Only full tanks can be cashed in, partial tanks are wasted.
- Jettison any amount of fuel from your rocket, by simply moving the fuel figure to the left a desired number of steps. If this is done before you move your rocket, this may have the advantage of reducing your wet mass and improving your *net thrust*, see **F4**.
- Jettison any amount of cargo from your rocket, which causes a dry mass adjustment. This can be done at any point in the move, but it only impacts your move if done before you start moving. The cargo can be left as an *outpost* (this is an exceptional case of stack formation during movement), or decommissioned.
- Decommission cards, which returns them to your hand for reuse. A crew card can only be decommissioned at LEO or a factory site. If the latter, it converts into an additional cube (representing a space colony).

NOTE: Decommissioning also occurs during free market, industrialization, hazards, flares, radiation belts, and combat.

- Discard cards from your hand to the bottom of the patent deck.

If the rocket takes on or discharges cargo, after you finish moving your fuel figure will need a dry mass adjustment. (Even if you haven’t changed the dry mass, its a good idea to check it anyway per **E5** to make sure your fuel figure in the correct row.)

NOTE: You may transfer cards to create or add to the stack of any cooperating player in the same space

at the beginning or end of your move. In the case of Rocket Stacks, WT (as fuel) can be transferred as well.

D2. INSPIRATION

For each time your rocket or Bernal enters a *triangle burn* (B5), perform one **Inspiration** on any chosen patent deck. Simply take the top card and put it on the bottom, thus exposing a fresh card on the top. **You are limited to two Inspirations per turn.**

*Example: Player Green's rocket moves through two triangle burns. For the first burn, he chooses to move the top radiator card to the bottom. For the second, he chooses the colonist deck for his **inspiration**. Assuming he has not yet done his operations this turn, he may research or recruit the freshly-revealed cards. Thematically, he has inspired new entrepreneurship and the new generation.*

D3. DEAL-MAKING

At any time, you may exchange WT, claims, factories, stack cards, **or** promises for future services or actions as terms of a deal. These services can **include** faction privileges such as use of the ESA powersat or the UN cyler. **Hand cards** can be swapped as part of a deal, as long as the number of **hand cards** for each trader remains unchanged (this rule is necessary to avoid abusing the hand card limits during research auctions). **Crew or Bernal Cards can't be sold or traded.**

- **Cards located in space or WT can be exchanged among players either if they are colocated, or if using the Bernal module they can be swapped between the Bernal starting locations.**

E. STACKS AND STACK LIMITS

Cards enter your **hand** through trade (D3), research (H2), or decommission. They represent patents and potential products. Once played into a **stack**, they become tangible objects, either boosted from Earth (if played on their white side), or built in space (if played on their black side).

- Stacks can be created by *cargo transfer* (D1), *jettisons* (D1), *boosting* (H4), *production* (H8), or (Colonization) *digital swap* (N1).
- Your stacks can have any number of cards, except your Freighter Stack is limited to one card when not using the Freighter Module (P).

IMPORTANT: Your WT, hand cards, and stacks are free for anyone to examine.

E1. HAND CARDS

Hand cards are stored face-up to the right of your *playmat*.

- Your hand is not a stack. Operations move cards from hand to a stack, decommission moves cards from a stack to hand.
- Limits. There is no Hand Limit, however there are drawbacks to having too many Hand Cards (H3).

You can discard Hand Cards per **D1**.

E2. STACK LIMITS

To represent mission control and spacesuited human limitations, the number of stacks you are allowed at the end of your turn is strictly limited to the following five stacks:

1. Rocket Stack - this stack is represented on the map by your rocket token.
2. Freighter Stack - this stack is represented on the map by your big cube.
3. LEO Stack - this stack is always at the space on the map marked LEO, and is not represented by a token.
4. & 5. Two Outpost Stacks - these stacks are represented by your two outpost markers.

If the Bernal Module (**Q**) is being used you may have two additional stacks (for a total of seven stacks):

6. Bernal Stack - this stack is represented on the map by your Bernal token.
7. Ersatz-Bernal Stack - this stack is always located at your faction's Bernal start location and is represented by your second Bernal token.

***Example:** A big Rocket Stack arrives at Mercury, too heavy to land for an unfueled landing, even by decommissioning its primary thruster and switching to a 9•6 afterburning crew. The refinery becomes outpost #1, allowing the crew & robonaut to land for free. On its next turn, the crew lifts off to pick up the refinery, and the robonaut remains as surface outpost #2. On their next turn, the crew & refinery may land and build a factory.*

- *Limits. You are allowed two outpost stacks, and one of every other type of stack. If you boost or build a stack over your limit, by the end of your turn you must decommission one of them, or convert it into an outpost stack (if not at your outpost limit).*

E3. LEO STACK CREATION & DEFINITION

Your **LEO stack** represents the game components located in Low Earth Orbit (marked LEO on the map).

Unlike other stacks, this stack does not have its own token. Any cargo in the stack is simply assumed to be in LEO. An LEO stack can be created through either of the following mechanisms.

1. When using the boost operation (**H4**), if cards are boosted to LEO and your LEO stack does not yet exist, you can create your LEO stack and place the boosted cards into it.
2. As a free action by converting a stack in LEO to your LEO stack.

NOTE: Once your rocket is underway, you can no longer use WT's at LEO for refueling.

E4. ROCKET STACK CREATION & DEFINITION

Designate a stack as a **Rocket Stack** by placing cards to the left of your *playmat*. It will usually include a thruster (**F1**) and perhaps crew, but neither are required. Indicate its location on the map using a rocket

figure, and indicate its fuel using a second rocket figure, called the **fuel figure**, placed on the playmat's Rocket Diagram per the following:

- Compute Dry Mass Row. Add up the mass of every card in the Rocket Stack [Remember: use the top left mass number for Basic Game and the top right for the Advanced Game]. This is your dry mass, telling you which row to put your fuel figure. You are limited to a dry mass of 15. [For exceptions in the Advanced Game, see Increased Maximum Dry Mass.]
- Fueling Your Rocket. Add fuel to your rocket by *Refueling in LEO* (**D1**), or by *site refuel* (**H5**). Move the fuel figure along the Dry Mass Row (see previous bullet) and set it in the column indicating the number of fuel tanks.

WARNING: If the fuel figure is on the spot marked with an exclamation point (!), the rocket is out of fuel.

Example: A rocket has a Hall Effect thruster (mass 2), a crew (mass 1), plus a Kuck mosquito robonaut (mass 0) in cargo. Its dry mass is 3. Loaded up with one fuel tank, it has 5 steps of fuel, as shown. <illustration>

TIP: A rocket will often have a crew, but does not need one. It may also have more than one thruster, although it can only use one in any turn.

E5. FREIGHTER STACK CREATION, MOVEMENT, & DEFINITION

A Freighter Stack can only be created by an *ET production operation* (**H8**), which creates both the freighter cube and the black card as its cargo at the same time. When the freighter stack is created, place your big cube next to the factory that produced it, and move the freshly built black card into the “Freighter Stack” slot.

- Committed Cargo. Your freighter can only carry the one card that was produced at the same time that it was. Once this card is *jettisoned* (**D1**) or *decommissioned*, return the cube to your reserves.
- Movement. A freighter can move the turn it is produced. It moves one burn at a time (plus *coasting* per **F8** and, in the advanced game, *slingshots* per **K1**). Fuel expenditure is not tracked. It can land or lift-off per **G5**. Freighter movement is unchanged if using the Freighter Module (**P**).

E6. OUTPOST STACK CREATION

At the beginning or end of your movement, you can freely convert a stack into an **outpost** (e.g. for a Rocket Stack that has broken down or is out of fuel). This moves the cards into the Outpost Stack location on the *playmat*, and marks their map position with a yellow disk so they can be retrieved later. You can also drop off outposts by jettisoning them during movement per **D1**.

