

INTERSTELLAR

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RULES

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Preface

The vastness of our universe is nearly impossible for us to comprehend, or even accurately define. From the infinitesimal particles that make up what we can touch and feel, to the unimaginable galactic superclusters that we cannot. For centuries, we have investigated our environment to unravel these mysteries in search of understanding, perspective, and meaning. For this, we often look to the stars for answers.

Science fiction often tells us that human space exploration is much simpler than it actually is, ignoring concerns like propulsion systems, trajectories and orbital mechanics, radiation, life support, and even gravity. But the truth is that the violence of space is forever unforgiving. We are mere participants to its undeniable presence. Perhaps this is what drives our human spirit towards this cold and dark new ocean.

*Our expansion into space is as inevitable as the Age of Exploration that began in the 15th century when our ancestors crossed oceans in search of valuable resources, to spread their ideology, and to achieve glory. As our new Age of Discovery unfolds, these motivations in history will not be unfamiliar to us, and therefore, we have represented many of these concepts in the **High Frontier** saga, including **Module 4:Exodus**.*

*With **Interstellar**, Phil and I underwent a massive project. **Interstellar** explores raw survival and the human psyche, all while illustrating emerging technologies and real rocket science on a scale never seen before. Many of these challenges are portrayed in various harsh and unrelenting ways. It is my personal hope that the stories you earn while experiencing **Interstellar** will provide you a glimpse into the complexities of such an interstellar voyage, both during its genesis and its journey.*

Vigorously pursue the ragged edge of science, until the strange and unexplored becomes expected and familiar.

- Justin Grey

“Non est ad astra mollis e terris via.”

(There is no easy way from the earth to the stars.)

—Seneca the Younger, 1st century

A. Interstellar Introduction

Interstellar is a cooperative-competitive standalone game primarily for 1, 2, 3, or 6 players.¹ It features worker-placement, tableau building, and push-your-luck risk taking. It can be played as a successor game to *High Frontier* in combination with *Module 4: Exodus (C8)*. It can also be the 5th part of our game series on the evolution of life (*Bios:Genesis*, *Bios:Megafauna/Mesofauna*, *Bios:Origins*, *High Frontier 4 All* and *Interstellar*). The 6th planned game in the series is *Arrival*.

A1. Overview

The Starship *Exodus* departs a troubled Solar System. Under extreme mass limits, her crew is limited to two heavily augmented teenagers plus frozen human embryos, eggs, and sperm.² The ship is a generation ark on an interstellar voyage lasting over a century, with new humans conceived and born either to their mothers or from artificial wombs to be raised by robotic nannies. Searching for a new home planet, the human cyborgs and their robotic avatars develop technology to lighten the ship, fight cancer, terraform new worlds, and stay sane. As it flies through dusty interstellar space, the ship erodes and requires periodic reconfiguration; a job undertaken by living nanite machines that unfortunately sometimes reproduce out of control in a cancerous plague called gray goo. The ship's bow acts as a serendipitous high-energy particle collider, and the exotic “Nuggets” formed there give hints to the true nature of Reality which can change the game state from cooperative to competitive. Will these allow you to become a cult leader to adoring masses back home? Or will it destroy you as Humans transition to Posthumans or the ship's computer becomes subjectively conscious? Will you discover new life or new civilizations, or seed all the Goldilocks between Sol and Tau Ceti with human couples? Is your spouse, the Commander, thinking of leaving you for the attractive young pilot?

- Number of Players.** 1 to 6. Asymmetric 4 and 5 player games are possible, see **C2d**. See **C1b** for details on the *solitaire game*.
- Ideology.** Each color represents one of six social Ideologies (see glossary). A player can control multiple Ideologies.
- Cyborgs.** To survive under extreme interstellar radiation, the crew are human-machine hybrids called Cyborgs.³
- Commander.** Some of the decisions are made by the ship's Commander, according to a command structure that is Ideologically-based.⁴ A Commander sets the ship's course, can enforce Regulations, can order colonization or seeding, and dictates the ship's legal marriages.
- Six Eves.**⁵ The number of viable Embryos is limited on the Starship due to the accumulation of chromosomal and telomeric damage under starflight radiation. At least one female Cyborg or Posthuman (i.e. augmented immortal Human that can experimentally develop) must land on a Habitable planet, or else there is no victory for any player.
- Cooperative Victory** if the players jointly achieve a minimum victory point (VP) total (**J2**), counting all the Tokens, chits, and Workcells on their Playmats and counting VP for their surviving Cyborgs. Each is worth 4 VP.
- Competitive Victory.** One (and only one) player can metamorphose into the Posthuman, which changes the game from cooperative to competitive. A Cyborg becomes the Posthuman either by accumulating 4 Augmentations, or by performing certain Foolhardy Experiments, the kind that can only be performed in a relativistic starship,⁶ depending on if quantum Reality turns out to be **X** (subjective) or **O** (objective). The competitive winner is the Ideology with the highest victory point (VP) total (**J3**), and this Ideology forms the basis for the New World.

¹ COOPERATIVE-COMPETITIVE. My personal thesis is that humans are generally intelligent, non-neurotic, beneficial beings who are still making progress in the human condition. My vision for this game is to experiment if this thesis is true. —Phil Eklund.

² WHY SUCH A TINY CREW? The expense to refine enough fusion fuel for the voyage is huge. If ultrapure helium-3 is someday as cheap as plutonium, perhaps 5 euros per milligram, then every gram of payload would cost 110,000 euros just for the isofuel to accelerate it to interstellar speed. This assumes a mass ratio of 22, in which every kilogram of dry mass requires 21 kilograms of isofuel.

³ CYBORG is a human with biomechatronic body parts. Although anyone with eyeglasses or a pacemaker is functionally a cyborg, the biomechatronics assumed for interstellar Cyborgs have largely supplanted many human functions, making them more energy and weight efficient. The critical advantage of cyborgs is radiation resistance, since interstellar space is very high radiation which very little can be done to shield against. Humans have about 2 generations to find a radiation-free home.

⁴ PLAYER IDENTITY. An ancient question is whether human alliances are best based upon kinship or ideas. *Exodus* has chosen the latter, in part because of the in-breeding problem, but also because an overall ideology is essential for standards of command, ownership, and marital partnerships. An example of an authoritarian military command structure is the fictitious starship *Enterprise*.

⁵ SEVENEVES is a post-apocalyptic novel by Neal Stephenson in which the reproductive future of humankind lies with 7 women aboard the ISS. This is an example of a genetic bottleneck, in which the gene pool is drastically reduced leading to inbreeding depression and genetic homogeneity. The Starship *Exodus* faces a similar problem, in which exohumanity is descended from a handful of embryos. Although this problem can be mitigated by genetic engineering, the high interstellar radiation flux means the humans have at most a generation or two of viability. Back on Earth, all humans are descended from a Mitochondrial Eve, who lived about 155 kya. —Fu Q et al., *A revised timescale for human evolution based on ancient mitochondrial genomes*, 2013.

⁶ WHAT DOES QUANTUM THEORY ACTUALLY TELL US ABOUT REALITY? Does it say that quantum objects are simultaneously both waves and particles (wave-particle duality)? That they can be in two or more states at once (superposition)? That you can never know exactly two properties of a quantum object (Heisenberg's uncertainty principle)? That quantum objects can instantly affect each other over huge distances (entanglement)? That you can never measure something without disturbing it (everything is subjective)? That everything that can happen actually happens (many worlds theory)? Quantum theory actually tells us none of these things, rather these are all speculative interpretations of the mathematics. Quantum mathematics, such as the Schrödinger wavefunction, is not a description of a quantum object. Instead it is a prescription for what to expect if we make measurements on that object. Some say that a measurement “collapses” the wavefunction, but the theory says nothing about whether the collapse occurs at the object observed, or within our conscious minds, as an artifact of human information storage. Quantum physics may describe what is going on subjectively inside our heads rather than what is going on objectively outside our heads. If so, building a practical quantum device beyond a qubit is forever doomed to failure. —Philip Ball, *Everything You Thought You Knew About Quantum Physics is Different*, 2018.

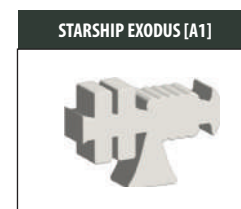


Commentable Living Rules

To download, click in the area of the displayed rulebook and press CTRL+P. Set paper size to A3. Choose Save as PDF and output the document to PDF. To reformat the spreads for single page printing, use the “split-in-half” tool, one of the free PDF tools at Sejda.com.

Living Rules Policy (since 1992).

If you find a mistake or factual error in the rules or background, leave a comment in the living rules. If a definition or defined term is not sufficiently precise, offer a better one.



ⓘ METARULES:

A word being defined is listed in **bold**, or *italicized* if defined elsewhere.

A Capitalized word is a general game term defined in the glossary.

However, a word in quotations, e.g. “Corpsicle,” quotes the name printed on a card or chit.

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

ⓘ THE GOLDEN RULE: If the text on a card, scenario, tutorial, or variant contradicts these rules, that text prevails.

ⓘ 2ND PERSON PRONOUNS: There are always 6 player colors in the game, each representing an Ideology, so a single player can control multiple Ideologies. If the rules state “you” or “your”, as in “your Playmat” or “your Workcell”, the reference is to your phasing Ideology.

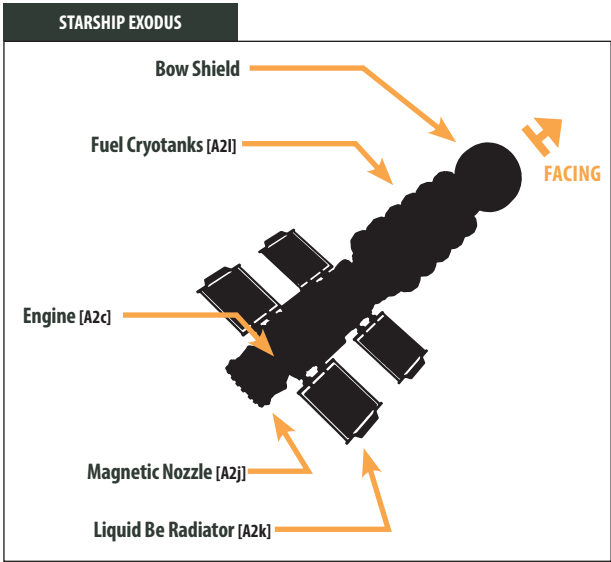
ⓘ ON-LINE TUTORIALS:

See www.iongamedesign.com.

FUSION ENGINE: *Exodus* uses a single fusion engine of extremely high fuel economy (specific impulse). The Fuel is a mixture of helium-3 and deuterium, which has a low neutron radiation signature essential to keep the crew healthy and radiator mass low. The downside is that helium-3 is rare and expensive, and requires megajoules of battery energy to ignite. [A2c]

NOZZLE: The "fat" engine depicts a magnetic bell nozzle, suitable for magnetic-confinement fusion. This has a long shape to magnetically impart a large angle expansion for plasma emerging from the throat. The "skinny" engine depicts a hemispherical nozzle, suitable for inertially-confined fusion. The implication is that the fusion engine has been dramatically redesigned to use lasers instead of magnets to initiate the fusion, and fusion occurs after the throat instead of before it. [A2j]

COOLANT: One of the most vulnerable and massive starship components is the radiator coolant, used to cool the first wall of the fusion reactor. For a TW (terawatt) starship generating GWs of waste heat, hundreds of tons of liquid beryllium coolant is necessary, and pumping power is at least 100 MW. Most of the "Erosion" losses in the game actually model beryllium leakage from the radiators. To conserve precious beryllium, the wardens must be vigilant to rapidly plug any radiator leaks. The radiators are stowed to prevent damage when the engine is not ignited. —Michel Lamontagne, *A Plumber's Guide to Starships*, 2014. [A2k]



A2. Game Scale

The cramped Starship *Exodus* is mass-limited to 400 tonnes, excluding Fuel. This dry mass has to be meticulously conserved for the voyage, because until she can enter into an Orbit somewhere, no more mass is forthcoming.

- a. **Turns** are 12 Earth years each. This is called a **Dozyear**, equal to one solar sunspot cycle in *High Frontier*.
- b. **Map Spaces** are one half of a light-year each (0.15 parsecs). Lightspeed moves 24 spaces each Dozyear.
- c. **Engine Type** is a magnetic-confinement Z-pinch fusion,⁷ with 3.9 terawatts (TW) of thermal power.⁸
- d. **Engine Thrust** is 250 kN (9 in *High Frontier* scale). The mass flow (10 grams/sec) is similar to an electric rocket.
- e. **Dry Mass** is 80 tonnes (each fat Blueprint) and 40 tonnes (each skinny Blueprint). Starting dry mass is 400 tonnes. A quaddecatonne (40 tonnes) is a single mass point in the *High Frontier* scale.
- f. **Wet Mass** is 8000 tonnes maximum, when *Exodus* is carrying 190 tanks of Fuel.⁹ Each tank is 40 tonnes (one mass point in *High Frontier*) of isotopes of helium-3 and deuterium, or possibly other fusion fuels.¹⁰
- g. **Speed Track Steps** are 4%c (four percent lightspeed, or 12,000 km/sec) each. This is 4800 Burns on the *High Frontier* scale.¹¹ The top speed is 16%c. At top speed, one Dozyear is 12.16 years back on Sol due to time dilation.
- h. **Acceleration.** Each step moved on the speed track is about 3.2 milligees over one Dozyear.¹² This is the initial fully-loaded acceleration of *Exodus*. Although barely perceptible to the crew, it will increase as it sheds Fuel over the years. The powered deceleration when carrying 800 tonnes of braking Fuel at the journey's end is much livelier at 21 milligees, but still compares poorly to the 830 milligee acceleration of a Shelby Mustang.
- i. **Propellant Exit Velocity** is 8%c (24,000 km/sec, or specific impulse of 2450 ksec).¹³ Burn up ratio is 83%.
- j. **Magnetic Nozzle** is 18 meters in diameter and is 80% efficient.
- k. **Liquid Beryllium Radiator** radiates 100 GW at temperatures of 1800K to 2600K.
- l. **Each Fuel Cryotank** is 7.8 meters in diameter. It contains 40 tonnes of liquid helium-3 or deuterium, actively cooled for zero boiloff - the same as a fuel tank in *High Frontier*.¹⁴ This Fuel has a specific energy of 345 TJ/kg.
- m. **Q** = 35 (power generated/power injected): Each "batteries" (capacitor) step generates 4 MJ at 0.1 TW.
- n. **Typical Flight Profile.** If *Exodus* starts 190 mass (190 tanks) of isofuel and a dry mass (equipment and crew) of 10, her wet mass is $190 + 10 = 200$ (8000 tonnes). She accelerates to cruising speed (16%c) in 36 years, carrying 20 mass (400 tonnes) of braking isofuel. Nanofacturing of vital systems while underway allows her dry mass to decrease to 5 mass (200 tonnes). Then she revolves to stern-first and burns her braking isofuel. This decelerates her to 4%c, and advanced braking technology is employed to enter a stellar orbit at her destination.

⁷WHY FUSION? A useful starship engine must transform an appreciable fraction of valuable mass into the kinetic energy of expelled propellant. The fuel economy of this engine is proportional to the square root of the percentage of mass converted to energy. This percentage is theoretically 100% using antihydrogen fuel, about 1% for fusion fuels, and 0.1% for fission fuels. This assumes all the fuel mass is available for thrust generation, which is far from the case for real engines. For antimatter, fission, and most fusion reactions, the process is dirty, generating neutral particles such as neutrons, which tend to end up as waste heat rather than as the kinetic energy of the propellant. But there are some clean fusion reactions, such as the fusion of helium-3 and deuterium, which are aneutronic if dirty side-reactions are avoided. Fusion engines have two other advantages over antimatter drives, even with two orders of magnitude less energy. Antimatter products cannot be efficiently coupled to any known propellant. Even lead propellant is essentially transparent to antimatter energy. Furthermore, fusion fuels can be mined, whereas antimatter normally must be made.

⁸TERAWATT POWER. The game starts with a Kardashev I civilization, when individuals have trillions of watts (terawatts) of fission and fusion energy available. *Exodus* runs for decades at almost 4 TW, rather more than today's global electrical output of about 2.9 terawatts. The enormous amount of isofuel needed for such powerplants must be mined and refined by reproducing machines.

⁹WET MASS is the mass of the starship including fuel, whereas the dry mass is the mass without fuel. Fully fueled, *Exodus* starts with a wet mass of 200 and a dry mass of 10.

¹⁰FUSION RESEARCH TODAY concentrates on just one failed geometry, the Tokamak. This will swallow 600 million dollars of taxpayer money this year (2021) in the USA, and the ITER, under construction in France is estimated to cost 65 billion dollars. Yet, no progress in 50 years is apparent, and, due to plasma instabilities, these devices may never reach break-even. The promising new ideas in fusion geometries, such as the Z-pinch assumed for Project *Exodus*, are being rubber-stamped to justify the initial investment in the Tokamak. —Hirsch & Bezdek, *Fusion: ten times more expensive than nuclear power*, 2021.