LIMIT: You can only have **two** outposts at the **end of** any turn. You must keep track of which Outpost Card Stack belongs to which yellow disk on the map.

NOTE: Crew stranded in space can either be rescued (by yourself or another player if you agree, which allows the card in his stack without passing ownership), or left as an outpost. If you choose the latter, you won't have crew available (since new volunteers are scarce if you are in the habit of abandoning them in space!). Crew normally can't be voluntarily decommissioned.

E7. FUNGIBLE FUEL (optional)

Normally WT's can only be stored in your fuel depot, or converted to fuel on your rocket diagram (E2). This optional rule allows WT's extracted by Site Refueling (H5) to be treated and carried as cargo, using a clear disks stored on top of the stack cards. Each one is treated as a card with a mass of one **and a red hardness of 8**. It can be jettisoned (D1) to an outpost stack (E5), decommissioned, or used to fuel a rocket (E4).

- If the fungible fuel is anything other than water, then some means (paper & pencil) must be provided to indicate what the fuel type is (dirt or isotope fuel).
- Carrying any amount of fungible fuel in a rocket or Bernal stack has a minus one thrust penalty.

F. ROCKET MOVEMENT PROCEDURE

To move a rocket figure on the map, choose a thruster, expend fuel for afterburning and lift-off, calculate net thrust and move up to this many burns on the map. For each burn entered, expend fuel steps equal to the thruster's fuel consumption.

- No Stacking Limits. You may freely pass and share a space with all other units, both yours and your opponents'.

F1. CHOOSE THRUSTER

Choose one card with a thruster triangle to be the thruster, and place this card on top of your Rocket Stack. The Thrust Triangle Anatomy is shown below:



- **Base Thrust:** the first number shows how many basic Thrust Movement Points (TMP's) the rocket has. It is modified by mass, solar and beamed power, and afterburning.
- **Fuel Consumption:** how many steps of fuel are consumed per burn entered.
- **Afterburner:** the **flame icon** shows steps of fuel expended to increase the *net thrust* (F4) by one.
- **Solar-Powered:** the **solar icon** indicates the thruster's *net thrust* is modified by the *heliocentric zone* (B5) that the rocket starts in.

Example: The NASA crew has a (terrible) fuel consumption of 6, representing its SSME chemical engines. It must move its fuel figure 6 steps to enter each burn!

NOTE: Thrusters cannot be combined. Only one thruster can be used in a turn.

TIP: Thrusters can be divided into two broad types - high thrust (chemical, nuclear) or high fuel efficiency (sails, electric rockets). It can sometimes make sense to equip a rocket with both types and use the best each turn.

COLONIZATION: See “[Hybrid Rockets](#)” for fuel compatibility issues when choosing a thruster.

F2. AFTERBURN DECISION

If the thruster has the flame icon and you decide to afterburn, reduce fuel the number of steps indicated. This boosts the net thrust by one step in Step F4. You may afterburn only once per turn with your spacecraft.

COLONIZATION: Afterburning increases cooling as well as boosting thrust, see [open cycle cooling](#).

F3. LIFT-OFF (if on a site)

If making a *fueled lift-off* (G1), decrease the fuel by a number of steps equal to the site size.

- You may not use an aerobrake path when lifting off.
- You may continue to move after lifting-off.

F4. CALCULATE NET THRUST

Before the rocket figure is moved, but after expending fuel for both afterburning and lift-off, compute the **net thrust** to see how many thrust movement points (TMP's) your rocket has, and how big a world it can land on. To compute net thrust, start with the thruster's *Base Thrust* (F1), then add or subtract the following modifiers:

- **Wet Mass Modifier.** Take the thrust of the chosen card, modify it by the starting wet mass class of the rocket (i.e. what column the fuel figure starts in). This number, which can be +1, 0, -1, or -2, is shown in the waterdrop icon in the row above the Rocket Diagram on your playmat.
- **Solar Power Modifier.** If your thruster (or one or more of its supports in the Colonization) has the solar icon on its *triangle* (F1), check which heliocentric zone the rocket map figure starts in. Add or subtract the modifier indicated to the net thrust.
- **ESA Beamed Power.** Add one to your net thrust if you either get power from Player Green or from a factory industrialized by the ionosphere lasing refinery **at an atmospheric site**. (This can be part of a deal per D3).
- Afterburning increases the *net thrust* by one.
- Place a blue disk in the Acceleration Track on your playmat to mark your net thrust. Once set, this value remains constant for your entire move.

Example 1: Player Green builds a sail at his Martian factory, and lifts off with 8 tanks of fuel. He subtracts 10 steps for lift-off (just over 2 tanks left), then computes net thrust starting with a Base Thrust of two. With two tanks it has a wet mass modifier of -1, a solar modifier of -1, and an ESA Beam Power modifier of +1. The sail's net thrust is $2 - 1 - 1 + 1 = 1$.

Example 2: A rocket with a dry mass of 6 and one tank of fuel is transport class (wet mass thrust modifier of -1). Using a thruster with a thrust of 1, its net thrust is $1 - 1 = 0$. It can't move with zero thrust, so it jettisons one step of fuel to bring it to scout class. This class has a wet mass modifier of 0, allowing it to move.

NOTE: Even if a rocket sheds mass (cards) during a turn, its net thrust depends on its state before it starts moving.

NOTE: If using the Support Module (Part O), see [thrust-modifying supports](#).

F5. THRUST MOVEMENT POINTS

Each rocket (including sails) has a number of **thrust movement points** (TMP's) equal to its *net thrust* (F4). During a rocket's move, each burn and each pivot expends both TMP's and fuel (see next section).

- To move, a rocket needs a working thruster with a net thrust of at least 1. See F8 for exceptions.
- Freighters move with 1 TMP and do not expend fuel. [If using the Freighter Module, in order to move, a freighter's cargo is mass-limited by its *load-limit* (P4)].
- Outposts cannot move.

F6. MOVE FIGURE AND EXPEND FUEL

A rocket figure moves from space to space along the *routes* (B2). It may choose to stop in any space it enters. However, moving into a site (which triggers a landing) ends movement. Except for landings and lift-offs (Part G), it expends neither TMP's nor fuel to enter an intersection or space which is not a burn.

- Burn (magenta circle): For each burn entered, expend a number of fuel steps equal to the fuel consumption of the thruster. Round up any fractions at the end of the move.
- In contrast to adding fuel (H5), burning fuel is always done in steps, not tanks.
- Pivots. If in mid-move you turn on a Hohmann intersection, so as to move in a new direction, this is called a pivot. This maneuver costs 2 TMPs plus fuel equal to entering two burns. **If you begin your move on a Hohmann, you may freely move in any direction, regardless of the direction moved last turn.** Turning is free in Lagrange Points. See the examples on page 24 of the basic rules.
- No U Turn. You can't reverse direction during your move. However, if you halt on an intersection, on your next turn you may move in any direction.

Example: An ion drive thruster (output $2 \cdot \frac{1}{2}$) expends half a step for each burn entered. If it enters one burn in a turn, half a step is expended, which is rounded up to one step to the left.

TIP: In the early game, water is scarce and largely spent on boosting tech into orbit or fuelling ships. Later in the game, water becomes less valuable as boosting is replaced by ET production, and income is replaced by water obtained at sites.

F7. HAZARDS

As you move a stack, roll one die for each hazard space entered, both crash (the skull icon) and aerobrake (the parachute icon). If you roll a "1", the entire spacecraft stack is decommissioned!

- Failure is Not An Option. You may avoid this risk by paying 4 WT instead of rolling. (This simulates paying a tiger team of elite programmers back on Earth for a software upload.)

F8. COAST

After you have moved over the desired number of burns, you may **coast** (not entering any burns or making any pivots) until you either land or wish to stop.

- You must stop to land if you enter a Site.
- You need a working thruster to coast. Exceptions are *factory-assisted landings or lift-offs (G4)*, moving along an *aerobrake path (B4)*, and the next bullet.
- Dry Slingshot (Colonization). You may gain slingshot bonuses (**K1**) while coasting, *and you may use slingshot bonuses even if your thruster stops working (see “Mission to Callisto” Example Q8).*

G. LANDING & LIFT-OFF MOVEMENT

Entering a site hex lands on a world, and leaving a site hex blasts off. For a rocket, there are four ways: *fueled, unfueled, aerobrake, or factory-assist.*

- Lander. Cards that have already moved in a turn cannot move *again* (e.g. as cargo).

G1. FUELED LANDING AND LIFT-OFF

If your rocket thrust is too feeble for the surface gravity of the world you are landing or lifting off of, you must pay a lander fuel penalty. (This simulates chemical fuel burned by strap-on boosters).

- Lander Fuel Penalty. If you enter or leave a site hex and your *net thrust (F4)* is less than or equal to the *site size*, then you must expend a number of fuel spots equal to the site’s size. **This penalty costs fuel only, and does not expend any TMP’s.**
- Suborbital Hop. Some sites are connected via suborbital hops (yellow dashes, taking off and then landing in one move), you can hop between them by expending a number of fuel steps equal to the world’s size. However, ~~if your rocket or Outpost Stack includes a buggy, or if~~ your net thrust is greater than the site’s size, you can move the stack along a dashed yellow line without expending fuel.
- *Subtract fuel expended for all fueled lift-offs and suborbital hops before calculating TMPs, see F4.*

NOTE: When blasting off a planet or large moon, you will immediately enter a burn. You must spend both the take-off penalty, plus pay for the burn entered. This creates an asymmetry between landing and lift-off, because when landing you can use the fuel efficient engine to enter the last burn, then switch to high thrust, while on take-off you must suffer the burn and take-off with the same engine.

TIP: For routes with a signpost, the Lander Fuel Penalty for fueled landings is shown on the signpost’s lander icon.

G2. UNFUELED LANDING AND LIFT-OFF

If your rocket has a thrust greater than the site size, it may land or lift-off from the site without expending

any fuel. (Except of course for the fuel expended to enter the burns that surround the planets and larger moons.)

Example: A rocket with a net thrust of 3 lands on Nysa (size 3). Its fuel is decreased three steps for a fueled landing. On its next turn, it reduces its dry mass (by dropping off a refinery on Nysa), which increases its net thrust to 4. It can blast-off without burning fuel using an unfueled lift-off.

G3. AEROBRAKE LANDING

Some sites have a path to the surface marked by a parachute. Following this path to land avoids expending the *lander fuel penalty* (G1), but you still expend fuel for any burns entered. As soon as a spacecraft enters a parachute spot, it rolls 1d6 for an aerobrake hazard.

G4. FACTORY-ASSIST LANDING AND LIFT-OFF

If the site is **industrialized** (i.e. contains a factory), your spacecraft may make an unfueled landing or lift-off. However, this entails a risk equal to a crash hazard ! [F7]

- You may use a foreign factory to land or lift-off, with permission.

Example: A low-thrust rocket on a Martian factory can lift-off either per F1 (costs 10 steps of fuel) or by factory-assist (F4). In the latter case, assuming it survives the crash hazard or pays the 4 WT programming fee, it moves into the adjacent burn (spending fuel only for the burn entered).

G5. FREIGHTER & BERNAL LANDING AND LIFT-OFF

Bernals and both basic and advanced freighters can make unfueled land or lift-off from size one sites without restriction. They can land on larger sites only by using *factory-assist* (G4) or *aerobrake* (G3), and can lift-off larger sites only by factory-assist.

- When landing on a claimed site, an unpromoted freighter is placed alongside the claim disk to avoid being mistaken for a factory cube.
- Freighters may lift-off or land off sites larger than size one by being towed per P4.

FREIGHTER MODULE: A mobile factory cube can use itself as the factory for factory-assisted lift-off or landing, see P6.

H. BASIC GAME OPERATIONS

In the basic game, you may choose and perform one operation in your turn.

H1. INCOME OPERATION (engineering)

Take 2 WT (water tanks) from the pool. (Represents boosting water into LEO from the Earth's surface.)

H2. RESEARCH OPERATION (science)

Select a patent card from the top of one of the decks to auction (including the Colonist Deck, if playing with the Colonist module). All players can examine both sides of this card (and see the next card in the deck). Starting with the **phasing player** (i.e. the player whose turn it is), players bid WTs for this card. Bids can start at 0 WT and must raise or see any previous bid. **Bids can be in any order.**

- **Ties.** The phasing player wins ties if his bid is tied with another. If two or more non-phasing players are tied, the phasing player decides between them.
- The winner pays the phasing player the price, and gets the card into his hand. If the phasing player is the winner, he pays the pool and gets the card.

IMPORTANT: A player with more than 3 hand cards (not counting *starting cards* [B2]) cannot bid in or initiate an auction.
COLONIST MODULE: This is a science op, so it can be performed by a colonist with the science specialization.

H3. FREE MARKET OPERATION (finance)

Sell a white card in your hand to the bottom of its patent deck for 4 WT. Alternatively decommission [D2] a black card in LEO for WT equal to current VPs of the card's product letter on the exploitation track.

NOTE: Your starting cards cannot be sold.

COLONIZATION: You can also sell black cards to a Bernal per Q9. Note that if you sell to your Bernal, the card is returned to the patent deck (i.e. you sold the idea), but if you sell to a foreign Bernal, the card is decommissioned (i.e. you sold a product).

H4. BOOST OPERATION (engineering)

Move one or more white cards (including crew) from your hand to your LEO Stack (or Rocket Stack in LEO) by paying water equal to its combined mass.

- You may move a stack that was boosted earlier in the turn.

REMEMBER: The black side of cards can only be produced in space factories and can't be boosted from Earth.

H5. SITE REFUEL OPERATIONS (engineering)

These operations extract water from a site and add it to your rocket as fuel tanks. Water is always added to the rocket in **tanks** (i.e. the blue stripes on the rocket diagram). Each water tank added moves the fuel figure to the next tank to the right of the fuel figure's position.

- **ISRU Refuel Op.** If the site is not industrialized, you need a unit with an ISRU rating to refuel. The number of water tanks obtained by this operation equals one plus the site's hydration (i.e. number of drops) minus the ISRU rating of the refueling unit.
- **Factory Refuel Op.** If the site is industrialized (and the factory is cooperating), you may add as many tanks of water as the rocket can hold (up to 8 tanks).
- **LEO Refueling.** Can be done without an operation, see **D1**.
- When fuel is transferred (rather than burned or jettisoned), it is discharged as tanks (extra steps not

- equal to a full tank are lost). To be transferred, fuel must be compatible, see [Hybrid Rocket](#).
- Certain refineries, carried as cargo, can perform site refueling using [Atmospheric Scooping](#).
- If a thruster has a “dirt bucket” icon, it allows the rocket to refuel with regolith at any site, see [dirt rocket](#).

NOTE: Sites never run out of water (fuel).- We

IMPORTANT: Unless you are allowed [Water Theft](#), you cannot factory refuel without the owner’s permission. You must instead ISRU refuel.

WARNING: Refueling often increases your wet mass class, resulting in a lower net thrust (**F1**).

Example: An unfueled Rocket Stack with an ISRU of 3 and a dry mass of 3 sits on Mercury (hydration = 3). By performing an ISRU refuel operation, it gains $1 + 3 - 3 = 1$ fuel tank, which lowers its net thrust by one. If a factory is present, it gains up to 8 tanks, lowering its net thrust by two.