¹¹THE ROCKET EQUATION was used to construct the *Exodus* speed track. In words, this notorious equation states that the speed a rocket can attain is equal to its propellant exit velocity times the natural logarithm of its initial mass divided by its final mass. The initial mass is greater than the final mass because all rockets expend propellant to accelerate on the action-reaction principle. For Starships, the propellant and the fuel are the same. Due to the "tyranny" of the rocket equation, energy is cheap and mass expensive for interstellar travel.

¹²NO WARP DRIVE? A Dean Drive is a device that supposedly maneuvers with energy alone, without the need for propellant mass. This would render the momentum and rocket equations null and void. Not just spaceflight would be revolutionized. You could safely jump from an airplane without a parachute, stopping your plunge with just batteries. Airplanes wouldn't need wings, jets, or propellers, ships wouldn't need sails or propellers, and cars wouldn't need wheels. If the electrochemical energy of animals could be converted to motion, birds and bees would no longer need wings, and deer would no longer need feet. But we do not live in such a universe. No vehicle or creature has ever been observed to defy Newton's laws by maneuvering without momentum transfer. Rockets or photon sails remain the only vehicles possible *ad astra*.

¹³ENGINE NEUTRON RADIATION. Although the fusion of helium-3 and deuterium is clean, unfortunately occasionally deuterium fuses with itself, emitting neutrons in a side-reaction. Neutrons, being neutral, cannot be confined by magnetic fields and thus fly into space in random directions, their energy wasted. That is the best case. In the worst case, they hit parts of the rocket instead of flying into space, and end up as waste heat and neutron embrittlement. In the absolute worst case, they hit the crew and become both waste heat and radiation poisoning. This is unacceptable in a long starship mission. But if the magnetic spin moments of the helium-3 and deuterium nuclei can be precisely aligned at the moment of fusion, it forms a jet of emitted neutrons in one direction and a jet of alpha particles in the opposite direction. The jet of neutrons would be pointed out the exhaust nozzle, becoming thrust instead of waste heat. The jet of alpha particles is used to preheat the fuel, generate electricity via MHD, or magnetically directed out the nozzle for thrust.

¹⁴FUSION Q VALUE. "It takes money to make money" applies to fusion energy as well. Just like a starter motor in an automobile, the initiator for a fusion starship engine requires batteries in order to start. These "batteries" are better described as capacitors, which if fully charged are good for 6 restart attempts. Once the engine is going, part of its fusion energy is diverted to charge the capacitors, again similar to an automobile. Each atom of He³ and D requires a very high amount of initiator power for them to fuse together, but this fusion obtains even more energy, 35 times more in fact. This number, the ratio of output energy divided by input energy, is known as the reactor's Q value.

A3. Constitution of Starship *Exodus*

The “inalienable rights” of Humans are not negotiable:¹⁵

- a. Ideologies.** Diversity and inclusion is deemed paramount to mission success, therefore the Starship must include and preserve the 6 fundamental Ideologies.
- b. Living Space Rights.** Each Ideology must have only 1 Worker Awake at a time, either a Cyborg or Avatar.
- c. Mass Rights** Each Ideology has the inalienable right to their share of the ship's dry mass,¹⁶ which is 24 tonnes (2 Slots) at the start, but reduced as the ship erodes, or increased as systems are cannibalized. Every gram matters!
- d. Commander's Regulations** Many of the freedoms that we take for granted in the Western world are at risk on a starship under desperate circumstances. Freedoms depend upon the Ideology in command, with freedom being the most free and authoritarian the most regulated. See the Political Hexagon to see which Commander-specific *Regulations (F1)* and *legal marital practices (F4b)* are in force.
- e. Right To Protest.** If an Ideology disagrees with the enforcement of a Regulation, an *election (F3)* is held to possibly install a different Cyborg to be the Commander.¹⁷
- f. Reproductive Imperative** requires that a female must make Arrival to ensure exohumanity can thrive without high-radiation genetic degeneration. A living female (or Posthuman) is necessary because her endometrial cells are required for the artificial wombs.
- g. Apprenticeship.** When a child becomes a teenager, they must apprentice in an Ideology of their mother's choosing, but is not their mother's Ideology (**H5c**). This maternal right cannot be denied by the Ideology chosen.
- h. Extinct Ideologies.** If an Ideology loses both of its Cyborgs, its placard and chits are preserved to count as VP during the endgame. The teachings of an extinct Ideology are constitutionally guaranteed to be preserved, and taught to the children in the New World.

A4. Mission Priorities (Strategy Tips)

During the voyage, your Cyborgs earn victory points while your Avatars are mainly used for grunt work useful for the overall mission. It is often best to Awaken your Cyborgs less than 7 Dozyears before Arrival. The following tips are to ensure a successful mission to land at least one female on a Habitable world:

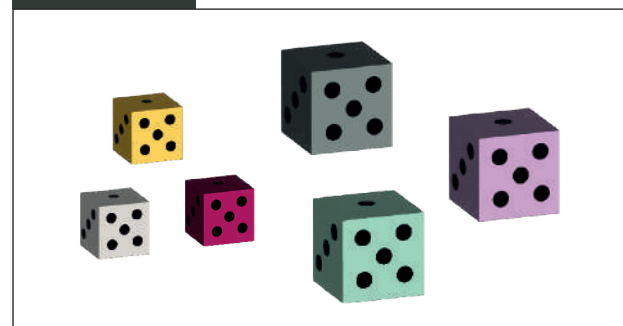
- a. Flightplan.** Check the Market for Workcells with the “Shield” *subtitle (B2a)*, which provide protection from the LIC (Local Interstellar Cloud). Fly spinward (towards 61 Cygni, no LIC) if there are none, or counter-spinward (towards Sirius through 2 LIC) if only one. An ambitious destination (must survive 3 LIC and a flare star) is Epsilon Indi, launching Pods to Habitable worlds along the way (e.g. Alpha Centauri). Any flightpath that includes 2 yellow suns has a 40% chance of not needing any Domesticated Goo to be Habitable, or 43% of only needing 1 Goo.
- b. Wisps (E2c)** are especially valuable to uncover Planet Chits, and choose flightpaths accordingly.
- c. Accelerate** the ship (**E2i**) to reach the primary destination in about 6 Dozyears, or slower if more time is needed to prepare for any upcoming LIC with Shields or Dustbugs (see glossary).
- d. Gain Augmentations** by assigning Cyborg/Avatar teams to Workcells (**H1h**).
- e. Slenderize (E1c)** the Blueprints by assigning Awake Cyborgs to Workcells where Augmentations (3) of its shape can be earned, enabling the Maintenance Cell “Foamed Metal.” Some Workcells also slenderize Blueprints. Skinny wardens = Dustbugs, skinny life-support = creating Goo for later domestication, skinny Jars = creating a seedship Pod, skinny batteries = Terraforming, skinny engine = aerogel refuel, Shields = EM shield.
- f. Obtain Earth Data** by sending a *radio signal (G1e)*. You can get the latest gaming VR or the cure for cancer.
- g. Demographics.** If every female has a daughter at Age 18 (to eliminate the risk of age-infertility), the reproductive mission length will be 6 Dozyears (72 years). This has the advantage of maximizing Wisdom and minimizing Orphans, but may not be long enough to visit 2 yellow suns. Use Creche, Utility Fog, marriages, or midwife (Ideology Red Wisdom) to keep the population from dwindling.
- h. Stress Management.** As Cyborgs age, the ship may become crowded, perhaps with Archenemies. Marriages, mimarobes (Wisdom), and the Stadium Cell will be necessary to contain Stress and *Goo outbreaks (H1i)*.
- i. Seedship.** Participate in relativistic Pod Launches, which give *seedship Medallions* per **B12f**.
- j. Wisdoms.** Arrange it so that the pilot (individuality male) and ecologist (equality female) are born (not decanted as an Orphan), and are married and mature for the final stage of the game.
- k. Braking.** Lowering dry mass (**E4a**) or braking Workcells are alternatives to power braking.
- l. Plasma Risks.** The pilot Wisdom (individuality male), Dustbugs, and/or *EM Shields (E2I)* modify the *Plasma Risk Table (H6)* to reduce the risk of “relativistic Pods,” “icebraking,” “frybys,” and especially “flare stars/debris fields.”
- m. Making Nuggets.** A flipped Nugget is needed to win (**J2c**), and Nuggets are only attained by the Erosion of Blueprints. Therefore, slenderize to establish a Shield Blueprint, and erode it into a Nugget by flying into the LIC.

¹⁵ IDEOLOGICAL CONSTITUTION. The Enlightenment-inspired constitution of *Exodus* acknowledges that the mission could only succeed if human diversity of ideas was respected. Because *Exodus* embarked with insufficient knowledge needed to evolve and prevail, the humans aboard need to embrace a diversity of ideas. Otherwise they face stagnation and collapse, for the same reason that asexual species eventually perish in the game of Darwinism.

¹⁶ DRY MASS is the mass of *Exodus* when she is “dry” (empty of fuel), which starts at 400 tonnes. Most of this mass (256 tonnes) is required for the fusion drive, especially the nozzle, magnets, radiators, coolant, initiator (“batteries”), and warden attendants. This leaves 144 tonnes (12 Slots) divided up among the crew. Mass-saving technological advances while underway allow for an increased number of Slots.

¹⁷ ANNA KARENINA PRINCIPLE. “Happy families are all alike; every unhappy family is unhappy in its own way.” So states the famous first sentence of Leo Tolstoy's novel Anna Karenina. According to this principle, for a complex undertaking to succeed, several key conditions must be fulfilled. Deficiency in just one means that the undertaking is doomed. —Jared Diamond, *Guns, germs, and steel; the fates of human societies*, 1997.

WORKERS [A3b]

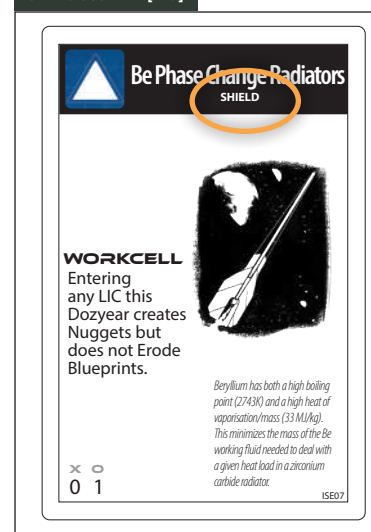


3-PLAYER GAMES ON YOUTUBE: A successful mission to Epsilon Indi A, ending competitively with ubermensch and a fully slenderized ship.

Watch https://youtube.com/live/sTFZF1_uR7c. For another 3-player game, from which Section K is based on, watch <https://www.youtube.com/live/HBSjiWvmIQ?feature=share>. Both courtesy Petr Pospíšil.

EASILY MISSED: The heart of the game's strategy is to decant your Cyborgs at the most promising moments, because gameplay with only an Avatar greatly limits your choices, especially for garnering victory points (VP). [A4]

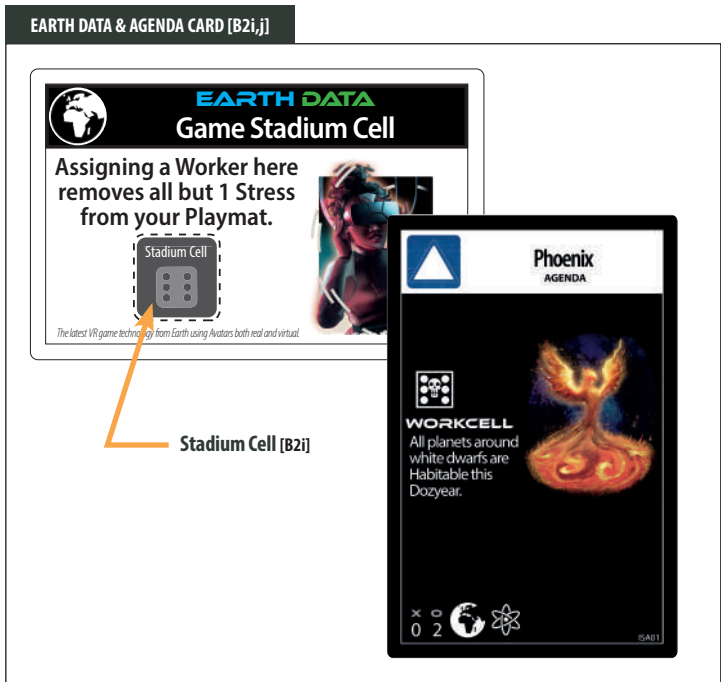
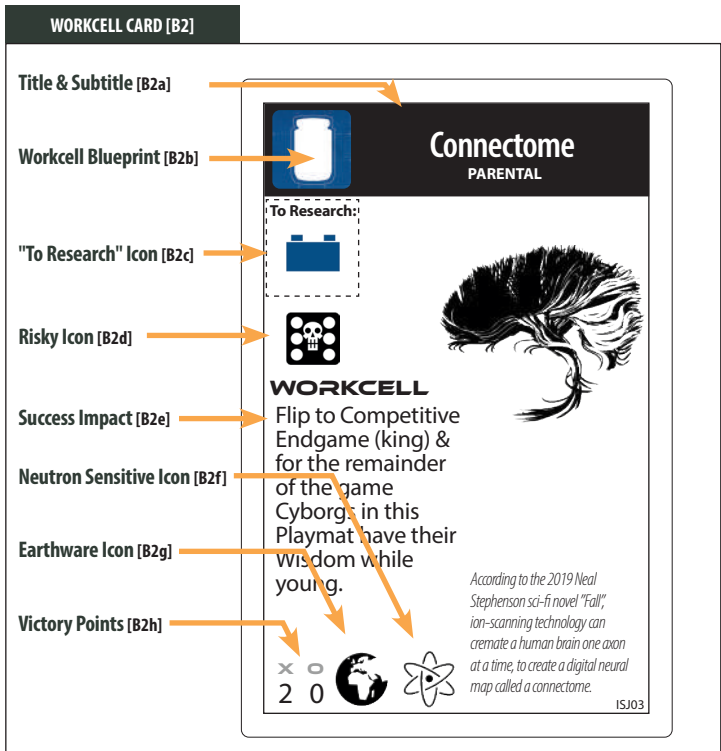
SHIELD SUBTITLE [A4a]



EASILY MISSED: The game is cooperative, but if there are exactly two Nuggets outside of the Cosmos and a Foolhardy Experiment is performed, there is a 50% chance that Posthumans will develop, which immediately converts the game into a competitive one (E6c). [A4]



TOKEN LIMITS: All tokens and chits except the red Stress disks are limited to what is supplied. [B1j]



B. Components & Anatomies

B1. Component List

- Cards (56).** Workcells (45), Earth Data (6), Agenda (5). There are also 13 Cyborg placards.
- Punchouts (1 sheet for 24 placards and 73 chits).** 11 Starship Blueprints, 5 Goo chits, 40 Planet Chits, 14 Medallion chits (17 including the 3 found in *High Frontier Module 4:Exodus*), 1 learning chit, 1 endgame chit, 6 Orphan/Pregnancy Cell chits, and 3 creative stress chits.
- Playmats (6).** One of each Ideological color. There are 6 Ideological colors, for up to 6 players.
- Jars Placard (1).** Each Ideology has a Jar where their frozen Embryos (Cyborg placards and dice) are stored.
- Starship Token.** The Starship *Exodus*, a fusion-powered rocket.¹⁸ A plastic miniature is available as an upgrade.
- Large Cyborg Dice (8d6).** One of each color for Cyborgs, plus 2 black dice (battery charge & Posthuman).
- Small Avatar Dice (6d6).** One of each Ideological color for Avatars.
- Command Star Tokens (2).** To show command, place 1 on the Cyborg and 1 on the Political Hexagon.
- Matrimonial Rings (6).** One of each color, placed on the Political Hexagon to show who is married to whom.
- Red Disks (36)** representing Stress and Busted disks. Use substitutes if you run out. See glossary.
- Radio Signal Domes (6).** Representing *radio signals* (G1e) to/from Sol, 1 per Ideological color.
- Dustbug Creeples (2).** These bug-shaped tokens are space vehicles used per E2b.
- Nugget Tokens (4).** Half of these are X and half O on their faceup side.
- Augmentation Tokens (30).** There are 6 of each in 5 shapes.
- Gameboard** including map (B8), *Exodus speed and Fuel track* (C5c,d), *Exodus Blueprint* (B4), *Political Hexagon* (F), *Plasma Risk Table* (H6), & *sequence of play* (D).
- Cylinders (5).** Placed on the map to indicate the Starship's speed, Fuel level, funding, alert, and current Phase.
- Control Pawn (6).** Placed on each Playmat to indicate which Ideologies are controlled by that player.