H6. PROSPECT OPERATION (science)

Attempt to make a claim at an unprospected site. To prospect, choose a card at the site (or [adjacent](#) in the case of raygun prospecting) that has an [ISRU](#) less than or equal to the site [hydration](#) (i.e. number of drops). Then roll a die. If the result is less than or equal to the site size, then the prospect is successful; place a [claim disk](#). If unsuccessful, place a black “busted” disk showing no one may prospect there again. (But rockets can still perform the site refuel operation (**H5**) there.) ISRU units with the “raygun” or “buggy” icons can perform special types of prospecting:

- [Raygun Prospecting](#). Able to prospect at range, prospecting all [adjacent non-atmospheric sites](#).
- [Buggy Prospecting](#). If it fails a prospecting roll, able to make one re-roll. Alternately, able to prospect multiple sites along a road (i.e. dashed yellow line).

NOTE: The prospect procedure can be modified by [raygun prospecting](#), [buggy prospecting](#), or [assaying smelters](#).

NOTE: If you run out of black disks, use substitute markers. If you run out of claim disks, see [logistics](#).

H7. INDUSTRIALIZE OPERATION (engineering)

Place a factory cube on top of your claim disk by [decommissioning](#) a robonaut and a refinery card at a prospected site. This lowers the *exploitation track* by one step, in the column corresponding to the site’s [spectral type](#). This factory can produce the black side of patent cards with this spectral type.

IMPORTANT: Any robonaut or refinery card, regardless of its product letter, can be decommissioned to Industrialize the site. Its product letter is only used when it is produced at a factory.

NOTE: If you are out of cubes, see [logistics](#).

Example: The UN player decommissions a refinery and robonaut to build a factory on Luna. He adds a purple cube, lowers the S Resource Exploitation marker.

SUPPORT MODULE: You must additionally decommission all supports other than radiators for both the robonaut and the refinery. If the supports are [solar-powered](#), they cannot be used for Industrializing in the Neptune heliocentric zone (or beyond).

H8. ET PRODUCTION OPERATION (engineering)

Produce advanced technology by choosing a black card from your hand with a *product letter* (**B2**) matching the spectral type at your factory, and playing it into an existing or new stack at the factory site.

- The produced card goes into a stack, either a Rocket Stack (**E4**), Freighter Stack (**E5**), Outpost Stack (**E6**), or Bernal Stack (**Q2**). This stack must be colocated with the factory which is doing the ET production. If you are at your stack limit and thus cannot create a stack at your factory, you cannot produce anything.
- **Freighter Production.** Any *ET production operation* can additionally produce a Freighter. Place your big cube next to the claim disk of the factory that produced it.
- A card or freighter produced at a factory can move the turn it is produced.

BERNAL MODULE: If you perform an ET Production using a dirtside factory, the product appears either at the factory or in the Bernal Stack, as desired.

Example: The UN player from the previous example decides to build and ship his first lunar product. He plays his S black card into his Freighter Stack slot, and places a purple freighter cube next to his lunar claim disk. He can produce as many S cards as he wishes. Note that if playing with the Freighter Module, the card produced goes into an Outpost Stack and no freighter cube is produced.

H9. EXAMPLE MISSION TO LUNA AND BACK

The PRC (i.e. Player Red) has two mission objectives: to land a robonaut on Luna as a pedestal for a future factory, and to return Taikonauts quickly for glory.

Year 1: Launch of Lunar Mission. After years of research, the PRC pays 4 WT to boost his crew, a mirror steamer (output 3•4), and a cat fusion robonaut (ISRU = 2, mass = 3, assuming basic game masses). He puts a rocket figure in LEO, and a fuel figure in the row for a dry mass of 4. He spends 3 WT to add 3 tanks of fuel, bringing it to “Transport Class”.

Year 1 (continued): Cis-Lunar Move. The Rocket Stack burns 8 steps of fuel to move to the lunar L1 point (2 burns at cost of 4 steps each). Because the rocket is “Transport Class”, its net thrust is $3 - 1 = 2$. The 2 TMP's are just enough to enter the two burns to Luna.

Year 2: Lunar Landing. The PRC uses his crew (output 9•6) to land. They spend 2 afterburning fuel steps, bringing the thrust to 10. Since this is greater than the size of Luna, he makes an unfueled landing. During prospecting, the PRC robonaut claims Luna (prospecting is automatically successful).

Year 3: ISRU Refueling. The rocket used every drop of fuel to land. The robonaut spends one year digging up regolith and squeezing out water drop by drop, until it accumulates 1 tank of fuel. This is just enough for the return.

Year 4: Ticker Tape Return. Leaving the robonaut and steamer behind as an outpost, the crew card (dry mass = 1) makes a unfueled lift-off. All eight steps of fuel in the tank are expended, 2 for afterburning,

plus 6 more to enter L1 Lagrange Point. Having no fuel to enter the HEO burn, the crew takes the aerobraking “shortcut” to LEO. Assuming their parachute opens properly, the crew is decommissioned in LEO to gain a 3VP glory disk at “any site” (see Part I).

Year 5: The Next Mission. The PRC plans its next mission, flying a refinery to Luna. Together with the robonaut already there, an Industrialize Operation would create an S Factory in Crater Shackleton.

ADVANCED GAME: A Radiation Risk must be rolled in years 1 (using a net thrust of 2) and in year 4 (using a net thrust of 10, so no danger).

I. VENTURES & GLORY

These **achievements**, if achieved before your opponents, give you **victory points** (VPs) at the end of the game. Some also confer useful abilities. If you are the first to fulfill these conditions, mark the relevant spot with one of your **disks**.

I1. GLORY

- You are first to return **humans** (i.e. crew or human colonists) from “any site” and decommission them at LEO: 3 VPs.
- You are the first to land humans on Mars (3 VPs), Mercury (3 VPs) or a science site (3 VPs) and return them to LEO and decommission them there. These VPs are additional to the previous bullet.
- **Heroism star.** If you feel that you have accomplished something heroic, you may call for a vote on that turn. If the majority of players agree that you have earned it, place a **disk** on the heroism star in the Glory Arena, worth 3 VP. **Each player can have one disk here.**

NOTE: Glory is awarded for a site even if it is *busted* (B5). To claim glory, humans must travel the entire distance by spacecraft (e.g. no decommissions).

I2. VENTURES

- **Space Pharmacy Venture** - You are first to claim three S sites: 5 VPs but no extra ability.
- **Space Elevator Venture** - You are first to claim three M sites plus pay 7 WT: 8 VP and you are able to use the **routes** marked “space elevator” to move between LEO and L2 **or between Phobos and the Caves of Mars.** Your vehicles adjacent to one end of the elevator are considered adjacent to the other end.
- **Space Tourism Venture** - You are first to claim three V sites plus pay 5 WT: 7 VP and you can do 2 operations a turn **(starting with the following turn).**

J. BASIC GAME END & VICTORY

J1. THE GAME ENDS WHEN...

After the specified number of Factories are built the game ends **at the end of the following year. So if the third player ends the game, the remaining players for the year get their turn, and then everyone gets one final turn the following year.**

- The number of factories to end the game are four (if 2 players), six (if 3 players), or seven (if 4+ players).

J2. VICTORY POINTS

Winning is decided by victory points (VPs), with WTs as a tiebreaker. VPs are awarded for:

- Each claim, **colony**, or factory (i.e. each **disk or cube** of your color on the map **except freighters**): 1VP.
- Each factory: Extra VP as listed on the *Exploitation Track* (the exploitation disk should be adjusted to reflect the number of factories built for each spectral type - C, S, M, V, or D).
- Each venture **disk**: Extra VP as listed on the map.
- Each glory **disk**: 3VP.
- Each **factory** at a science site (i.e. with a microscope icon): an extra 2VP, or 4VP if a TNO science site (i.e. with the yellow star-microscope icon).
- (Colonization) If in power at the end of the game: 5 VP.
- (Colonization) Each claim disk on a *futures star* (U1): VP as indicated.
- (Colonization) Black disk denoting a failure during an epic hazard: 3 VP instead of VP indicated.

NOTE: VP conditions stack. So a factory scores for the cube plus for the factory value and the possible science site.

Endgame example: The red player ends with claims on the V worlds of Mercury, Vesta, and one of its moonlets. He also has a factory on Mercury, which is worth 8 VP on the Exploitation Track. He has 3 disks and 1 cube on the map, plus a disk (worth 7 VP) on Space Tourism. His total is $8 + 3 + 1 + 7 = 19$ VP.

GLOSSARY, Basic & Colonization

Terms underlined in the rules are defined here. These include the game's core rules.

Adjacent – A spacecraft is adjacent to a position if it is in the next space, where each intersection, burn, and site counts as a space. However, for this purpose crash hazards do not count towards adjacency.

Also sites connected by buggy roads are not adjacent (because of line of sight).

- **Any space adjacent to one end of a *space elevator* (I2) is also adjacent to the space on the other end.**

Aerobrake Hazard – A space marked with the parachute icon. When entering an aerobrake hazard, roll the die. A “1” = spacecraft decommissioned.

Assaying Smelters - Certain refineries (as listed on the card) improve the ISRU rating or prospecting roll, if carried by the stack doing the prospecting.

Atmospheric Site – If the map image of the site is encircled by a halo, the site is atmospheric. This includes Venus, Mars, Saturn, Titan, and Uranus. This is relevant in raygun prospecting, atmosphere scooping, climate mirrors (U2), or using an ionosphere lasing refinery (F4).

Atmosphere Scooping - A rocket carrying an operational Atmospheric ISRU Scoop refinery may perform aerobrakes without risk. If spending **its entire move** on an aerobrake hazard, it may then perform a *Site Refuel Op* (H5), which adds as many tanks of fuel as the rocket can carry. (You are scooping and liquefying the atmosphere to use as propellant.)

- If starting on an aerobrake hazard, you may move in any direction.
- **Due to terrestrial environmental prohibitions on nuclear spacecraft, no scooping is allowed on aerobrakes in the Earth heliocentric zone.**

Bernal (Bernal module) – A type of space station that can move like a rocket, and follows all rocket rules. It forms its own stack, and has its own **dome-shaped** map and fuel figures. You can boost a second (stationary) Bernal called an *ersatz-Bernal* (Q4).

Bernal Privilege (Bernal module) – You gain this privilege, as listed on your Bernal card, upon promoting your Bernal. The privilege is active as long as your Bernal remains promoted with a working generator.

Buggy Prospecting - Using a buggy allows two attempts for a successful prospecting roll with one prospect operation. Alternately, if prospecting a site linked to others by a dashed yellow line (indicating a “buggy” road), you may prospect all the linked sites with one *prospect operation* (H6), assuming the buggy has the necessary ISRU for those sites. **If the buggy road is marked by a hazard (e.g. Io), failing the hazard decommissions the buggy and its supports without prospecting the linked sites.**

Example: A buggy prospects Dresda. The roll is a “3”, which fails because Dresda is size 2. But a second roll of “2” succeeds and places a claim disk.

Burn – A magenta-colored circular space. It costs 1 TMP and (for rockets) fuel to enter a burn. If a burn contains a white triangle, it additionally enables *Inspiration* (D2).

Card Anatomy – The patent and crew cards have one or more of the following data:

- Mass.
- Product Letter. (H8).
- Radiation-hardness (Colonization). Resistance to combat damage, solar flares, or radiation hazards, (K3).
- Support Cards required (Support Module). The example data field shown in the rules requires an “x” reactor, plus one therm of radiator cooling (Q5).
- Thrust Triangles (F1).
- Support Triangles (Support Module). See Fuel Economy Reactors and Thrust Modifying Supports.

Cargo – The cards and cubes carried by a spacecraft. Fuel is not cargo.

Claim Disk – A disk of a player’s color showing that he has successfully prospected and has mines and claims at a site. Each claim is worth a VP. Player Purple collects taxes (1 WT from the pool) every time a claim disk is placed.

Claim Jump – If you are allowed to commit felonies, you may land on the unindustrialized claim of another player, and immediately replace the claim disk with one of your color. You must have a human at the site, and the site must be undefended by humans.

- It is not a felony to merely land **or ISRU refuel** on another player’s claim or factory. You need the owner’s permission (**D3**) to factory refuel.

Example: Both NASA and PRC have rockets on Encke’s comet. NASA prospects successfully, placing a white claim disk. On his turn, the manned PRC rocket feloniously decommissions its refinery and robonaut to industrialize the claim, replacing the NASA disk with a red disk and a red cube.

Crash Hazard – A space marked with the skull icon. When entering a crash hazard, roll the die. A “1” = spacecraft decommissioned (**F7**). Making a factory-assisted landing or lift-off (**G4**) also suffers this risk.

Decommission – Scrap a card from one of your stacks to your hand, so that it can be rebuilt anew (either by boosting or by ET production). This is a free action at any point in your turn (**D2**). If part of your Rocket Stack is decommissioned, see dry mass adjustment.

- Radiators. If a radiator is “heavy” (**O4**), an involuntary decommission rotates it to its “light” orientation.
- Decommissioned **robots (unless emancipated)** and crew and go into your hand, but decommissioned **human** colonists **go to the bottom of the colonist deck**. (Colonists have no loyalty to their former employer if decommissioned).
- Humans can only be decommissioned if you are allowed felonies, or per the next two bullets. **The Botany Bay Convicts can self-decommission, because they are allowed to commit felonies (this represents them going AWOL).**
- Ticker Tape. Humans can be decommissioned in LEO (e.g. for obtaining a glory **disk** per **I1**).
- Space Colony. Humans can be decommissioned at a factory to start a Space Colony. If they have an on-board nuclear reactor (**R3**), they can act as a support for the factory.
- **Involuntary Decommission.** If a stack is destroyed or loses its last card by a hazard roll, epic hazard roll, event, radiation, combat, etc., decommission all its cargo and remove its map and fuel figures. Note that the Bernal Card is invulnerable (**Q2**).

Dedicated (Colonization) – The Bernal and Freighter cards are **dedicated**. The Bernal cannot be removed from the Bernal Stack, and the Freighter Card can be removed from the Freighter Stack only by decommissioning. Although dedicated cards cannot be part of your rocket stack, you may tow freighters per **P4**, and move Bernals with thruster cards by forming a hybrid rocket. Fuel can also be **dedicated** to a specific isotope, and GW thrusters can only use fuel dedicated to that isotope (**S2**).

Dirt Rocket - The “dirt bucket” icon on a thruster card allows a rocket to use **regolith** (space dirt) as propellant. All the promoted Bernals except for Player Orange are also dirt-rockets (**Q8**). An operational dirt rocket can do the ISRU refuel operation (**H5**) at any site hex, adding as much fuel as it

can carry, even if no ISRU unit is present. If it does so, its fuel cannot be later used as water fuel, isotope fuel, or as WTs.

- Phileas Fogg Tactic. Besides regolith, a dirt Rocket Stack can decommission its cards as fuel (the machinery is ground up and fed into the engine hopper). Each mass point adds a tank of fuel. This may be “on the fly” as part of your move.

Dirtside (Bernal Module) - Each of your factories on sites adjacent to your Bernal Token is called a **dirtside**. See Example Q5.