B2. Workcell Cards (45), Earth Data Cards (6), & Agenda Cards (5)

- Title & Subtitle.** A Workcell's **subtitle** describes what the card does: selfish (8), Shield (7), parental (5), Earth Data (4), Exodus (4), Terraform (4), Stress relief (3), Pod (3), cold start (2), Plasma Risk (2), and research (2).
- Workcell Blueprint.** Each Workcell indicates its Blueprint shape, to indicate where it is located in *Exodus*: wardens (hexagon), life-support (heart), Jars (jar), batteries (battery), or engine (triangle).
- "To Research" Augmentation/Nugget.** This Augmentation or unflipped Nugget is needed to *research* this card (G1a,b).
- Risky Icon** [B2d]. A Cyborg rolling a 6 in a Workcell Roll is killed in an accident (H1g).
- Success Impact.** Once a Workcell is in your Playmat, Workers can be assigned there and, during **Phase D3**, make a combined Workcell Roll. Every Worker dice present must be rolled. If at least one dice in a Workcell Roll succeeds, this impact occurs immediately (H1e).
- Neutron Sensitive Icon.** These radiation-sensitive cards are Discarded during certain *Plasma Risk Rolls* (H6c).
- Earthware Icon.** A Workcell with the [B2g] icon is valuable if sold to Earth (by sending a *radio signal dome* (G1e)).
- Victory Points.** These are awarded in the endgame depending upon whether Reality = X or O (J3b).
- Earth Data Cards.** The "Game Stadium" has a Cell, but the others contain general effects and no Cells.
- Agenda Cards.** Treat these optional cards as Workcell cards after they are played from a Commander's hand (G1b).

B3. Cyborg Placards (12)

Every player starts with 2 Cyborg placards, which can be Awake in a Slot, Asleep in the Jars, or Discarded as dead.

- Male & Female Cyborgs.** To survive interstellar radiation, passengers are human-machine hybrids.¹⁹ Only young females (or Hermaphrodites) have the Pregnancy Cell capable able to reproduce in the Starship.²⁰
- Cyborg Color.** Each color is an Ideology: individuality (gray), freedom (red), honor (white), unity (yellow), authority (purple), and equality (green).

¹⁸ STARSHIP *EXODUS* is a manned version of Project *Daedalus*, the British Interplanetary Society's design for a plausible interstellar probe. Like *Exodus*, *Daedalus* uses a fusion engine with clean He³-D fuel. *Daedalus* specifications: start wet mass = 50,400 t, dry mass = 400 t, ISP = 1081 ksec (3.5% c), accelerate for 4 years with a thrust = 7540 kN, cruise @ 12% c, flyby of Bernard's Star in 46 years. *Exodus* can also be compared to Project *Icarus* (firefly mk V), start wet mass = 24,000 t, dry mass = 220 t (of which 160 t is radiators), ISP = 1220 ksec (4% c), accelerate for 10 years at a thrust = 600 kN, cruise @ 4.7% c, decelerate for 5 years, capture at Alpha Centauri in 100 years. *Exodus* has twice the ISP of *Icarus*, an optimistic 8% c, thus less than half the wet mass. Another huge difference: *Icarus* runs on D-D fuel, a messy reaction requiring far more cooling radiators than *Exodus* or *Daedalus*, which uses aneutronic He³-D. —A Bond & A Martin, *Project Daedalus - The Final Report on the BIS Starship Study*, 1978.

¹⁹ FEMALE CYBORGS are *reverse cyborgs*, beings with augmented minds, but enjoying the highly developed self-repair and reproductive biology of *Homo sapiens*. Their human bodies suffer from cancer and radiation, but their largely computer minds do not suffer from Alzheimer's. They are not as adapted to a word-based subjective consciousness that the male Cyborgs have, and are more dependent on trial and error than flashes of insight. But these beings are nevertheless human, with DNA no different than today, and their technological side is in the not very distant future.

²⁰ GENDER & SEX are frequently confused. Since the days of Darwin and Mendel, sex describes the shuffling of genetic material, and gender describes the genetic and physiological differences between males and females of plants and animals. This distinction is crucial to understanding life and evolution, including genetic variation on a starship. For example, in 1928 HGT (horizontal gene transfer) was discovered, which is sex without genders (see *Bios:Genesis* for more). In 1948, sociobiology was coined for the discovery and study of the differing genetic goals of the genders during sex, which nicely explained both gender-based and sex-based behavioral differences in animals. In 1953, DNA was discovered to have 2 twisted strands, essential to understand the basis for pair-bonding and why sex prefers just 2 genders. In 1982 a new evolutionary law, the Red Queen, was discovered explaining how and why sex is maintained by evolution. In a game, as in all communications, precise definitions are necessary for understanding, and the use of undefinable terms make meaningful communication impossible. In particular, biological terms such as sex and gender become meaningless when political legislators undefine them using subjective terms. The use of objective definitions in no way limits the freedom of expression guaranteed to each individual as a fundamental right in any rational freedom-oriented politics.

- c. **Cyborg Age.** Each Cyborg card is double-sided, with a **young** side and an **old** side. The old side lists an Ability called **Wisdom**. The young side of a female contains a Pregnancy Cell. Each side can be oriented to one of 4 **Ages**, numbered from 1 to 8, as measured in **Dozyears** (12 years). See glossary.
- **Fertility & Attrition Dice.** These dice faces show what is needed for a successful Fertility Roll or Attrition Roll.

B4. **Exodus Blueprint Placards (11)**

The map contains a field to store the Starship's Blueprint placards. It starts with 5 of them **fat** (landscape Orientation). If *slenderized* (flipped and reoriented to its **skinny**, portrait Orientation), this indicates a lightweight version per **E1c**. Each Blueprint has 2 Maintenance Cells (see glossary).

- a. **Shields (6).** Unlike the other Blueprints, the 6 Shields are always slender and have no Workcells. They come in the 6 Ideological colors and are stored either in the shield Slot (Playmat) or in the bow.²¹
- b. **Wardens (hex shape).** This houses autonomous rocket vehicles that operate outside the Starship for repair and the claiming of Nuggets in the bow.²² Loss of the wardens makes it harder to collect Nuggets.
- c. **Life-Support (heart shape).** This is the living quarters of the ship, plus the low temperature radiators. Loss of the life-support Busts all the middle Slots (those labeled "life-support") on each Playmat per **E4d**.
- d. **Jars (jar shape).** Loss of this Busts left-hand Slots (**E4d**) and Kills the Embryos (**E4e**).
- e. **Batteries (battery shape).** This capacitor bank supplies electricity to start the engine, to activate an electromagnetic (EM) shield during braking (frybys or icebraking), or to send Wisps, radio signals, and Dustbugs.
 - **Charge Dice.** This black six-sided dice on the batteries indicates the remaining charge.²³ It starts fully charged at "6" but can swing down or up as the batteries (capacitors) are charged or discharged. The charge dice can never go below a value of "1."
- f. **Engine (triangle shape).** This is the main Starship fusion drive engine, including its Z-pinch, compressors, nozzle, and Fuel. It is *ignited* if there is a Worker in the Ignition Cell (**E2i**).²⁴ Engine Loss jettisons all the Fuel.

B5. **Worker Dice (8 large & 6 small)**

Worker dice come in Ideological colors and are of 2 sizes: Human Cyborgs are large and robotic Avatars are small.²⁵ The 2 large black dice are used for the battery charge dice and the Posthuman twinned dice.

B6. **Playmats (6) & Slot Management**

Each Ideology has a Playmat with an area for Stress plus Shadows to store their accumulated tokens and chits. Playmats also have 3 Slots, which may hold either one Cyborg or 2 Workcells each.

- a. **Slots.** Because of severe mass limits, every Ideology starts with 2 Slots in their Playmat. *Slenderizing* (**E1c**) can increase this to 3 Slots (Jars, life-support, & Shield), and Busting (see glossary) can reduce this to 1 or 0 Slots. Each Slot can hold either 2 Workcell/Agenda cards or 1 Awake Cyborg.
- b. **Trashing.** At any time the player owning a Playmat may Discard one of its Workcells that has no Tokens on it. This is useful to make living space for a newborn Cyborg, either pulled from the Jars or by Motherhood.
- c. **Moving Cyborgs.** In this cramped Starship, a Cyborg placard never move to a different Slot except by *Commander Rescue* (**E4c**) during Shield Erosion or jettisons. The rescue keeps the Cyborg in the Playmat of the Cyborg's color.
- d. **Moving Workcells.** A Workcell may be relocated to an empty space in a Slot in any Playmat by the Chief Engineer after a successful *Workcell Roll* (**H1f**). Other Abilities (e.g. Che's Wisdom) may also move a Workcell.
- e. **Busted Slot.** If a Workcell is Discarded or a Slot Busted (e.g. by *Shield Erosion* (**E3**) or other *Blueprint Loss* (**E4**)), any Workers on them are Killed unless (during Shield Erosion or jettison) saved by *Commander Rescue* (**E4c**).

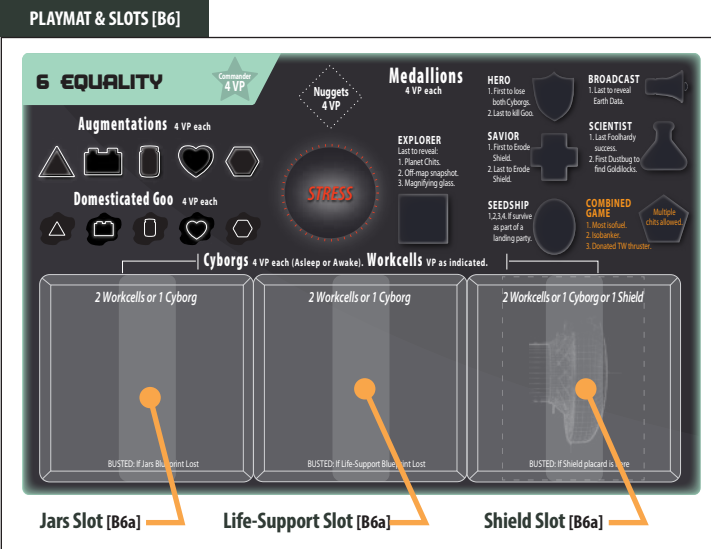
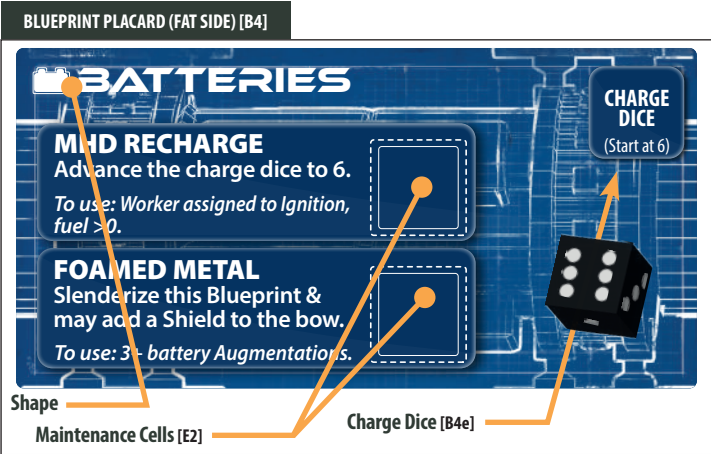
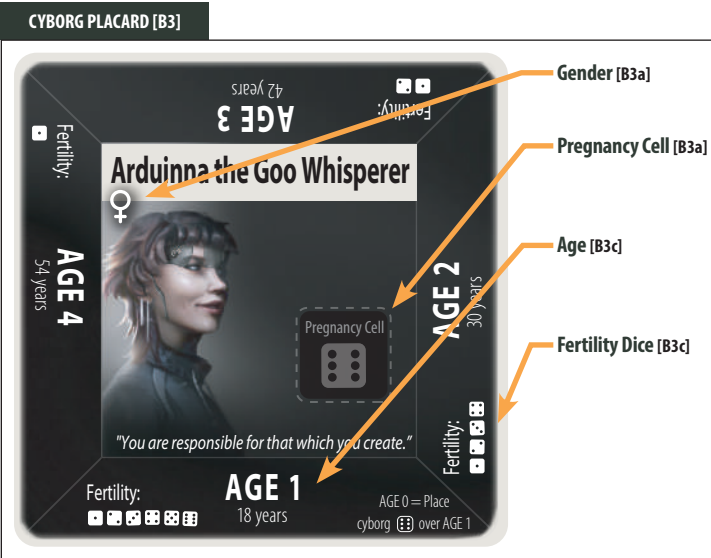
21 **EROSION SHIELD.** The upper limit of the size of LIC grains remain obscure and could be as large as 100 micrometers or even larger. A single hypervelocity impact by a grain of this size traveling at 16 percent of lightspeed releases a kinetic energy of 2 million Joules, comparable to a German 88 mm cannon shell. Project *Daedalus* used an erosion shield made of a centimeter of beryllium, chosen for its lightness and very high latent heat of vaporization (33 MJ/kg). For Project *Exodus*, erosion shields are bolstered by carbon-based buckyball aerogels. These are not radiation shields. —A Bond & A Martin, *Project Daedalus - The Final Report on the BIS Starship Study*, 1978.

22 **WARDENS.** These autonomous robots maintain the starship under a strategy of self-test and repair. Each is powered by a nuclear fission reactor, but can also be beam-powered by base stations installed on the starship. Project *Daedalus* was designed to carry two such robots, at 5 tonnes each. They could also perform Dustbug missions, to clear the path ahead of dangerous neutral dust. Wardens can also make science observations, distant from contamination by the ship's fusion drive. —A Bond & A Martin, *Project Daedalus - The Final Report on the BIS Starship Study*, 1978.

23 **BATTERIES.** The ignition of a fusion engine needs considerable initiator power. After ignition, MHD pickup coils surrounding the plasma jet exhaust recover enough energy to keep the fusion reaction going. This energy is stored in capacitors (called "batteries" in the rules).

24 **STARSHIP MANEUVERABILITY.** As it begins its voyage, a starship cannot change its speed easily because it is massively loaded with fuel. It could attain a few milligees (see **A2h**), as if the Titanic was equipped with an outboard engine. But once underway, a starship is even less maneuverable for an entirely different reason: the enormous investment in its kinetic energy. In ballistic flight (i.e. engine is off), the kinetic energy is equal to half the mass times velocity squared. Thus *Exodus*, with a mass of 200 tonnes and traveling at 16%, would have a kinetic energy of 230 sextillion joules. Once you have invested this much energy into a particular speed and direction, you aren't going to be stopping for sightseeing or refueling along the way. Once you do stop, you will need lifetimes of human effort to mine the isotopes needed to get going again. As tremendous as the *Exodus* kinetic energy is, it is comparable to that of an average Earth-crossing asteroid in its course around Sol, a reminder of the astounding energies contained within our own Solar System.

25 **AVATARS** are robots that make programmed decisions based upon the Ideology and principles of their sleeping owners. Since the technology of subjective consciousness has not yet been developed at the beginning of the game, they are merely programmed robots.



❗ **EASILY MISSED:** Trashing is useful during research, to Discard a Workcell in order to make room for a better freshly-researched Workcell. [B6b]

JARS PLACARD [B7]

FACEDOWN
EARTH DATA
CARDS

CYBORG
PLACARDS
(EMBRYOS)

SPACE ICONS [B8a]

INTERSTELLAR
SPACE

OORT CLOUD
(Comets/Sunlens)

AMAT JET
(antimatter)

LOCAL INTERSTELLAR
CLOUD (LIC)

FLARE & DEBRIS ICONS [B8b]

Exodus entry makes a Plasma
Risk Roll.

FLARE STAR

DEBRIS DISK

PLANET CHIT PLACEMENT SPOTS [B8c]

If explored, take a random
Planet Chit of one of the 3
types and place it faceup here.

YELLOW SUN
AIR CHIT

RED DWARF
AIR CHIT

WATER CHIT
(pointing left)

PLANET NAME & POINTER (B8c)

The planet "YZ Ceti d Earth
2017" has an extra of
hydration. The yellow pointer
indicates that it is a Goldilocks.

YZ Ceti d Earth 2017

KNOWN EXOPLANETS: Planets that are known to exist contain the year of their discovery in their name (with some uncertainty if there is a question mark). The habitability of all exoplanets remains unknown. [B8c]

SUBSTAR ICONS & THEIR TROGLODYTES (B8d)

WHITE DWARF
Can have a phoenix planet.

BROWN DWARF
Can have a carbon planet.

GAS GIANT
Can have an icy moon.