- You cannot use an opponent’s factory as a dirtside.
- A Bernal must land on a **size one synodic comet** to use it as a dirtside.

Example: If there are red factories on the Martian moonlets Phobos and Deimos, a red Bernal on the burn between them has both as dirtside. Factories on Mars would not be dirtside, since the aerobrake paths to the Martian surface do not indicate adjacency.

Dry Mass – The mass of a rocket not counting its fuel. Find the dry mass by adding the masses of all the cards in the Rocket Stack.

Dry Mass Adjustment - Should the rocket’s dry mass change (cards are added or lost), move the fuel figure up or down to the correct dry mass row, keeping the number of tanks constant. If the fuel figure is on a spot that is between fuel tanks, it must follow the dashed line when moving to its new dry mass row. This adjustment takes effect on your next turn.

Example: Your rocket, with an initial dry mass of 4, has a fuel figure positioned as shown. It drops off cargo with a mass of 2. The fuel figure moves up to the new dry mass of 2, following the dashed arrow, as shown. <illustration>

Emancipated (Colonist Module) – Robots are emancipated using the *suffrage operation* (N3). If emancipated, robots are treated exactly as humans except they still do not count against your *Maximum Human Colonists In Space* (R4). They prevent glitches and in peacetime have loyalty to the *Emancipator* (N3). Because consciousness is not fungible, neither humans nor emancipated robots can be *digitally swapped* (N1).

Epic Hazard Op. (Colonization) - Certain *Futures* (U1) call for an operation marked with a skull icon. This operation is called an **epic hazard op**. Either the colonist containing the future must perform it, or a colonist colocated with the card containing the future. **This operation cannot be performed at an opponent’s factory.**

- Epic Hazard Roll. Make a 1d6 roll, which cannot be modified by *Failure is Not An Option* (F7). You fail if the roll is a “1” if **you have one of the following: a TNO Lab, factories on sites of at least four different Spectral Types, or claims on least two synodic comets with one having your Bernal Lab. If you don’t have one of these, you fail if the roll is anything but a “6”.**
- Failure Effects. If you fail the roll, then all cards **and cubes colocated with** the performing colonist are decommissioned (except **Bernals**). If on a site, the site itself is destroyed (place two black disks to indicate this). Bust the *Futures Star* (U1) with a black disk stacked on your disk, indicating that although the future was not met, the game is one step closer to ending, and you still get 3 VP for the notoriety (J2).

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

Faction - Each player is a distinct “basal societal unit” (BSU): world organization (purple), national government (white), socialist regime (red), worker union (green), and private entrepreneur (orange).

Faction Privileges - Each faction has a special privilege, as listed on its crew card. Except for “War Declaration”, this privilege is lost during *Anarchy* or *War* (**K5**). If playing with the Bernal module, it is also lost per **Q3**.

- NASA Launch Fees (Player White). Receive a 1 WT bonus from the pool after any player (including self) boosts one or more cards.
- Shimizu Skunkworks (Player Orange). You may participate in a Research Operation (**H2**) or a Recruit Operation (**N4**) regardless of your hand size.
- ESA Powersat (Player Green). A power-beaming satellite in GEO allows you to increase the net thrust of any Bernal or MW rocket (but not freighter or Colonization GW rocket) by one (**F4**), during any player turn.
- Chinese Territoriality (Player Red). As free actions during your turn, you may perform felonies: claim jumping, human decommission, and water theft.
- Chinese War Declaration (Colonization). As a free action during the start of your turn, you are allowed to move the *politics* from anarchy to war per **K5**.
- UN Taxes (Player Purple). Receive a 1 WT bonus from the pool for each claim disk (**H6**) or ET factory cube (**H7**) placed by any player (including self). No tax bonus for claim jumping.
- UN Cycler (Colonization). You may grant passage of any spacecraft through the radiation hazards surrounding Earth without risk.

Factory – A claim disk topped with a cube of the same color (large or small) is called a **factory**, and the site is said to be **industrialized**. There are four special types: dirtside, lab, push, and lunar. **For the last, its possible the claim and cube are different colors.** If there are multiple cubes on a claim, one is the factory and the others are space colonies. **Note that when landing on a claimed site, an unpromoted freighter must be placed alongside the claim disk per **G2**, to avoid being mistaken for a factory cube.**

Felonies – Free actions that are allowed only to Player Red, or during Anarchy or War. You may perform them only with humans, and if no opposed humans are present. They include claim jumping, human decommission, water theft, and use of a foreign Lab for *promotion* (**N2**) without permission.

Flyby (Colonization) – A space representing a close pass to a planet, allowing *slingshots* (**K1**). It follows the rules for Lagrange Points. A *moon boost* (**K1**) is a type of flyby.

Fuel Economy Reactors (Support Module). Some space-built reactors have a *triangle* that halves or quarters your fuel expenditure, if used in support of a thruster per **O1**.

Hohmann – An intersection of two routes, unmarked by a circle. Changing direction mid-move in a

Hohmann requires a pivot maneuver.

- If routes cross without touching, pivots are not allowed.

Human – A crew card, Robotic Colonist Card (if emancipated), or Human Colonist Card. A space colony is also human.

Hybrid Rocket (Colonization) - A Rocket Stack can have multiple thrusters with different fuel requirements, including MW thrusters, GW thrusters, and dirt-propelled Bernal. At the beginning of your turn, **activate** one thruster by placing it on top of the stack.

- A hybrid rocket can activate a GW thruster only if it had completely isotope-refueled at the proper spectral type at its last refueling.
- A hybrid cannot activate anything but a dirt rocket if it had dirt-refueled at its last refueling. **It may however activate another thruster by jettisoning its fuel (e.g. for making an unfueled landing).**
- A hybrid rocket cannot activate a freighter.

Example: A Rocket Stack contains both a crew card with a 9•6 thruster and a GW thruster (“fuel isotope” = M). It loads up with 8-tanks of dedicated fuel at an M factory, and flies to a size 9 world. The 9•6 thruster may be used to land on this world, using the dedicated fuel for its afterburn.

Hydration - The availability of water on a site. This will be between zero and four, and is denoted by the number of waterdrops on a site hex. This is used for *refueling* (H5) and *prospecting* (H6), as well as the optional *colonist module* (R4).

Science Note: A site with hydration 4 is an icy or permafrost body. 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. Dr. Noah Vale.

Increased Maximum Dry Mass (Colonization) - In order to move, your Rocket Stack using a GW thruster and your dirt-propelled Bernal Stack are limited to a **maximum dry mass of 20**. Their performance at a dry mass of 14 to 20 is as indicated on the lowermost dry mass row on the Rocket Diagram (i.e. treat the “14-15” row as if it stated “14-20” instead).

In Power (Colonization) – The seven spots on the Space Government that are colored with a faction color (see end page). You are in power if the politics is on a polity of your faction color.

ISRU – Units able to prospect or dig for water have an “In Situ Resource Utilization” rating, ranging from zero (the best) to four (the worst). In order for a unit to be able to *prospect* or *ISRU refuel* at a site, it must have an ISRU number less than or equal to the site hydration.

Lab - There are two kinds of **Labs**. A factory at a **TNO science site** (the yellow star-microscope icon) is called a **TNO Lab**. A promoted Bernal with at least one *dirtside* on a science site is a **Bernal Lab**.

- Either kind of Lab is required to promote a Colonist, Freightier, or GW Thruster (N2).

Lagrange Point – Any intersection marked with a circle, either filled (i.e. a burn) or unfilled, indicates a

junction where you can turn for no movement or fuel cost. (Course corrections are easy in these areas because the heliocentric-dominated gravity is partially nullified by the presence of planets or large moons. In physics lingo, these are where the gravitational pulls of two massive bodies provide the centripetal force required to orbit both of them.) Note that there are many circular spaces not on an intersection, and are not technically Lagrange Points. These places (which include LEO, radiation spaces, and spaces on zone boundaries) nevertheless follow the rules for a Lagrange Point.