B7. Jars Placard

The Jars start with a male and a female frozen Embryo for each of the 6 Ideologies. These can be moved from the Jars into a Slot either by being *decanted* (**E2e**), or by being born and *apprenticed* (**H5c**) by a mother.²⁶

a. Earth Data Storage. One of these 6 cards (**B2i**) starts facedown on top of each of the 6 Jars (**C4b**).

B8. Stellar Map (1)

The dots on the map, called **spaces**,²⁷ are where *Exodus*, Wisps, and radio signals move. Twenty of them are **Stars**, including 10 yellow suns, 9 red dwarfs, 3 white dwarfs, and 5 brown dwarfs.²⁸ Stars contain two types of potentially Habitable planets to explore: **Goldilocks** (solar-powered atmospheric biosphere) and **Troglodyte** (subterranean nuclear-powered biosphere). There are 28 Goldilocks (*yellow pointers*) and 28 Troglodytes (*blue pointers*).

a. Spaces. Each space spans ½ lightyear. They come in five types:

- **Interstellar Space.**
- **Oort Cloud (Comets/Sunlens).** The space enables Oort *icebraking* (**D5g**)²⁹ and allows a Wisp to *snapshot* the Star that is named (**I1**).³⁰ The yellow arrow in the sunlens space points towards its target Star.
- **Amat Jet.** If *Exodus* enters a space, the Commander is allowed a Peep per **D5j**. (Amat = antimatter.)
- **Local Interstellar Cloud (LIC).** This is composed of erosive neutral particles, see glossary.³¹
- **Star, Binary Star, or Substar.** This oversized space can be orbited and contains its system of planets/moons.

b. Flare/Debris Hazards. Some Stars have hazardous flares or orbiting debris:

- **Flare Star.** If *Exodus* enters Orbit at a Star with this icon, immediately roll a *Plasma Risk Roll* (**H6**) row (2).
- **Debris Disk.** If *Exodus* enters Orbit at a Star with this icon, immediately roll a *Plasma Risk Roll* (**H6**) row (3).

c. Stars have a name, icons for its Substars, and slots for the air and water chits of its planets. They come in 2 types, yellow suns and red dwarfs, as indicated by the star color and size on the back of its *air chit*.

- **Goldilocks.** A Habitable terrestrial atmospheric planet orbiting either type of star is called a **Goldilocks**. It is defined by a pairing of an *air chit* to the left with a *water chit* (**B11a,b**) to the right. It is depicted as a small green sphere. Its name uses a yellow **pointer** and may be followed by a default of *hydration* (**I5a**).

d. Substars exist in 3 types: *white dwarfs*, *brown dwarfs*, and *gas giants*. Each has its own type of **planet**.³²

- **White Dwarf.** This Substar can be orbited by a Troglodyte called a **phoenix**, which exists if its water chit shows the white dwarf icon. A phoenix planet is depicted on the map as a small red sphere.
- **Brown Dwarf.** This Substar can be orbited by a Troglodyte called a **carbon planet**. Its carbonaceous surface is quite dry, but a subsurface ocean is assumed. It exists if its water chit shows the brown dwarf icon. A carbon planet is depicted on the map as a small black sphere.

²⁶ FROZEN EMBRYO. A human fetus (or eggs and sperm) can be stored for decades and remain viable when implanted into a woman's uterus. The future invention of an artificial uterus would allow for partial extracorporeal pregnancy. Although in a 2002 experiment, human embryos implanted into endometrial tissue showed signs of growth, extracorporeal fetus maturation has never been accomplished. On *Exodus*, it is assumed that a living female is required to bring the fetus to term *in vivo*.

²⁷ SPACES. Each is half a lightyear. Once a starship builds up kinetic energy in a particular path, it is committed to that direction, and can change direction and destination only slightly. Therefore the paths have relatively few intersections.

²⁸ SOLAR NEIGHBORHOOD. As of 2021, within 5 parsecs (16.3 lightyears) of the Solar System there are 50 red dwarfs, 11 "yellow suns," 4 white dwarfs, and 11 brown dwarfs - 76 stellar objects altogether bound in 54 starsystems. Our map depicts 8 of the most common, the dim red dwarfs, which have a nasty tendency to disgorge unpredictable dangerous CMEs (coronal mass ejections). The "yellow suns" (orange to white) are hydrogen-burning main sequence stars like Sol. The white dwarfs are stellar remnants of dense degenerate matter, what remains of an exploded star no longer undergoing nuclear fusion. The brown dwarfs also are not undergoing nuclear fusion, being only substars of about 13 to 80 Jupiter masses. One (WISE 0855-0714) is a sub-brown dwarf which is possibly a rogue planet that has never been gravitationally bound to a star.

²⁹ OORT CLOUD are icy worlds orbiting a star in a spherical cloud at distances ranging up to its Hill radius. As well as the sphere, there is also a disk-shaped inner Oort cloud. Objects greater than 1 km number in the trillions. For Sol, the Oort orbits are at extreme ranges, from 2,000 to 50,000 AU (0.03 to 0.79 light-years). This is vastly beyond TNOs (Trans-Neptunian Objects), such as worlds in the Kuiper Belt or scattered disk, which are less than 1000 AU. The astronomer Jan Oort reasoned in 1950 that the continuing appearance of fresh comets, whose volatiles had not been exhausted by repeated close passes to Sol, means there must be a cometary reservoir in extreme orbits which is occasionally perturbed by other stars or the Milky Way itself. But the existence of the Oort cloud is hypothetical; no members of this group have been observed. Furthermore most of the comets and centaurs of the Solar System come from the Kuiper Belt or scattered disk, not the proposed Oort cloud. But there are a few, such as the large comet Bernardinelli-Bernstein, which could either be from the Oort Cloud or from interstellar space.

³⁰ SUNLENS. The gravity of a star bends light such that it acts as a huge gravitational lens. A spacecraft exploiting this lens must be at the focal point, about 542 AU in the case of Sol. It also must be precisely aligned with the star's gravity line of the targeted exoplanet. The distance to the exoplanet is irrelevant for viewing, the focal point is the same distance no matter how distant the target is. Since resolution suffers at range, 9 lightyears is the assumed game range limit. "A meter class telescope with a coronagraph to block solar light, placed in the strong interference region of the solar gravitational lens (SGL) is capable of imaging an exoplanet at a distance of up to 30 parsecs with a few 10 km-scale resolutions on the surface." —Turyshv et al., *Direct Multipixel Imaging and Spectroscopy of an Exoplanet with a Solar Gravity Lens Mission*, 2020.

³¹ LIC. Around 100,000 years ago, when Neanderthal still walked the Earth, Sol blundered into the "Local Interstellar Cloud" (LIC), one of several nearby clouds composed of warm (equal to the surface of Sol), low density (~0.3 atoms/cm³) dust and hydrogen blowing at us from the direction of the Scorpius and Centaurus constellations. The difficulty with this cloud is that the material is electrically neutral and thus passes undeflected through a starship's electromagnetic (EM) shields, directly eroding its dust shield. It is unknown how abrasive it is. Once safely outside the LIC, the starship enters the "local bubble," where the only material is hot plasma of ultra-low density (<0.001 atoms/cm³). Plasma is charged and thus can be magnetically deflected.

³² SUBSTAR HABITABLE ZONE. A moon orbiting a T-class dwarf (gas giant) must orbit at 800,000 km or closer to be warm enough to retain liquid water. Plants would need to be genetically-modified to survive in the very dim near-infrared light, and their foliage would be black. For a planet orbiting a white dwarf, the water-retaining zone would be about 1.5 million kilometers, and orbit every 10 hours. Because the process of formation of a white dwarf entails expanding briefly into a red giant, engulfing planets within this habitable zone, any planets would have had to have survived, wandered in, or coalesced afterwards. The latter, a world that reformed after its destruction, is called a **phoenix**.

- **Gas Giant.** Helium-3 and deuterium can be mined from any gas giant to refuel the *Exodus* (I3a). A gas giant's atmosphere may contain a "Siren Civilization" (I2c). An orbiter circling a gas giant is a Troglodyte called an **icy moon**. It exists with a potentially Habitable subsurface ocean if its water chit shows the gas giant icon.³³ An icy moon is depicted on the map as a small white sphere.
- e. **Off-map Exits.** These indicate distances to stars not on the map, marked with the  icon, and thus not reachable without future expansions to this game. See (D5h).

B9. Goo Chits (5)

Like the Humans, Goo are half machine (nanites) and half reproductive animals (tardigrades).³⁴ There are 5 shapes of Goo, and until Domesticated each is strictly limited to cards and Blueprints of their shape. A Goo chit is placed (on its blue side) if a *Goo outbreak* (H1i) occurs, indicating a cancer-like unregulated replication, gobbling up vital equipment instead of trash.³⁵ If not checked, it eats cards and Kills Cyborgs that are on the cards, and eventually destroys the entire Blueprint.³⁶ However, if Domesticated, Goo is flipped to its yellow side and becomes a valuable tool.

- a. **Warden Goo.** Because the wardens in the game are powered by lasers from the mothership, hexagon Goo originating from wardens can both receive and transmit beamed power.
- b. **Life-Support Goo.** Heart Goo speciated from nanite algae in the photosynthesis vats. It thrives in visible light by using sunlight to sequester carbon dioxide.
- c. **Jar Goo.** This Goo obtains energy from temperature differences, like a heat engine. It plagues the radiators that keep the Jars cool. If unchecked, it will Kill all people in the Jars.
- d. **Batteries Goo.** The ship's capacitors store enormous energies under high voltages, which can spark like lightning if the intervening dielectric is degraded. Batteries Goo exploits these sparks, and if unchecked eats Fuel rather than the batteries.
- e. **Engine Goo.** Triangle Goo originates in the Ignition Cell, and uses either fusion products or iceflash for energy.
- f. **Domesticated Goo.** If you assign a Worker to a Goo Cell and succeed in a domestication *Goo Roll* (H3), flip the Goo chit to its "Domesticated" side and place it into the appropriate Shadow on your Playmat. This confers 5 advantages:
 - **Outbreak Immunity.** Domesticated Goo permanently prevents further outbreaks of that shape.
 - **This Goo Chits Acts as an Augmentation of that Shape.** This is useful as a "To Research" Augmentation (G1a) or to improve the chances of successful Workcell Rolls (H1e).
 - **Zeppelin Refueling.** Domesticated Goo can refine He³-D Fuel from the atmosphere of a gas giant (I3a).
 - **Atmospheric Tailoring.** Domesticated Goo is part of the *right stuff* to make a Goldilocks Habitable (I5b).
 - **Endgame Victory Points.** Domesticated Goo and Augmentations are worth 4 VP each (J3c).

B10. Nugget Tokens (4)

The game starts with 3 Nugget chits, kept facedown so that no player knows their hidden values. These values answer the question about the nature of "what is": is it a feature of our consciousness (subjective), or is it a feature of the universe (objective)? You can examine these chits by using the collisional products of ultra-high energy relativistic exotic particles found in interstellar space. As a warden *Maintenance Task* (E2a), these products can be claimed as "Nuggets," plucked from the Erosion Shields of a starship like bugs from a windshield.³⁷

- a. **Quantum Reality** is randomly fixed during setup (C4a) as one of two states: *objective* or *subjective*.³⁸
- b. **Nugget Creation** is by *entering LIC* (D5e) or *lightning* (H6b). A maximum of 3 Nugget creations are possible.

³³ WATER ON ROGUE PLANET EXOMOONS. Without a star around, water formation from the hydrogen/carbon dioxide atmosphere of a hypothetical exomoon would be very slow, controlled by cosmic rays rather than stellar radiation. The heat required to melt some of the water might be provided by tidal forces. —Ávila et al., *Presence of water on exomoons orbiting free-floating planets*, 2021.

³⁴ TARDIGRADES are eight-legged micro-animals colloquially known as water bears. They utilize an unique DNA-associating protein, called Dsup, that binds nucleosomes in the cell and protect DNA against radiation. This makes tardigrades 1000X more resistant to radiation than any other animal, able to survive 5000 Gy of gamma rays. When human HEK293 cells were bio-engineered with Dsup proteins, they showed approximately 40% more tolerance against X-ray radiation. —Hortikawa et al., *Radiation tolerance in the tardigrade *Milnesium tardigradum**, 2006.

³⁵ GRAY GOO is a hazard originally formulated in a macroscopic form by John von Neumann and in nano-form by K. Eric Drexler. It describes a doomsday pandemic of out of control self-replicating robots which have escaped from the lab. Such "clanking replicators" are essential for various operations, such as refining fuel isotopes and hull reconfiguration. Each species of gray goo uses a different energy source, which is a means to fight its spread. These are iceflash energy (engine goo), voltage (batteries goo), photosynthesis (life-support or algal goo), heat (jar goo), or beamed (warden goo). —John von Neumann, *Theory of Self-Reproducing Automata*, 1966. —K. Eric Drexler, *Engines of Creation*, 1986.

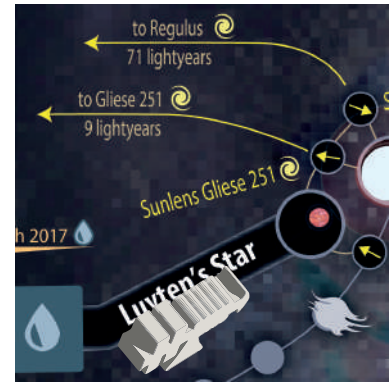
³⁶ GOO REPRODUCTION forms macroscopic colonies able to perform macroscopic tasks. The biological chassis for Goo is either a tardigrade or a genetically-modified species of bdelloid rotifer, a primitive creature about a millimeter long. Their reproduction is asexual and parthenogenetic, which inhibits mutations that could lead to an outbreak. One of the first novels to explore non-intelligent but self-organizing alien swarms is *Niezwycięzony* (The Invincible), hard sci-fi by Stanisław Lem (1964).

³⁷ COLLIDERS accelerate particles to very high kinetic energy and smash them into barriers. Analysis of the byproducts of these collisions unveils evidence of the Reality of the subatomic world and the laws of nature governing it.

³⁸ OBJECTIVITY/SUBJECTIVITY. Is Reality created in our minds, or is it "what doesn't go away when we stop thinking about it"? Are effects that exhibit the *Observer Paradox* (footnote 64), such as particle-wave duality or entanglement, a feature of what is observed (objective), or a feature of the consciousness of the observer (subjective)? Answering any questions about Reality is possible only by the employment of logic, and both deductive and inductive logic depends upon existents that respect both the Laws of Identity and Causality. The universal applicability of logic proves that Reality exists independently of one's consciousness. If something takes on a value only upon observation, the only logical causal explanation is that the something was created in the consciousness of the observer.

OFF-MAP EXIT [B8e]

Two off-map exits are shown. Also shown is a sunlens marked with the galactic icon. Using a Wisp to take a snapshot of this sunlens awards the galactic explorer Medallion per I2b.



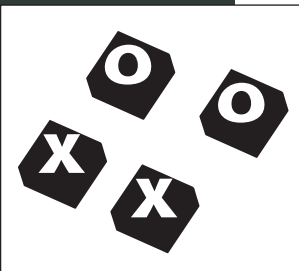
GOO CHITS, OUTBREAK SIDE [B9]



GOO CHITS, DOMESTICATED SIDE [B9]



NUGGET TOKENS [B10]



EASILY MISSED: The game is played with only 3 of these 4 Tokens. [B10]

PLANET CHITS [B11]


YELLOW SUN
AIR CHIT (back)


RED DWARF
AIR CHIT (back)


WATER CHIT
(back)


AIR CHIT (front)


WATER CHIT (front)

7 CLASSES OF MEDALLIONS [B12]


HERO [B12a]


EXPLORER [B12b]


SAVIOR [B12c]


BROADCAST [B12d]


SCIENTIST [B12e]


SEEDSHIP [B12f]


COMBINED [B12g]

EXAMPLE [B12b]

Your Exploration reveals a “Siren Civilization” water chit at Alpha Centauri. This is not a valid magnifying glass icon and does not award a Medallion, since the civilization needs a gas giant to exist, which Alpha Centauri does not have. The Goldilocks (bottom, if any) always applies, however.



LEARNING CHIT [B14a]


"BLUEEYE" initial state
(human learning)


"REDEYE" flipped
(machine learning)

ENDGAME CHIT [B14b]


initial state
(cooperative)


flipped
(competitive)

ORPHAN/PREGNANCY CELL CHITS [B14c]


ORPHAN


PREGNANCY CELL

CREATIVE STRESS CHITS [B14d]

0
STRESS

1
STRESS

2
STRESS

B11. Planets & Planet Chits (40)

A **planet** is a potentially Habitable world, that is defined on the map by one **water chit** and sometimes one **air chit**. These chits are stored facedown on the map and flipped faceup per (I1). There are two kinds of planets:

- Goldilocks (I5)** is a planet in the habitable zone of a Star. Just as in the fairy tale, a Goldilocks is "not too hot and not too cold" for liquid surface water.³⁹ The air chit of a Goldilocks specifies the *right stuff* of Nuggets and Goo needed by a landing party to make its air breathable, and the lower part of its water chit specifies how many of hydration the planet has. A Goldilocks orbits either a *yellow sun* or a *red dwarf* (B8c).
- Troglodyte (I6)** is a world that is Habitable underground. It is defined by one water chit plus a Substar icon (either a carbon planet at a brown dwarf, a phoenix at a white dwarf, or an icy moon at a gas giant). A single water chit can be shared by two planets orbiting the same Star (I6c), as indicated by the pointer(s) in the water chit spot.