LEO – Low Earth Orbit, a space on the map where cards boosted from Earth start.

Logistics – Because of mission control limitations, you are limited to the 9 disks and 6 cubes that you started with. If you need a 10th disk, withdraw one of your glory disks (place a black disk so nobody else can claim it), or claim disks (the vacated site must be re-prospected to be claimed again). If you need a 7th cube, withdraw one of your freighter cubes or mobile factory cubes. You can withdraw one of your Space Colony cubes only if you are allowed felonies. Other cubes cannot be withdrawn.

Loyalty (Colonist Module) – When not in War (**K5**), the **loyalty** of a colonist is indicated by the faction color of its *election button* (**R3**). A gear-shaped button indicates the colonist is robotic with loyalty to the *Emancipator* (**N3**), if one exists. Loyalty is used during *Hostile Recruiting* (**N5**) and peacetime *elections* (**N6**).

- Loyalty (wartime). During War, all colonists have **loyalty** to the holder of their card (e.g. their employer).

Lunar Factory (Colonization) – Per **C5**, a factory on Luna is possible only in the 5-player game.

- Moon Treaty Operation. If a lunar factory is built, the faction that is in power can use one of his operations to seize control of that factory by swapping its cube for a cube of the new owner's color. A Moon Treaty Op steals only the cube, not the claim disk. Space colonies cannot be seized. If the claim-holder is in power, he can perform the Moon Treaty Op to reclaim his factory.¹
- The Orange Bernal starts adjacent to Luna, allowing Player Orange to prospect it from his Bernal, or use his lunar factory as a dirtside. Player Orange is disallowed from factory refueling from the "Shackleton Polar Rim" site (The Moon Treaty states that all factory water is donated "for the common good").

Example: Player Orange has a Bernal at Callisto (4 drops) and an ersatz at his lunar factory (2 drops). His dirtside hydration (Q5) is six.

Open-cycle Cooling (Colonization) – If you afterburn at any point in a move, in addition to adding to your thrust, you can also satisfy one therm of cooling. (This simulates dumping coolant into the exhaust to increase thrust and get rid of heat.) Afterburners can be used to cool missile robonauts during prospecting or site refuel, if they have expended the afterburning fuel that turn.

- Expenditure of afterburning fuel also counts as cooling during combat, for combat-capable thrusters or missile robonauts.
- GW Thrusters have *enhanced afterburning*, see **S3**.

¹ The ill-advised 1979 U.N. Moon Treaty prohibits ownership of lunar resources because "the use of the moon shall be the province of all mankind."

Example [advanced game]: A rocket uses a vortex-confined thruster (1 therm) and a D-T Tokamak as a support (2 more therms). This rocket has but a single 2-therm radiator; however, and thus must use open-cycle cooling every move the thruster is used, to keep from melting down. This increases the thrust (from 6 to 7), at a cost of an extra fuel step.

Order of Decision-Making (Colonization). Rarely, an *event* (M3) or *combat* (Part T) requires an order-significant decision from multiple players simultaneously. If so, the first player makes his decisions first and then go clockwise around the table.

Example: A Pad Explosion is rolled. The first player has two mass 5 cards in his LEO Stack, and chooses one to decommission. Then the next player clockwise chooses.

Pivot – A maneuver whereby a spacecraft changes direction on a Hohmann. A pivot costs 2 TMPs and fuel equivalent to making two burns.

Politics (Colonization) – The position of the transparent blue disk on the Space Government Diagram, indicating the faction in power, the *policies* (K5) enforced, and the endgame VP.

Push Factory (Colonization) - A factory on Mercury, Venus, or Io² is called a **Push Factory**. These sites are marked on the map with a small “push” icon. For Player Green, a promoted Bernal in its *start orbit* or with a *dirtside* is also a **Push Factory**.

- A Push Factory adds one to the TMP's of freighters (P4) and lets a Bernal use solar-powered supports as far out as Saturn (Q6). However, a Push Factory cannot push itself. Multiple push factory benefits are not cumulative.

Example: Player Green uses solar-powered supports for his promoted Bernal. Assuming he has an Ersatz-Bernal to act as a push factory, he can operate his Bernal all the way to Saturn.

Radiation-Hardness (Colonization) – A number measuring how robust a card is to radiation damage, abbreviated “rad-hard” or “rad-hardness”. First determine a radiation level (during flares, combat, or radiation hazards), then decommission any card with a radiation hardness less than this level.

Radiation Hazard (Colonization) – A space marked with the radiation icon. Upon entering, a spacecraft rolls a die and subtracts its *net thrust* (F4) from the roll to obtain a radiation level. All cards **and cubes** in the stack with a rad-hardness less than this level are decommissioned.

- Freighters have a net thrust equal to **their TMP's for this purpose. This is usually 1 but can be higher (e.g. push factories, antiproton sails).**

Raygun Prospecting - If you are *prospecting* with a raygun, you may prospect any number of *adjacent* site hexes (where each intersection, burn, and site counts as a space). However, ignore crash hazard spaces; they may be skipped over.

- You can't fire into an atmospheric site.

Example 1: A raygun (ISRU = 0) on the HEO for the Koronis Family may prospect ten asteroids in one operation! This includes the asteroids in the Karin Cluster. Roll separately for each prospect.

Example 2: A raygun (ISRU = 1) on the surface of Kleopatra can prospect Kleopatra and both its moonlets in one operation since they are joined by a crash hazard space.

² A push factory on Io obtains its energy from Jupiter (using an electrodynamic tether) rather than from Sol.

Sails - Two thruster cards are sails, huge gossamer films propelled by the sun (solar photons, solar wind, or solar magnetic field). Sails move as a rocket with a fuel consumption of zero. They still may need fuel for *fueled landings* (**G1**).

- The sail card is automatically decommissioned if it enters an aerobreak hazard, even if it is not in use.
- Sail Bonuses. Sail cards are immune to damage from radiation hazards and solar flares. The Mag Sail receives a +1 thrust bonus for each radiation hazard it enters in a move. However, each radiation hazard can boost a sail only once per turn, in the case where a sail circles and re-enters the same point.

Example 1: A sail with a mass of 1 takes on cargo with a mass of 6. The total dry mass is thus $1 + 6 = 7$. Place the fuel figure in the empty position of the “7 dry” row (it’s flying without any fuel). If it has a thrust of 1, it would be fully loaded, since it cannot take on any more mass or fuel without going into transport class, which modifies its thrust to less than 1.

Example 2: A sail spends its 1 burn to enter the Mars HEO (highly eccentric orbit). It then coasts to the aerobreak hazard. The sail card is decommissioned, but the rest of the stack parachutes onto the Hellas Basin.