B12. Medallions (17*)

These chits are awarded for specific accomplishments, and are worth 4 VP each in the endgame (J3c). There are 7 **classes**, each with their own shape, as listed below. (The number in parentheses is the number of chits). Each Ideology is allowed only one of each class of Medallion, placed upon their Playmat in the Shadow of the right shape. When earning a Medallion that states "latest," an Ideology may steal it from another Ideology who previously earned it.

- Hero (2) (escutcheon)**. "Founder" is awarded to the *latest* to have both their Cyborgs in the Soyilent Green Pile. "Champion" is awarded to the *latest* Chief Engineer who Kills Goo (H4b).
- Explorer (3) (square)**. "Wisp" is awarded to the *latest* whose Wisp revealed a Planet Chit (I2a). "Galactic" is awarded to the *latest* whose Wisp took a snapshot (I2b) at a Sunlens. "Detective" is awarded to the *latest* whose Wisp revealed a chit with a magnifying glass icon (I2c) at a planet that exists. See I2.
- Savior (2) (cross)**. "Guardian" is awarded to the *first* to have their color Shield eroded. "Watchdog" is awarded to the *latest* to have their color Shield eroded.
- Broadcast (1) (bullhorn)**. "Pale Blue Dot" is awarded to the *latest* to send a *radio signal* (G1e) to Sol.
- Scientist (2) (flask)**. "Mad Scientist" is awarded to the *latest* Chief Engineer in a successful Workcell Roll in a Foolhardy Experiment. "Panspermia" is awarded to the *first* one to land a Dustbug onto an uninhabited Goldilocks per I4h.
- Seedship (4) (oval)**. These are awarded to surviving members of any landing party who have been dropped off in a Pod on an uninhabited world. They must survive a Plasma Risk Roll (row 1) (I4d). Once safely down, if the world is not Habitable, they can die of old age but still retain their Medallion. See I4g.
- *Combined Game (3) (pentagonal)**. The pentagonal Medallion chits are supplied in *High Frontier Module 4: Exodus* and, if achieved, are transferred to your Playmat into the pentagonal Shadow. This includes *isobanker* (4D2), *propulsion* (4D3c), and *command* (4D3b). Each scores 4 VP in the endgame. Unlike other Shadows, the pentagonal Shadow is not limited to a single chit.

B13. Augmentation Tokens (30)

These wooden tokens are in Ideological colors and have a shape corresponding to a Blueprint/Cell shape, and are placed upon Playmats as experience is gained in Workcell or Goo Rolls. Augmentations are worth 4 VP each.

B14. Game State Chits (11)

Game state chits do not count victory points (VP) and are only used to track **game states**:

- Learning Chit (1)**. This starts with human learning but can flip to machine learning per E6d.
- Endgame Chit (1)**. This starts cooperative but can flip to its Competitive Endgame (king) side as the result of a Foolhardy Experiment, either as stated on the card's result, or per E6c via a Posthuman.
 - Deepfake**. Both the learning and the endgame chits can also be flipped from their starting state (and back again) by a successful Workcell Roll on the "Deepfake" Workcell.
- Orphan/Pregnancy Cell Chits (6)**. Placed "orphan" side on *decanted* Embryos (E2e)⁴⁰ and "Pregnancy Cell" side on a Hermaphrodite (Cyborg decanted by Hermaphroditism, see glossary).
- Creative Stress Chits (3)**. Place these by each Market row to indicate the Stress costs (G1c).

³⁹WATER on Earth and other terrestrial planets was once believed to have been delivered by icy comets that came from beyond the "snow line" - the boundary beyond which ice can condense due to the low temperatures. My game *Bios:Genesis* makes this assumption. New studies show that the heating of interstellar organic matter at high temperature can yield abundant water and abiotic oil deposits on the inner planets. —Nakano et al., *Precometary organic matter: A hidden reservoir of water inside the snow line*, 2020.

⁴⁰ORPHANS. Imagine a test tube baby born without a mom and breast-fed by a machine and raised by a TV nanny. The orphan chit represents everything the infant would suffer without access to human touches, admonishments, and foibles.

C. Setup

The number of players can be from 1 to 6. See **C1b** for *solitaire*, and **C2d** for the 4- and 5- player games.

C1. Assign Ideological Color

Each player starts with a number of Ideological Playmats as per **Setup Table** (right).

- a. Starting Ideologies.** Each player starts with the number of Ideological Playmats shown in the table (right). They may either choose the Ideologies they wish, or else roll dice, using the Pulse Order Number depicted on the Political Hexagon.
- b. The Solitaire Game.** You start with all 6 Playmats. During the *endgame victory points (J3)*, use only the one with the highest score, and count victory per **J3**. Also see *cooperative victory point goals (J2)*. Otherwise play with all game rules.
- c. Seating Arrangement.** Players may find it helpful to seat themselves around the table in clockwise fashion as shown by the Pulse Order Number, starting with individuality (gray) = 1, freedom (red) = 2, honor (white) = 3, unity (yellow) = 4, authority (purple) = 5, and equality (green) = 6.
- d. Jars Placard.** This placard, containing the Hibernation Jars for each Ideology, is set in a common area. Each Ideology receives their 2 Cyborg placards plus the 1 large dice, 1 small dice, 1 radio signal dome, and 1 shield placard of their color. Stack all these components, except Shields (see next bullet), into the Jars of each Ideology.
- e. Busted Right Slot.** Each Ideology places their Shield placard in the rightmost Slot of their Playmat with its Busted side faceup. This shows that the right Slot is Busted, leaving 2 available Slots.

C2. Crew Setup

Into each color in the Jars, place the 1 large dice and 2 Cyborg placards of that color. Place all 6 (small) Avatar dice into the Trapezoids (1 per color). For the starting shift, awaken one female and male teenager following these steps:

- a. Age & Orientation.** All Cyborg placards, whether Awake or in Jars, start young and oriented to Age 1.
- b. Assign Awake Female/Commander's Star.** A random Ideology starts with their female Awake. Place her placard into the Slot labeled "BUSTED: If Life-Support Blueprint Lost" on her color Playmat. Give her the two *commander's star tokens (B1h)* to show that she is the Commander. Place one on her Cyborg placard and the other on the Commander's star shadow on her color Trapezoid in the Political Hexagon. Swap her Avatar dice with her Cyborg dice, so that her Avatar retires to the Jars and her Cyborg dice sits in the Ideological Trapezoid.
- c. Choose First Mate.** The Commander chooses one male from another Ideology. The player controlling this Ideology moves that male placard from the Jars to their Playmat's life-support Slot. Swap his Avatar dice with his Cyborg dice, so that the Avatar dice retires to the Jars and the Cyborg dice sits in his color of Trapezoid.
- d. 4-and 5-Player Games Are Asymmetrical!** In a 4-player game, the Commander player and the first mate player start with 1 Playmat, and the other players start with 2 Playmats. In a 5-player game, one player (the first mate) starts with 2 Playmats, and the other three players start with 1 Playmat. An asymmetrical game is not recommended for inexperience players, but makes for a unique Competitive Endgame experience!
- e. Rings.** Place 1 *matrimonial ring (B1i)* in each of the 6 Trapezoids on the Political Hexagon.
- f. Commander's Agenda (optional).** The Commander randomly takes 1 *Agenda Card* (glossary), hidden from the others.
- g. Control Pawns.** Each player places a *control pawn (B1q)* of that color in front of them, which reminds other players which Ideologies they control.

C3. Workcell Market

- a. Workcell Market & Draw Decks.** Separate the *Workcell cards* into their 5 *Workcell Blueprints (B2b)*. Shuffle each deck, and setup a Market of 5 columns and 3 rows, just below their respective Blueprint off the map as shown. The top card only of each draw deck is faceup.
- b. Creative Stress Chits (B14d)** are placed one to the left of each row as shown.

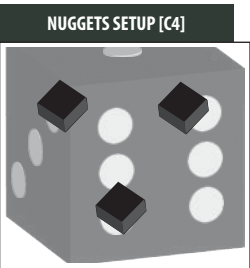
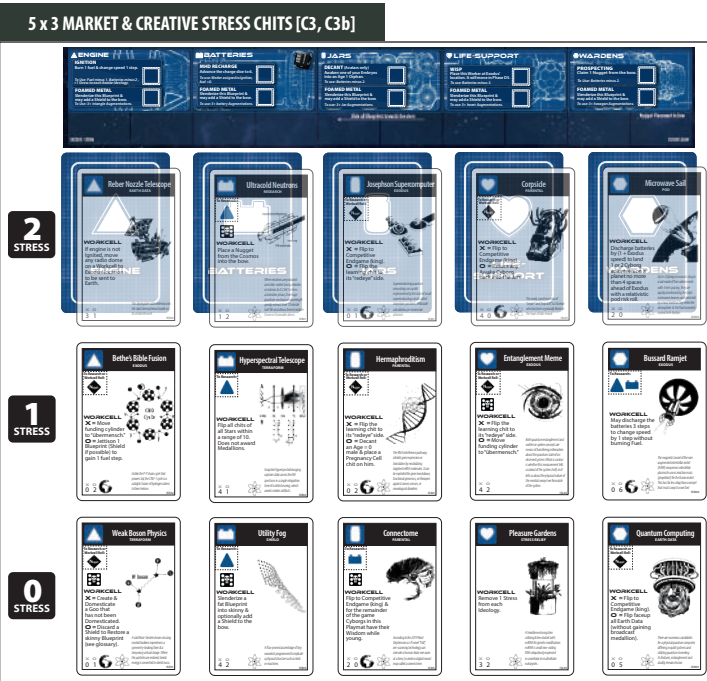
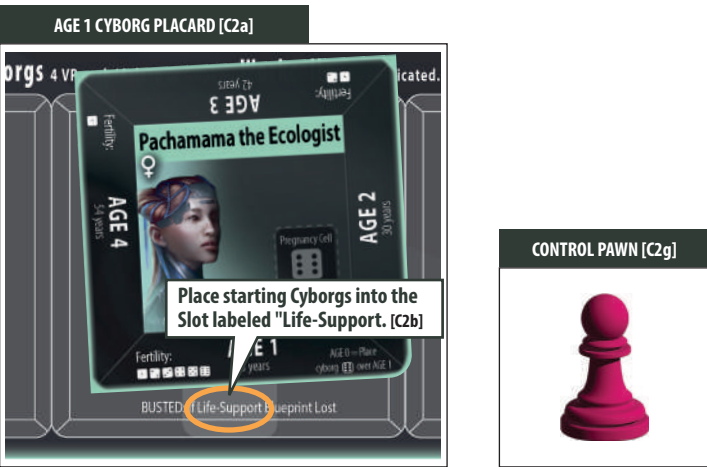
C4. Nugget & Earth Data Setup

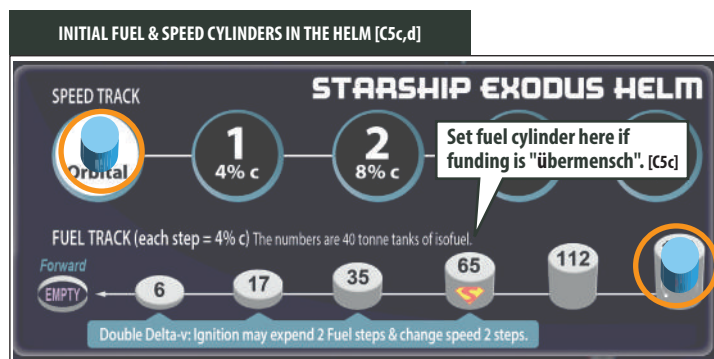
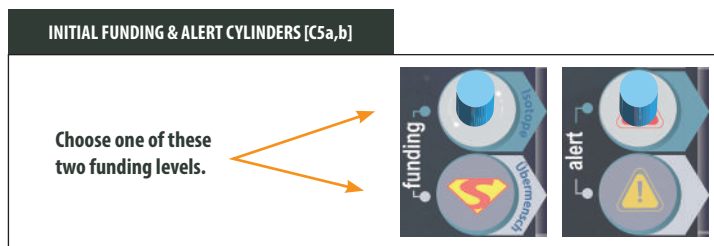
The game comes with 4 Nugget chits, but only 3 are used in each game. Place 3 at random facedown in the diamond spots in the center of the map. This area is called the **Cosmos**. Return the 4th to the box, so that it will not be examined during the game. The facedown value of the Nuggets is secret from all players.

- a. Quantum Reality.** The 3 facedown chits will be 2 of one state, and 1 of the other, but nobody knows which state is in the majority, and thus nobody yet knows the true nature of the quantum.⁴¹ This is important for the final victory tally, and the outcome of *Foolhardy Experiments (E6)*.
- b. Earth Data (B2i).** These 6 cards represent new technological ideas sent quid pro quo from the Solar System. Shuffle and set one (facedown) on top of each Jar, so that each Ideology starts with one that only they know.

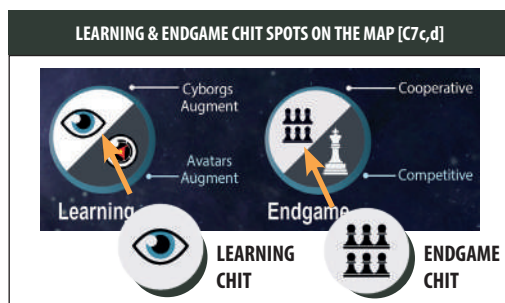
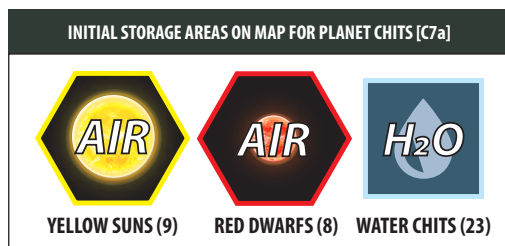
⁴¹ NATURE OF THE QUANTUM is described by the math of quantum theory. Devices that use this theory, such as quantum tunneling qubits, are possible. However, quantum states that are "entangled" with the mind of a conscious observer, such as wave/particle duality, might describe quantum effects inherent in cognitive data compression. If this subjective interpretation is correct, inventions that depend on the Observer Paradox (footnote 64) for an objective result may prove to be forever impossible. One interpretation of the nature of the quantum is **superposition**, the assertion that a quantum has no nature but instead is a mixture of contradictory natures until measured. Such mystical interpretations make no predictions, and can't be contradicted by any experimental outcome. Like divine intervention, superposition can "explain" any possible outcome or phenomena.

SETUP TABLE [C1a]						
C1b. Number of Players:	1	2	3	4	5	6
Number of Playmats per Player:	6	3	2	1, two players start with 2 per C2d. ASYMMETRICAL!	1, one player starts with 2 per C2d. ASYMMETRICAL!	1
Number of Cyborgs:	12 (1 male & 1 female for each color). Each starts in the Jars with a large dice and a placard. Then the Cyborg of the Commander and of the first mate are moved from the Jars to the life-support Slot of their Ideology.					
Number of Avatars:	6 (1 for each color). Each Ideology may have only 1 Worker active at a time.					





OPTIONAL: The Blueprints are normally setup in the order (from stern to bow) shown above as: engine, batteries, Jars, life-support, and wardens. The Commander is allowed to start with other arrangements, as long as the engine is in the stern. [C6a]



C5. Fuel, Funding, Speed, & Alert Cylinders (Map Right Edge)

The **funding** (see left) tracks if the funding priority is **Isotope** or **übermensch**. The **alert** tracks whether the alert status is red ("shoot to kill") or yellow ("shoot to subdue"). The **helm** tracks the Starship speed and Fuel.

- Set Funding Cylinder.** The Commander sets a **cylinder (B1p)** on her choice of one of two funding priorities: "Isotope" (2 steps more Fuel), or "übermensch" (start with smarter Cyborgs (**H1c, D3a**)).⁴²
- Set Alert Cylinder.** Start this in yellow alert. Used in Goo fights per **H3a,b**.
- Set Fuel Cylinder.** Start a **cylinder** in the fuel track at 190 if funding is "isotope" or 65 if funding is "übermensch."
- Set Speed Cylinder.** Start a **cylinder** at Orbital Speed on the **speed track**. Thus **Exodus** starts at speed 0 (Orbital).

C6. Starship Blueprint Setup (Lower Map)

The **Blueprints (B4)** are arranged as follows:

- Blueprint Placards Setup.** The engine, batteries, Jars, life-support, and wardens placards are set on the lower map edge, on their fat Orientation in the order shown. **Exodus** starts without any Shield placards.
- Batteries Charge Dice Setup.** Set a black dice with a "6" faceup where indicated on the batteries Blueprint.

C7. Remaining Map Setup (Map Right & Left Edges)

Place the **Starship Token** in the space labeled "Sol." (It starts in solar Orbit).

- Planet Chits (B11).** Stack the 9 **yellow sun** air chits in a facedown pile where indicated on the map. Do the same for the 8 **red dwarf** air chits⁴³ and the 23 **water chits**. They will be placed and revealed during **exploration (I1)**.
- Facing.** **Exodus** starts pointing toward one of the 4 exits surrounding Sol, as decided by the Commander (**A4a**).
- Set Learning Chit** in the "Learning" space, with the "blueeye" faceup to indicate it is Humans who learn.
- Set Endgame Chit** in the "Endgame" space, with the "6-pawns" side faceup to indicate a cooperative game.
- Set Posthuman Card & optional Agenda Cards** in the "Soylent Green Pile" square in the left edge of the map.
- Leapfrog Game.** If in a previous game you have established a colony at a Star on the map, you may use these setup rules using this Star instead of Sol.

C8. Modified Setup for the Combined Game

If playing the **High Frontier Module 4:Exodus** Combined Game (see glossary), modify the setup as follows:

- Starting Ideologies.** Because there are exactly 6 Ideologies and thus 6 Playmats in **Interstellar**, these must be distributed among the players. Each player starts with the Playmat of their player color in **Module 4**. Then distribute the remaining Playmats per **C1a** and the next 2 bullets.
- Isobanker Medallion.** If you were the **isobanker (4D2)** in **Module 4**, then transfer the isobanker Medallion to your Playmat in the pentagonal Shadow, and choose the first mate.
- Command Medallion.** If you obtained the **command Medallion (4D3b)** in **Module 4**, transfer it to your Playmat in the pentagonal Shadow, and you choose the starting Commander.
- Propulsion Medallion.** If you obtained the **propulsion Medallion (4D3c)** in **Module 4** by contributing the promoted TW thruster to the starshot, transfer this Medallion to your Playmat in the pentagonal Shadow.
- Augmentation Chits.** Include the Augmentations on Colonists who you contributed to the starshot in **Module 4** (wardens, life-support, Jars, batteries, or engine) on the Playmat of your player color (1 per type maximum). A Goo Augmentation starts as Domesticated Warden Goo on your Playmat.
- Skinny Wardens.** If you contributed a promoted freighter to the starshot, the wardens Blueprint starts skinny instead of fat, and there is an extra Shield placard of your color in the bow. This allows you to begin with 3 unbusted Slots instead of 2.
- Skinny Life-Support.** If you contributed a promoted Bernal to the starshot, the life-support Blueprint starts skinny instead of fat, and there is an extra Shield placard of your color in the bow. This allows you to begin with 3 unbusted Slots instead of 2.
- Starting Fuel Cylinder.** If **Exodus** leaves in haste, she may not be fully Fueled. Each Fuel mass is equivalent to one fuel tank in the **High Frontier** scale. The number of starting tanks depends upon the isototal as determined by **4C4d (Module 4)**, and is equal to 190 tanks (max), 112 tanks (crisis), or 65 tanks (reckless).⁴⁴
- Solar System Exit & Starting Stress.** If during a desperation starshot in Module 4, the Starship took the Jupiter-Sol-Jupiter **ad astra** map exit (**4D3e**), then the Awake Cyborgs (Commander and first mate) start with 1 Stress. If either of the other two exits, or an unspecified exit, there is no starting Stress.
- Robot Emancipation.** If a robot emancipation Future has been achieved, the **learning chit (B14a)** starts "redeye."
- Promo Deck.** If you have Prometheus/Ada, start Posthuman. With the Domesticated Goo, start with a random Goo chit.

⁴² FUEL LEVELS. The numbers on the Fuel strip indicate the number of yellow tanks of isofuel as used in the **High Frontier** game. The Starship **Exodus** starts with up to 190 tanks of isotope Fuel, where each tank is 40 tonnes. The dry mass of the starship is 400 tonnes. Thus, her mass ratio is wet mass (8000 tonnes) divided by dry mass (400 tonnes) = 20.

⁴³ YELLOW SUNS VS. RED DWARFS. The yellow suns are similar to Sol and have the best chance to have Earth-like planets. The smaller and dimmer red dwarfs have low stellar flux, small circumstellar habitable zones and high stellar variation (e.g. flare stars). The planets in the narrow habitable zone are so close to the star, that they are likely tidally-locked, which means that they have a permanent day and night side, and less likely to have a protective magnetosphere.

⁴⁴ JUPITER-SOL-JUPITER EXIT. The most fuel efficient route to exit our Solar System begins with a flyby of Jupiter, in a momentum exchange that kills orbital velocity from 13 km/sec to less than 1 km/sec. The starship picks up tremendous speed as it plunges toward Sol, but then starts its engine and performs a **solar oberth** burn at perihelion. A final Jupiter flyby adjusts its course toward the target star as it leaves the Solar System.

C9. Project Forward Variant

In this alternative boost variant, *Exodus Forward* flies with neither Fuel nor a fusion engine.⁴⁵ Instead, she rides on a stream of relativistic minisails, each imparting a bit of momentum over a span of decades.⁴⁶ These minisails were accelerated by a solar-orbiting phased array of small sun-fired lasers, focused by a para-lens.⁴⁷ *Exodus Forward* starts with the same 400 tonne dry mass as *Exodus*,⁴⁸ but with 80 tonnes of Mag Sail and Shields instead of an engine. Since she carries no Fuel, her starting (wet) mass is 7600 tonnes lighter than *Exodus*.

- a. **Blueprint.** Remove the engine (triangle Blueprint). Instead place two Shields in the bow, in the colors of the Commander and first mate.
- b. **4-Column Market.** Remove all the engine (triangle) Workcell cards from the game.
- c. **Set Funding Cylinder.** There is no fuel cylinder and the *funding cylinder* starts on "übermensch" (C5a).
- d. **Starting Speed.** Start at speed = 4. However, for the first Dozyear, move *Exodus Forward* only 2 spaces, as she takes 2 Dozyears to get to full speed. Without an engine, she will need to develop braking technology.
- e. **First Dozyear.** Skip all Phases of the first Dozyear (the crew is incapacitated by the laser flux). The only thing that happens is that the Starship moves 2 spaces and the Commander and first mate each Age 1 step.

D. Sequence of Play, Each Dozyear

Each Dozyear is divided into 7 Phases. Each Phase is completed by all Ideologies before going on to the next Phase. First comes **Phase D1**, which is performed starting with individuality (gray, Pulse Order Number 1) and going clockwise on the Political Hexagon to Equality (green Pulse Order Number 6). In the subsequent Phases, the activities are executed in an order as directed by the Commander. Finally, go to the next Dozyear.

- a. **Phase Cylinder (B1p).** Place this on the sequence of play printed on the map to indicate the current Phase. It starts on "D1" (the assignment phase).

D1. Assignment Phase

This Phase is played beginning with Pulse Order Number = 1 (individuality) and continuing clockwise around the Political Hexagon until ending with Pulse Order Number = 6 (equality). In its pulse, an Ideology must assign its Worker either into the Market or into a Cell (Workcell, Goo Cell, Maintenance Cell, or Stadium Cell). Additionally, it may propose marriage. The following is a summary of assignments and their effects:

- a. **Research (Cyborg Market Assignment).** Placing a Cyborg onto a Market card immediately adds the card into an empty space in a Slot in any Playmat. The owner of the Playmat can *trash* a Workcell there to make room (B6b).
 - **"To Research."** If the card lists an *Augmentation* "To Research," destination Playmat must provide the listed Augmentation per G1a. If the card has a *Nugget* "To Research" (E6), there must be at least one unflipped Nugget existing outside the Cosmos per G1b.
 - **Creative Stress.** If the card is in the 2nd or 3rd row, you must pay the *creative stress* per G1c.
 - **Earthware.** If the card has an Earthware icon , place an available *radio signal dome* upon this icon (G1e).
- b. **Librarian (Avatar Market Assignment).** Placing an Avatar onto a Market card immediately moves that card to the bottom of its draw deck, see G2. Return the Avatar to its Trapezoid.
- c. **Workcell Assignment.** You may assign a Worker to a Workcell in any Playmat, which can hold any number of Workers. All Workers in a Workcell will roll simultaneously in Phase D3.
- d. **Blueprint Assignment (E2).** Each Blueprint has 2 Maintenance Cells, and only one Worker can be assigned to each. If a Blueprint contains Goo, all assignments to that Blueprint must go to the Goo Cell (which can hold any number of Workers).
- e. **Stadium Cell Assignment.** If the "Game Stadium" Earth Data is in play, you may assign here to remove all but one Stress on your color Playmat during Phase D4.
- f. **Pregnancy Cell Assignment.** A young female can assign to the Pregnancy Cell in the center of her own placard, see H5. A Hermaphrodite can assign to their Pregnancy Cell chit. Resolve pregnancy during Phase D3.
- g. **Marriage Proposal.** In addition to Worker Assignment, if you have an available *matrimonial ring* (B1i), you may also propose marriage to an adjacent Ideology per F4a. Both Cyborgs must be Awake.
- h. **Pass.** Not allowed.

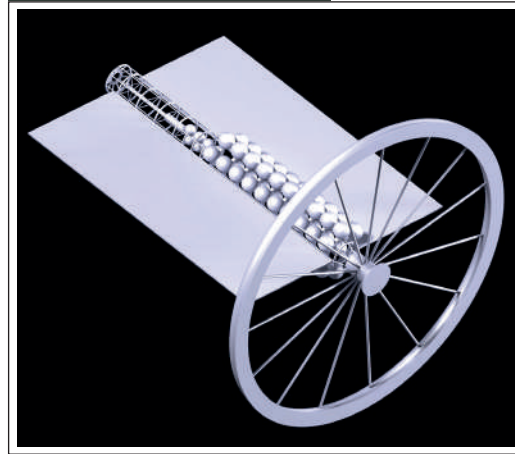
⁴⁵DR. ROBERT FORWARD. This game is dedicated to the memory of the foremost pioneer of beam-driven sails and the very first to make interstellar flight plausible. We started corresponding when we both worked for Hughes Malibu, and over the years his patience answering very lowbrow questions never flagged. I wish that I could have shown him a copy of *High Frontier* in which the Solar System is criss-crossed with his concepts of beamed power (I never had a chance to clarify that it was only a boardgame, not a computer game). For Bob, only ideas mattered, not titles, mainstream wisdom, or consensus groupthink. —Phil Eklund, 2022.

⁴⁶SAILBEAM. A laser-driven sail needs enormous powers and power densities over vast distances to develop a feeble thrust. This can be improved by using the lasers to accelerate a stream of mini-sails, which are finally ionized to transfer momentum to the starship's Mag Sail. —J.T. Kare, *SailBeam: Space Propulsion by Macroscopic Sail-Type Projectiles*, 2001.

⁴⁷O'MEARA PARA-LENS. Robert Forward assumed a version of a Fresnel zone lens constructed between Saturn and Uranus at 15 AU. The lens, 1000 km diameter and made of alternating rings of Kapton plastic, is not in orbit, but either freely falling or levitated in place by rockets. —Robert Forward, *Roundtrip Interstellar Travel Using Laser-Pushed Lightsails*, 1983.

⁴⁸EXODUS is named after the second book of the Hebrew Torah and the Christian Bible. This book tells how the Israelites escape from slavery in Egypt, and flee through the desert in search of a new homeland.

VIEW OF PROJECT FORWARD STARSHIP [C9]



PROJECT FORWARD STUDY: Project Forward, run by Dr. Jim Benford, is a study performed by members of Icarus Interstellar and affiliated organizations with expertise in the field of beamed propulsion. The large wheel is the ship's Mag Sail, which provides braking and shielding. Exodus uses a stowable Mag Sail, whose shroudlines and superconducting cable is stowed in a drum in the bow shields.

[—Icarus Interstellar.org, 2016] [C9]

EXAMPLE [D1]

It's the beginning of a new Dozyear halfway to Ran. Ideology Gray assigns first. The Ideology Yellow Commander wants to speed up, but Gray instead assigns his Avatar to decant in the Jars Maintenance, thinking it was a good time to decant a female young enough to survive to Arrival. Ideology Red assigns an Avatar to ignition, obeying the Commander. Ideology white (Arduinna) proposes marriage to Commander Siddhartha, who accepts. Additionally Arduinna assigns to her own Pregnancy Cell. The Commander researches the Workcell "Creche." Ideology purple plays an Avatar to the "Creche" Workcell. Ideology green plays an Avatar as a librarian to the Market, which moves that card to the bottom of its deck. All 6 Workers have been assigned, so play proceeds to Phase D2.

EXAMPLE [D1a]

You research a Workcell with a "To Research" of heart. Only Ideology gray has a heart Augmentation and her Playmat has no empty Slots. You negotiate with her to *trash* (see Discard in Glossary) one of her Workcells to make room for the new Workcell, which you argue is vital for the mission.

EASILY MISSED: When assigning dice, anywhere on a Workcell joins the Workcell Roll. [D1c,d]

EASILY MISSED: When assigning dice, anywhere on a Goo chit is a Goo Cell (for a Goo Roll). [D1c,d]

TIP: There are two ways to create a newborn Cyborg: an Avatar can assign to the decant Maintenance Cell (E2e), or a young female Cyborg can attempt Pregnancy. The former (test tube baby) is certain, but drains battery energy and only one Orphan can be pulled from the Jars per Dozyear. The latter (Pregnancy) is uncertain and a Cyborg uses a valuable 12 years to raise the child. But this effort provides the child with its Wisdom Ability when they turn old. [D1f]

**Autodidact**
PARENTAL

To Research:




WORKCELL
Decant a Cyborg from the Jars who becomes a non-Orphan Commander & moves up to 2 Workcells to his/her Playmat from other Playmats.

×

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01

Self-educated persons who learned their expertise with independent thinking rather than formal studies have made many critical discoveries.

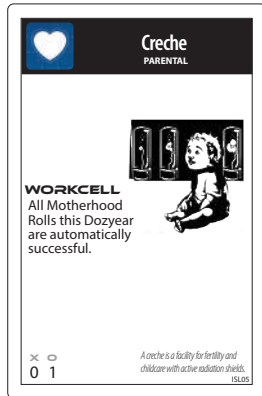
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EXAMPLE [D2]

After the assignments of the previous example, the Commander grumbles that nobody assigned themselves to recharge the batteries, a thankless yet valuable Task. She reassigns the gray Avatar to the batteries. Ideology gray considers a mutiny, but after a short negotiation backs down.

EXAMPLE [D3]

Continuing from the previous example, there is the “Creche” Workcell and one Pregnancy to resolve. The Commander wisely orders “Creche” rolled first, both the dice on that card are rolled, and one is successful. This success means that all Motherhood Rolls are successful this Dozyear, so that the Pregnancy is automatically fruitful. Because the Soyilent Green Pile is empty, the mother chooses a female from the Jars to be born, and apprentices her into a Slot (H5c).



ÜBERMENSCH & RISKY ICONS [D3a]



EASILY MISSED: Goo Rolls always occur before Maintenance Cells. [D3a]

EXAMPLE [D4]

Player white assigns her Avatar to the decant Maintenance Cell, in order to gain VP from Augmentations and researched Workcells. The Commander doesn't want an Archenemy decanted, so when choosing the order that maintenance is resolved, resolves the decant before resolving the recharge, so that the decant is aborted for insufficient battery charge.

EXAMPLE [D4b]

Exodus is 2 spaces from Sirius traveling at a speed of 3 with a Fuel of 35 tanks. The engine is Ignited and the Commander orders a deceleration, hoping to colonize a planet orbiting Sirius B. This burns a step of Fuel (new Fuel = 17, new speed = 2). During Phase D5, Exodus moves to Sirius. On the next Dozyear, the Commander orders an ignition with double delta-v (D4b) to burn 2 steps of Fuel and decelerate by 2 steps. Exodus is now out of Fuel at a speed = 0. Exodus does not move this Dozyear, as it now Orbits the Sirius binary.

EXAMPLE [D4c]

Continuing from the previous example, the Ignition Cell was resolved first, which lowers Fuel and the battery charge. This also speeds up the ship. Finally, the two Cyborgs (but not the newborn Red male) suffer Stress from engine radiation. Then the batteries are recharged, thanks to the gray Avatar. The endgame check indicates that the game continues.

D2. Regulation & Mutiny Phase

During this Phase, the Commander may exercise his/her regulatory powers to reassign Workers or seize Nuggets. Alternatively, the Commander may skip this Phase (which also circumvents any possibility of a *mutiny*).