Scale -

- Every round of player turns is one Earth year.
- Each mass point is a quadecaton (40-tonnes, or 40,000 kg).
- Every human mass point is an eight-man crew with life-support.
- Fuel consumption is inversely proportional to a rocket’s specific impulse in seconds as follows: 6 = 4.6 km/sec (460 sec Isp), 4 = 10 km/sec (1000 sec Isp), 2 = 20 km/sec (2000 sec Isp), 1 = 40 km/sec (4000 sec Isp), $\frac{1}{2}$ = 80 km/sec (8000 sec Isp), $\frac{1}{4}$ = 160 km/sec (16,000 sec Isp), $0 \geq 0.4\%$ lightspeed (121,000 sec Isp).
- 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.
- An acceleration (in the game this is called *net thrust*) of one is 0.38 milligees or 0.38 cm/sec², and each step more doubles this.
- A size one world has 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.
- Reactors produce from 650-2000 MW_{th} of thermal energy, either in neutrons, pions, or plasma jets. From this generators produce 60 MW_e of electricity. (Subscript e = electricity, th = thermal).
- Beamed power from a GEO solar power satellite emits a 60 MW laser beam. A push factory emits a 1 GW laser or mass beam.
- Each radiator therm rejects 120 MW_{th} of heat at 1200K when used to cool MW rockets, 240 MW_{th} at 1427K when used to cool GW rockets, and 960MW_{th} at 2000K for TW rockets. The increasing temperature of rejection simulates increases in technology as each class of rocket is attained, and radiator technology remains the main limitation to increasing rocket power. Note that for a TW rocket, the entire rocket will glow white hot (perhaps with the exception of the thermally-insulated payload).³
- Each burn requires a delta-v (velocity change) of 2.5 km/sec. Each pivot (brachistochrone maneuver) is 5.0 km/sec and a distance of about 2 AU.

³ “The only known method of long-term, high-power dissipation in space is thermal radiation. ...The dramatic sixth-power decrease of mass with radiator temperature is a strong motivation to run at very high temperatures. The crew and cargo spaces...will have to be refrigerated, but the rest of the ship will run hot. At the low acceleration values we will be using, the ship can be of extremely flimsy construction-for highest performance, we want a ship made of ‘incandescent tissue paper’.” John Trenholme, 2003.

- A solar flare die roll of 1 is an M1 flare with an X-ray power density of 10^{-5} Watts/m². Each point more is 4 times this. Thus, a die roll of 6 is an X95 (Carrington-class) flare with a power density of 10^{-2} Watts/m².
- Equipment with a rad-hardness of 1 can withstand a total ionizing dose of 4×10^{-7} krad (Si) without failing. Each point more is 4 times this. For example, equipment with a rad-hardness of 5 can survive a Mrad of dosage. This is the scale used by industry.
- Solar insolation is 1.38 kW/m² at 1 AU (1 AU = Earth-Sol average distance). Maximum sailing thrust is 12.2 N/km² from photon pressure at 1 AU, or 0.002 N/km² (2 nPa) from solar wind dynamic pressure. These values are in the Earth zone. Each zone closer to Sol doubles them.
- Each water tank (WT) is a 40-tonne bag with a diameter of 4.25 meters. For rockets that use hydrogen as propellant, 40-tonnes of LH₂ or slush hydrogen is held in a cryo-tank cylinder 7.5 meters in diameter and 16 meters long, including active refrigeration for zero boil-off (ZBO).
- The boost cost to LEO is \$4 million/tonne to LEO using the Falcon 9 by SpaceX, or about \$160 million/mass point.

Science Site - A site marked with the microscope icon. Science sites are useful for Glory (**I1**), and claims on science sites are worth extra VP (**J2**). Science sites with a yellow star are TNO science sites. In Colonization, science sites must be industrialized to claim the VPs, and some may be used as Labs.

- Eureka. The science site status of the Martian Trojan moon Eureka is questionable. **If you are the first to land on Eureka, immediately roll 1d6. There is a 50% chance of it not being a science site.**

Signposts - If taking the red, orange, yellow, green, blue, indigo, or violet routes, a sign helpfully lists the number of burns to get to the destination. This number multiplied with your *fuel consumption* (**F1**) equals the fuel steps you will need. The signpost also lists the fuel needed for a *fueled landing* (**G1**).

- Gravity Assist. The numbers of burns in the basic and Colonizations may differ due to slingshots. If so, the signpost lists them both, separated by a slash.
- The number of burns listed assumes a stop at every Hohmann, to avoid fuel costs for pivots.

Example: A rocket with an output of $3 \cdot 2$ takes the orange route to Mercury. It will need $7 \times 2 = 14$ steps of fuel for the 7 impulses, plus 10 steps of lander fuel. No ship can carry more than 21 fuel steps, so this trip is doomed.

Site Anatomy – <<illustration XXX>>

Solar-Powered - Cards with the *solar icon*. If a thruster or thruster support is solar-powered, the thrust is modified per **F4**. Solar-powered cards do not operate in the Neptune Heliocentric zone (labeled “NO SOLAR POWER”). A colonist card with solar-powered on-board equipment or sails can operate in this zone, but their equipment is shut down.

Space Colony - Humans can be decommissioned at a factory to start a Space Colony, which adds an additional cube to the claim disk, alongside the factory cube. This can be done multiple times for a larger colony. If decommissioned at the same time as the factory is built, and they have an *on-board reactor* (**P5**), this can act as the reactor card for the refinery and/or robonaut support.

- Certain refineries, as listed on the card, add an extra cube if its card is consumed to industrialize a claim. This automatically creates a space colony.

- **Space Colony cubes do not become Mobile Factories if you promote your Freighter Card (P6).**

- **Colony Disbandment.** If your crew is in your hand, you can convert a cube that started the turn as a space colony into a crew card in another stack at the site. (You can do this regardless which humans were used to found the colony to begin with.)

Colony Disbandment. If your crew is in your hand, you can convert any colony cube not created this turn into a crew at a rocket or outpost at the site. (You can do this regardless which humans were used to found the colony to begin with.)

Spectral Type – Each site has a letter indicating its resource type: **C** = carbon, **S** = stone, **M** = metal, **V** = vestoid, and **D** = dark.

Specialization (Colonist Module) – In order to perform an operation, a colonist must have an icon matching the operation’s specialty: wrench icon = engineering operations, microscope icon = science operations, and handshake icon = finance operations.

Starting Card – You start the game with one **starting card**, a crew card indicating your faction color. If playing with the Bernal Module, you start with a second starting card, your Bernal.

Sunspot Cycle (Colonization) – The diagram found on the last page that tracks the years, where each spot is one year, and entire cycle is 12-years (about the solar sunspot cycle length). The Sunspot Cycle is divided into three **sectors**: red, blue, and yellow.

Synodic Comet (Colonization) – A site hex with a border color (red, blue, or yellow). It cannot be entered **or raygun prospected at range** unless the current *sector* of the Sunspot Cycle is in the same color. (This simulates synodic planetary alignment and launch windows.) It can be exited anytime.

Thrust Modifying Support (Support Module) – Some reactor and generator cards have a thrust modifier listed in a support triangle on the card. This modifies your *net thrust* (**F4**) only if your thruster (or one of its supports) needs the card as a support. Modifiers anywhere in the entire support chain are effective. Supports for the Refrigerator Radiator are exceptional, see **O4**. GW thrusters (**S0**) and interstellar starships (**Y5**) are affected only by *solar-power modifiers* (**F4**), not by support modifiers to thrust or fuel economy.

TMP’s – Thrust Movement Points, equal to a rocket’s *net thrust* (**F4**), determine how many burns it can move in a turn. (Physically, this corresponds to a rocket’s acceleration, which is its Base Thrust divided by its mass. As it loses propellant mass throughout its journey, its acceleration increases.)

TNO Science Site – A site marked with the yellow star-microscope icon. TNO stands for Transneptunian Object, worlds far enough out that they may contain the original condensate from the protostellar nebula. If so, they will have rare isotopes (such as helium-3) in relatively high “cosmic” abundances.

Water Theft - Refueling from the Bernals, factories or outposts of other players without their permission. This is allowed only if you can perform felonies, and the site is undefended by humans. **It is never allowed at LEO or at a Bernal in its starting orbit.**

WTs - Water Tanks, the transparent disks used as fuel and money in the game, and normally stored in a special depot in LEO. Transparent disks are 1 WT, transparent red disks are 5 WT, and transparent blue disks are 10 WT. Because LEO is drier than any desert, water is valuable in space.