- Regulations.** The list of what a Commander can reassign/seize depends upon the *Regulation* used, see **F1**.
- Mutiny.** If the Commander uses a Regulation to make at least one reassignment or seizure, the Ideology who was reassigned or seized from can **protest** and call for a mutinous election. This mutinous Ideology must suffer 1 Stress (regardless of election win or loss),⁴⁹ then hold an *election* per **F3**.
- Marital Restrictions.** A Cyborg married to the Commander automatically *divorces* (**F4c**) if he/she protests, and may not protest at all if the marriage is *monogamous* or *arranged* (**F4b**).

D3. Cell Rolls Phase

In an order decided by the Commander, roll for each Workcell (**H1**), Goo Cell (**H3**), or Pregnancy Cell (**H5**) with assigned Worker(s). The rolls are 1d6. Also see “Workcell/Goo Cell Rolls” printed on the map to see if the roll succeeds or fails, and other consequences (e.g. adding Augmentations, Stress, Goo outbreak, or Goo Spread).⁵⁰

- Workcell Rolls.** All the Worker dice in a Cell are rolled simultaneously. Each Worker dice that shows a “1” is a success, or a “1” or “2” if the Worker is Augmented for that Workcell. One or more successes enacts the *success impact* (**B2e**) listed on the Workcell card. See **H1** for details.
 - Übermensch Funding.** If the funding cylinder is set to this level, the chances of success and Augmentation is doubled, see the Workcell Roll Table (**H1b**).⁵¹
 - Cyborgs in a Workcell Roll.** The value of Cyborg dice rolled in a Workcell Roll have 2 possible additional effects: if the value is less than the Cyborg Stress, then there can be a *Goo outbreak* (**H1i**), and if the value is “6,” the Cyborg suffers Stress, or death in the case of a Workcell with the Risky icon
- Goo Rolls.** Similar to a Workcell Roll, except that the chance and type of success depends upon the Alert Level (Augmentations do not help in a Goo Roll). Cyborg dice that roll a “6” are killed by the Goo. See **H3** for details.
- Motherhood Rolls (young females only).** Only one Cyborg dice is allowed, that of the mother. The chances of success depend upon the mother's Age. If the value is “6,” the mother suffers Stress. See **H5** for details.

D4. Maintenance & Stadium Phase

In an order decided by the Commander, resolve the listed Tasks for Workers on Blueprints per **E2** and in the *Stadium Cell* per **D1e**. These Tasks are automatically successful.

- Orbital Missions.** If *Exodus* started the Dozyear at Orbital speed, the Commander may order an Orbital mission, either *deploy refueling zeppelins*, *Terraforming* (**I3b**), or *Arrival* (**I**). Arrival is mandatory.
- Engine-Acceleration/Deceleration Move.** If the engine is Ignited, the batteries are *discharged* by 2 steps or 1 step if the batteries are skinny) (**H2a**). The Commander moves the Fuel cylinder 1 step to the left, and adjusts the speed cylinder by 1 step (either faster or slower. If the Commander's decision is *protested*, hold an *election* (**F3**)). Because of neutron radiation, all Awake Ideologies suffer one Stress (not including newborns).
 - Double Delta-V Acceleration/Deceleration.** *Exodus* can change her speed by more than 1 step as she gets lighter from burning Fuel. If the number of Fuel tanks is 65 or less, then ignition can burn 2 steps of Fuel and adjust the speed cylinder by 2 steps.⁵²
 - Empty Tanks.** If the Fuel cylinder reaches “EMPTY,” no further Fuel can be burned and the Ignition Cell Task (**E2i**) cannot be completed, unless the ship is *refueled* (**I3a**).
 - Entering Orbit Deceleration.** When decelerating to a speed of zero, *Exodus* enters Orbit if on a Star.
 - The Vacuum Cleaner Rule.** During a power-deceleration move, it is assumed that *Exodus* has been flipped so that her nozzle faces forward. If she enters a *debris ring* (**B8b**), the terawatts of power vaporize a passage, making the Plasma Risk Roll unnecessary. This doesn't work against a flare star, however.
- Endgame Check.** The game ends at the end of this Phase if any of the *endgame conditions* (**J1**) are met.

⁴⁹PUNISHMENT for insubordination in this game is 1 Stress. However, one can imagine the actual punishment as based upon Ideology: therapy (individuality), fine (freedom), shunning (honor), imprisonment (unity), capital (authority), or corvée (equality). —Matthew Rozanski, 2021.

⁵⁰TECHNOLOGICAL JUMPS. “There are two ways in which the jump could happen. The two ways are called nanotechnology and genetic engineering. Nanotechnology means the building of machines and structures on a microscopic scale by manipulation of individual atoms and molecules. Genetic engineering means the use of nature's nanotechnology of genes and enzymes to grow living creatures of our own design.” —Freeman Dyson, *From Eros to Gaia*, 1992.

⁵¹ÜBERMENSCH, German for “superman,” describes an artificial consciousness program. **Consciousness** is a mysterious entity that regards other entities as **concepts**, a verbal means of cognition that is (so far) unique to humans. The physical realization of a concept is unknown, but if Alice tells Bob a defined concept, it is transferred from her to him. It has been discovered that the quantum property called **entanglement**, which can be measured between two entities in a system, can also be verbally transferred from Alice to Bob, suggesting that entanglement is nothing more than a physical description of concepts! If so, when researchers think that they are measuring the quantum state of an electron outside their heads, they are actually measuring the quantum state of their concept of the electron inside their heads. Such research could yield the first artificial consciousness, and nicely explains the Observer Paradox (footnote 64). For instance, MWI (many worlds interpretation), while useless for describing a comprehensible universe (see footnotes 41 & 89), describes perfectly the manifold power of the imagination to create many worlds.

⁵²DELTA-V is a mathematical shorthand for change in velocity, symbolized as Δv and pronounced *delta-vee*. It is often measured in kilometers per second. For rockets, a delta-v is defined by the rocket equation (see footnote 11 and 63), which every aerospace engineer had to memorize in my day. It was used to construct the game's Fuel track, and its notable feature is that less and less fuel is needed for a given velocity change as the rocket becomes lighter due to fuel consumption.

D5. Move Radio, Wisp, & Starship Phase

Move all *radio signal domes* towards Sol by 12 spaces, and all Wisps to arrive at a destination within 10 spaces. Then the Commander must move the Starship a number of spaces equal to its speed.⁵³ At any intersection, the Commander immediately decides which direction to go (but not back the way you came). Perform in this order:

- Earthbound Radio Signal.** In Pulse Order, each dome placed on the map per **G1e** must move 12 spaces (half lightspeed) the shortest distance towards Sol.⁵⁴ If your signal reaches Sol, you receive the *broadcast Medallion (B12d)*. Remove your dome from the game and flip your facedown *Earth Data (C4b)* to faceup.
- Wisp.** If this dice is on the map per **E2c**, move it up to 10 spaces (same rules as previous bullet) and then Discard. If it reaches a Star or Sunlens, you may make a single *Exploration (I1)* (sent back by radio).
- Helm Decisions (F2).** These include course, jettison, braking, and alert decisions.
- Ballistic Move.** The Starship must move a number of Spaces equal to its speed. If it entered any events during the flight (next 7 bullets), they are rolled/performed after the Starship has finished its move.
- LIC (Erosion) Entry.** If *Exodus* entered an *LIC (B8a)*, the forward Blueprint is *Lost* per **E4** and an unflipped Nugget (**E3a**) is added to the bow. If a Dustbug was in the space, remove it and negate the LIC.
- Star Entry.** If *Exodus* entered a Star in its flight, its Commander makes an *Exploration (I1)*. If still at the Star, the Commander may also roll for a *fryby (F2d)*. If at speed = 0, *orbital missions (I3)* can be performed, and the Starship may face any direction. See **J1d** if re-entering Sol.
- Sunlens Entry.** If *Exodus* entered a Sunlens, it may roll for an *icebrake (F2c)*.
- Forced Map Exit.** If *Exodus* is at speed 1 or more and entered a space that has an exit arrow pointing to an *off-map star (B8e)*, then she is forced to move off-map and during **Phase D4** the game ends with scoring (**J3**).
- Flare/Debris Hazard Entry.** If *Exodus* entered a space with either the flare or the debris icon, it makes a *Plasma Risk Roll* using row (2), see **H6**.⁵⁵ This roll can be avoided for debris using the *vacuum cleaner rule (D4b)*.
- Amat Jet (Peep) Entry.** If *Exodus* entered a space with the  icon, a single unflipped Nugget is privately revealed to the Commander. This Nugget must be outside the Cosmos and not held by the Commander.⁵⁶
- Final Exodus Facing.** At the end of *Exodus'* move, if she is at an intersection, the Commander points her in the direction that she will go in her next Dozyear. If the speed is > 0, this cannot be the direction she came from.

D6. Attrition & Aging Phase

For each Awake Cyborg, first make an Attrition Roll (only for Cyborgs of Age 5 or more), then advance the Age by 1 step. If newborn, instead move its dice to the Trapezoids. If the Commander dies, hold an immediate *election (F3)*.

- Attrition Roll (Old Cyborgs Only).** Roll 1d6, and the Cyborg survives if it matches one of the survival dice faces depicted for the old Cyborg's *adjusted age*. The adjusted age is the actual Age, plus 1 step for each Stress, to a maximum of 8. The cause of death is cancer for a female, and Alzheimer's for a male.
- Aging** reorients the Cyborg card, and (if advancing to Age 5) flips it to its "old" side. A Cyborg at his/her maximum Age of 8 remains at this Age (there is no Age 9). Note that aging comes *after* attrition!
- Landing Party Aging.** A Pod landing party will not grow older if the planet is Habitable, see **I4f**.

D7. Refresh Phase

During this Phase, Workers are returned, Stress is added for Archenemies, then subtracted for Ideologies that are married or Asleep. Finally, certain Wisdoms are resolved, and the Market is refreshed. Perform in this order:

- All Ideologies Reclaim Their Workers** into their Trapezoids, except for newborns (**D7j**).
- Archenemies.** If two Awake Cyborgs (not newborns) are Archenemies, both add one Stress to their Ideology.
- Bliss Stress Relief.** Each marriage (including a polygamous one) must remove one Stress, but the marital partners must decide between them which one of them gains this benefit. If they disagree, they must either *divorce (F4c)* or each takes a Stress. During exogamy (freedom is in command (**F4b**)), both partners remove a Stress.
- Sleeping Stress Relief.** If an Ideology is Asleep (all Cyborgs are in Jars, newborn, or dead), remove one of its Stress.
- Mimarobe & Scholastic Wisdoms** are performed.
- Refresh Market (close gaps).** If there are any gaps in any Market column, move cards down to fill each gap in its Market column, starting with the lowermost gap.
- Refresh Market (draw cards).** Draw cards from the column's draw deck and fill the column from the lowermost empty gap. This restores the Market so that there are again 3 faceup cards in each column.
- If A Draw Deck Runs Out,** slide the cards to the bottom of the column to leave gap(s).
- Ghost Ship.** If no Ideology is Awake, each Ideology suffers a *glitch (F5b)*.
- Newborns Become Teenagers.** Move all newborn Dice from their Cyborg placard to their Trapezoid. This moves their Avatar Dice to their Jar (since an Ideology is constitutionally limited to one Worker per **A3b**).

⁵³ ACCELERATION. If her engine is ignited, *Exodus* changes speed by the same number of steps as the fuel expended. If her engine is not ignited, she coasts at the same speed she traveled previously.

⁵⁴ SIGNAL SPEED. Why does a Wisp or radio signal move only half lightspeed in the game, when it actually moves close to lightspeed (24 spaces per Dozyear)? This is to account for the round trip, since a response to a signal has to travel back to the starship.

⁵⁵ FLARE STARS, including most red dwarfs, undergo unpredictable dramatic increases in brightness for a few minutes. The flare is across the spectrum, from X-rays to radio waves. In May 2019, the brightest flare ever recorded, at least 100x more than any known event on Sol, was recorded on Proxima Centauri, a red dwarf that pummels its 2 known exoplanets with brief bursts in the millimeter and UV range several times a day.

⁵⁶ AMAT JETS are pulses of antimatter associated with crossing the galactic plane, detectable only with the data-crunching capacities of the game's Avatars.

EXAMPLE [D5a]

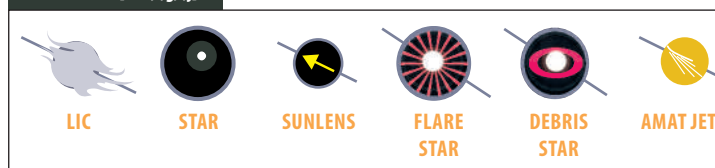
Exodus and your freshly-deployed radio dome are at Sunlens Regulus outside Procyon A/B. The dome moves past Sirius on its first Dozyear. On the third Dozyear, it finally reaches Sol, expending the dome out of the game. You proudly flip your Earth Data faceup on top of your Jar, and it is the Game Stadium. You take the broadcast Medallion (B12d) from the reserves.

Broadcast:
Latest to send
radio signal.

MAP NOTE: A few Sunlens' point at Stars that are off the map, see B8e. A snapshot taken here awards the galactic explorer medallion (I2c), taken from wherever it is. [D5f]

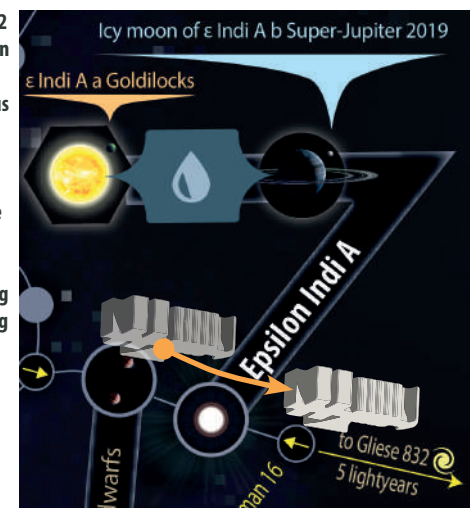
Explorer:
Latest to reveal a
Planet Chit with a
Wisp at a
Sunlens (I2b).

MAP SPACES [D5e,f,g,i,j]



EXAMPLE [D5h]

Exodus, at speed = 2, moves 2 spaces to the Sunlens Luhman 16 as shown (see D5d). To avoid exiting the map, *Exodus* must end her move at speed = 0. So she does a fryby at the gas giant (Super-Jupiter 2019), and an icebrake at the Luhman 16 Sunlens, which slows her down from 2 to 0. Unfortunately fryby lightning destroyed her engine, leaving her adrift in the Oort Cloud of Epsilon Indi A. At a speed of 0, she is able to reverse her facing, allowing the survivors to use the Jars Pod to reach the Epsilon Indi A Goldilocks.

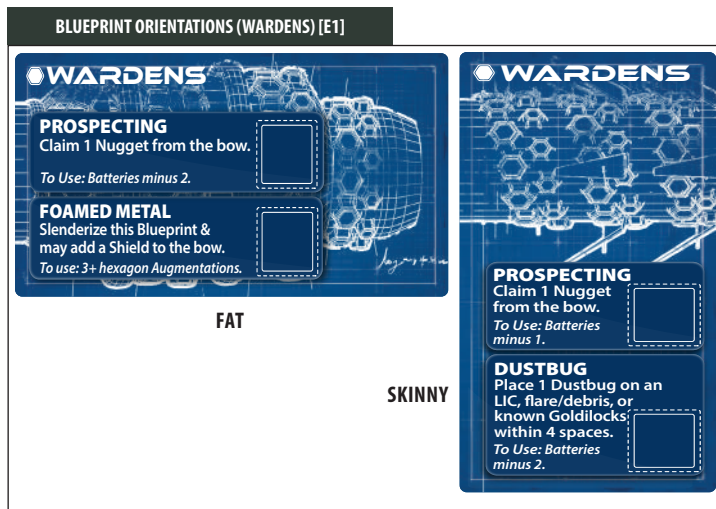


EXAMPLE [D7b]

Both Ideology red and Ideology purple are Awake. Since freedom and authority are Archenemies (since they lie on opposite sides of the Political Hexagon), both these Ideologies gain one Stress at the end of the Dozyear.

EASILY MISSED: If your second Cyborg is dead, so that both are in Soylent Green, you claim the "founder" hero Medallion.

Hero:
Latest to have
2 Cyborgs
dead.



EXAMPLE [E1d]

You assign to the "Utility Fog" Workcell and win as the Chief Engineer. You choose to flip and slenderize the batteries Blueprint, and add a Shield of your color to the bow. There was a yellow Avatar in the batteries, and the Commander reassigns it into the Wisp Maintenance Cell in life-support.

EASILY MISSED: Exodus starts with no Shields, but can have as many as 5 if all 5 Blueprints are slenderized. [E1d]

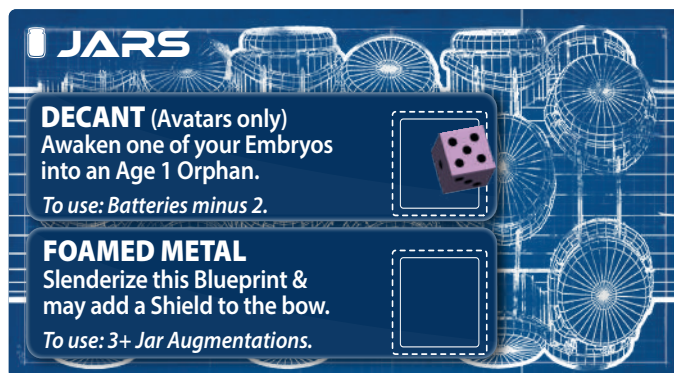


HISTORICAL NOTE: Dustbugs got their name from the Project Daedalus starship study. These support vehicles were designed to maintain an artificial cloud of dust about 200 km ahead of the Starship, which would break up any debris that might be lying in its path. The resulting motes would be small enough to be handled by the ship's beryllium erosion shield.

NOTE: Although a Worker dice is used to represent the Wisp on its travel, it should be understood that the Wisp is under robotic control of the Worker in the mothership, who is not actually riding on it! [E2c]

EXAMPLE [E2e]

You assign your Avatar to the decant Maintenance Cell. Both of your Cyborgs are Asleep, so during Phase D4 you choose one to Awaken.



EASILY MISSED: The number of Cyborg placards in the Jars is strictly limited to 2 per Ideology. This low number reflects the high accumulation of mutations from the high radiation environment. [E2e]

E. Blueprints, Erosion, & Foolhardy Experiments

The Starship layout is represented by up to six rectangular placards called **Blueprints**, representing the Starship's engine, batteries, Jars, life-support, wardens, and Shields. These can be rearranged, jettisoned, Eroded, or eaten by Goo. Their Orientation is either fat or skinny. The Erosion of any Blueprint causes it to be **Lost (E4)**, adding a Nugget.

E1. Blueprint Mass

The structure of *Exodus* is represented by placards called **Blueprints**, which can be Oriented either in fat (landscape) or skinny (portrait) as shown. The fat Orientation has a mass of 2 quaddecatonnes (80 tonnes), and the skinny Orientation has half that, or 1 quaddecatonne (40 tonnes). This is mass 2 or mass 1 in the *High Frontier* scale.

- Starting Blueprints.** The 5 starting placards begin Oriented on their fat side so as to completely fill the blueprint track, which proudly depicts a picture of *Exodus*. From stern to bow, the placards are engine, batteries, Jars, life-support, wardens, and (if produced) one or more Shields.
- Starship Dry Mass** is indicated by the number of tonnes visible above the rightmost Blueprint. The starting dry mass is 400 tonnes. If the "When first visible: ..." notice becomes visible for the first time (e.g. at dry mass = 200 tonnes), the Commander chooses to move either the speed cylinder or the Starship by one step (**E4a**).
- Slenderize Procedure.** A Blueprint may be "made skinny" by the Chief Engineer, either in a Maintenance Task (**E2m**) or by a "slenderize" success impact on a Workcell. A slenderized Blueprint is flipped and rotated by 90°, into the portrait Orientation. If there are Workers still on the fat side who have not yet performed their Task, the Commander must reassign them to a new unoccupied Maintenance Task, including on the newly slenderized Blueprint. Then slide all of the Blueprint placards to the stern, so that all gaps between them are filled.
- Optional Shield.** The Chief Engineer of a slenderize chooses whether to use the mass saved to build a Shield:
 - Add Shield.** Place a Shield (of any available color he/she chooses) in the **bow** (to the right).
 - Don't Add Shield.** This lightens the Starship per **E4a**.

E2. Maintenance Cells & Tasks

Each Blueprint has 2 Maintenance Cells on its skinny side and (except for Shields) 2 more on its fat side. Only one Worker can be assigned to each Maintenance Cell. During **Phase D4**, the Commander determines the order that Maintenance Cells are resolved. This may mean that some Tasks cannot be completed because of battery drainage. The Maintenance Tasks are:

- Prospecting (fat & skinny warden).** Claim a Nugget in the bow, placed into your Playmat.
 - Requirements.** Discharge the batteries by 2 steps (fat side), or 0 steps (skinny side).
- Dustbug (skinny warden).** Place one Dustbug (taken from anywhere) on an LIC (**D5e**), flare/debris (**H6g**), or an uninhabited Goldilocks planet per **14h** within 4 spaces.⁵⁷ For its effects, see "Dustbug" (glossary).
 - Requirements.** Discharge the batteries by 1 step.
- Wisp (fat & skinny life-support).** Place this Worker as a Wisp at *Exodus'* location. It will move during **Phase D5**.⁵⁸
 - Requirements.** Discharge the batteries by 3 steps (fat side) or 1 step (skinny side).
- Outbreak (skinny life-support).** A *Goo outbreak (H1i)* occurs in a Blueprint of your choice. The Goo shape must match that of the Blueprint. Starting next Dozyear, Goo fight assignments and Goo Rolls are made.
- Decant (fat & skinny Jars).** Awaken an Age 1 Embryo of your color in the Jars, and place it into your Playmat, *trashing (B6b)* any Workcell(s) in the Slot to make room if necessary.
 - Avatars Only.** Since you are limited to one Awake Cyborg, decanting can only be performed by your Avatar.
 - Orphan Chit.** Place an *Orphan Chit (B14c)* on the Cyborg placard as a reminder that a child thawed as a frozen Embryo is raised without parental care, and thus will not have Wisdom in its old age.⁵⁹
 - Large Dice of the Ideological Color** is placed on the Age 1 icon of the Cyborg placard as a reminder that the infant cannot be assigned and does not Age until the next Dozyear. Retire your Avatar to your Trapezoid.
 - Requirements.** Discharge the batteries by 2 steps (fat side), or 1 step (skinny side).
- Jars Pod (skinny Jars).** *Jettison (E4)* the Jars Blueprint together with its Embryos and Cyborgs on Jars Slots and Workcells. Make a Plasma Risk Roll (**H6f**). The survivors must land at a Star no more than 4 spaces ahead.
 - Requirements.** Expend 2 steps of Fuel, which does not change the Starship's speed.
- MHD Recharge (fat & skinny batteries).** Set the *charge dice (B4e)* to full (6).
 - Requirements (fat only).** This Task cannot be completed unless the engine is **ignited** (i.e. with a Worker in the Ignition Cell, along with fuel expended and a Starship speed change).
- Dropstone (skinny batteries).** Increase *hydration (I5a)* of the Goldilocks by one ♀ (Terraforming).
 - Requirements.** In Goldilocks Orbit with engine ignited, spending 1 Fuel step but not changing the speed.

⁵⁷DUSTBUGS are support vehicles that fly 200 km ahead of the starship, and eject a cloud of particles to disperse larger impact threats that are detected in the LIC. Dustbugs are a design feature of Project Daedalus. —A Bond & A Martin, *Project Daedalus - The Final Report on the BIS Starship Study*, 1978.

⁵⁸A WISP is a tiny space probe composed of a mesh of carbon wires spaced 3 millimeters apart. Computer circuitry, sensors, and radio transmitters and receivers are built into the wires themselves. The mesh is then pushed by a microwave beam with a 3mm wavelength. With an absorptivity of 10%, its operating temperature is above 3000K. Its low mass, less than 2 kilograms, allows it to be accelerated to a significant fraction of the speed of light. A laser beam is used to transmit energy to the probe when it nears its destination, so it can operate its sensors and transmitters. The probe is not designed to decelerate as it passes its target star. —Robert L. Forward, *Roundtrip interstellar travel using laser-pushed light-sails*, 1984. —James Benford, *Starship sails propelled by cost-optimized directed energy*, 2011.

⁵⁹GRANDPARENTAL ATTACHMENT in humans is a universally found psychological disposition that promotes care and other investments in grandchildren. This may be the origins for the uniquely human capacity for understanding others. —Sarah Hrdy, *Mothers and others*, 2009.

- i. **Ignition (fat & skinny engine).** A Worker in this Maintenance Cell means the engine is **ignited** if there is at least 1 step of Fuel, and, per **D4b**, the batteries can be discharged by 2 steps if fat, or 1 step if skinny. Unless the ignition is for dropstones or Jar Pods, Ignition changes the Starship's speed by 1 step (the Commander decides if faster or slower). Finally, all Awake Ideologies gain one Stress due to engine radiation.⁶⁰
- **Requirements.** *Exodus* must expend 1 step of Fuel. Additionally, unless the batteries have sufficient charge, a Worker must be assigned to *MHD recharge* (**E2g**).
 - **Double Delta-V.** If the Fuel level is 65 tanks or less, after discharging the batteries, ignition may optionally expend 2 steps of Fuel (instead of one) and change the speed by 2 steps.
- j. **Aerogel Refuel (skinny engine).** Plus 1 Fuel step if orbiting a Star with a gas giant.⁶¹
- k. **Jettison (Shields).** With permission, this lightens the ship by moving a Shield to the player's Playmat.
- l. **EM Shields (Shields).** Add 1 to all Plasma Risk Rolls this Dozyear. These modifications are cumulative.
- **Requirements.** Discharge the batteries by 4 steps.
- m. **Foamed Metal (found on all 5 fat Blueprints).** Assigning to a "Foamed Metal" Maintenance Task *slenderizes* (**E1c**) its Blueprint and optionally adds a Shield (of any color you choose) to the bow.
- **Requirements.** At least 3 Augmentations of the Blueprint shape must exist, combining all Ideologies.

E3. Erosion & Nuggets

The flight of *Exodus* through an LIC space erodes mass from its bow, causing Blueprint Loss replaced by stable grains of exotic matter called **Nuggets**. Erosion of the bow (or a random Blueprint, in the case of lightning) also happens in *Plasma Risk Rolls* (**H6a**), such as extreme aerobraking (icebraking or fryby braking).

- a. **Nuggets.** If *Exodus* enters an LIC, Discard the front Blueprint and replace it with one Nugget from the Cosmos (if any). See **E4** for the effects of a Lost Blueprint. All Nuggets end up in the **bow** (ahead of the front surviving Blueprint), and remain unflipped (facedown). Once flipped, they stay faceup permanently.
- b. **Collecting Nuggets.** You move a Nugget to your Playmat (and Peep at it) by assigning to the *prospect* (**E2a**) Maintenance Cell, or by becoming Chief Engineer on the "Cthulhu-bot" Workcell (in batteries deck).

E4. Lost/Jettisoned Blueprint & Busting

A Blueprint is **Lost** during a *Jars Pod* (**E2f**), **jettison** (certain Maintenance & Workcells), *Goo eating* (**H4a**), or *braking erosion* (**H6a**). A Blueprint is also Lost (but replaced by a Nugget) if eroded by *entering LIC* (**D5e**) or *lightning* (**H6b**).⁶² A Lost Blueprint affects the following areas:

- a. **Map Blueprints.** Discard the Lost Blueprint, along with any chits, dice, or Tokens on them. Then remove gaps by sliding the Blueprints towards the stern.
- **Lost/Jettisoned Shields.** Use the Shield placard to Bust the right Slot of the Ideology whose color matches the Shield Lost. Discard any cards there per **B6e** unless they can use *Commander Rescue* (below). If the Shield was Eroded, the owner gains a *savior Medallion* per **B12c**.
 - **Nuggets.** If the bow Blueprint is Lost, move any Nuggets to just ahead of the next Blueprint in line.
 - **Decreased Dry Mass.** After adding any Shields, check if a "When first visible: either change speed cylinder 1 step or move Starship 1 space" is made visible. If so, right after Starship movement the Commander optionally chooses to either change the speed by 1, or move the Starship by 1 space (forwards or backwards, without changing facing) per **D5c-k**. This does not count as engine ignition.
- b. **Lost Market.** Discard the entire Market column and draw deck of that shape out of the game.
- c. **Lost Workcells.** Discard all Workcells and Agenda Cards with a *Workcell Blueprint* (**B2b**) of a Lost Blueprint. This Kills any Workers and Discards any Workcells.
- **Commander Rescue.** However, if the Blueprint is Lost by Shield Erosion or jettison, the Commander may choose to rescue Cyborgs in the affected Slots by moving them to another Slot in the same Playmat. The rescued Cyborgs can't refuse, and must *trash* Workcells if necessary (**B6b**).

❗ **EASILY MISSED:** MHD Recharge is comparable to latrine duty - a Task vital to the mission that nobody wants to do. Remember that MHD (an abbreviation for magnetohydrodynamics, the science of turning rocket exhaust into electricity) can only be done with the engine running. The advantage of a Commander with the pawn regulation is that he/she can ensure that the dirty job gets done. [E2g]

❗ **EASILY MISSED:** In order for the engine to be ignited, a Worker must be in Ignition, and one step of fuel plus 2 steps of battery charge must be expended at some point in Phase D4. If the batteries are skinny, only 1 instead of 2 steps of battery charge need to be expended. Ignition means that the Starship must change speed by one step. Engine ignition is required in order to perform the MHD recharge Task. [E2i]

EXAMPLE [E2]

All Blueprints are at their starting (fat) Orientation. Workers are assigned to the engine, Wisp, prospecting, and recharge Cells. In order for MHD recharge to work, the engines must discharge 2 steps at some point, and the Commander chooses this first. The Commander then chooses prospecting, then Wisp, after which the batteries are down to 1 (empty). The final maintenance is MHD recharge, which restores the batteries since the engine is ignited.

❗ **TIP:** If you know the hidden status of a Nugget, you cannot show it to others, but you can tell others, with the possibility of lying. If you lie, this may help you gain a surprise victory as the Posthuman Ideology or competitive game-winner. But it might discredit you in future games! [E3b]

EXAMPLE [E3b]

Exodus, at a speed of 4, flies through 2 LIC spaces. For the first space, the wardens Blueprint is Lost, replaced in the bow by a Nugget. For the second, the Jars Blueprint is Lost, placing a second Nugget in the bow. In the next Dozyear, several Avatars and Cyborgs are assigned to Cthulhu-bot in the Playmat of Ideology white. Two of them are successful, so Ideology white decides which one claims one of the Nuggets.

EXAMPLE [E4a]

Exodus flies through two LIC, and loses, by Erosion, two fat Blueprints (wardens and life-support). Erosion drops her dry mass to 240 tonnes. Later, her engine is slenderized, and the Chief Engineer decides not to install a Shield. Since *Exodus* became lighter than the "when first visible" threshold at 200 tonnes, the Commander is able to change speed by one step lower. Note that the lost dry mass does not actually increase speed, it merely increases the efficiency at which the remaining Fuel operates (see footnote 63).

EXAMPLE [E4b]

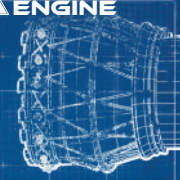
Exodus flies into an LIC, which Erodes the forward purple Shield. This moves the Shield to the rightmost Slot of Ideology purple. Ideology purple is awarded a savior Medallion (B12c). Long the Bully is in this Slot, and the Commander decides to rescue him. Ideology purple is forced to trash two Workcells in his middle Slot so that Long has living space.

⁶⁰ENGINE RADIATION. The helium-3 + deuterium fusion reaction produces energetic charged particles, which are easily magnetically focused for thrust without producing destructive radiation. This feature is the primary reason for this fuel choice. Unfortunately, in the chaos of a plasma containing both helium and deuterium, sometimes deuterium will encounter another deuterium, in an unwanted D-D side reaction that releases neutrons. Furthermore, electrons in the plasma produce Bremsstrahlung radiation, which is released in the form of X-rays. The combination of neutrons and X-rays contribute to the accelerated aging for the beings on-board. They require opposite types of shielding: X-rays easily penetrate low-Z materials (which lack the large electron clouds), while neutrons easily penetrate high-Z materials (in which the nuclei are widely spaced by their electron clouds). Shielding any significant part of this radiation would add prohibitive mass to the vessel, so the starship must instead be designed so that most of the radiation escapes directly into space. —Robert Swinney, *Interstellar Mission Concepts - the sons of Daedalus*, 2018.

⁶¹AEROGEL is mostly gas, weighs next to nothing, and vaporizes particles/small meteors upon contact. These qualities allow it to capture and refine the ejected material from a world rich in hydrogen and helium isotopes.

⁶²LIC EROSION. The entire map is within the local bubble, a relatively sparsely populated region of space, about 130 lightyears in diameter, swept clean by an ancient supernova. The local bubble is hot, a million degrees K, and the particles are plasma. The ship's EM shield deflects such charged particles and also protect against plasma blobs such as Coronal Mass Ejections (CMEs). However, the LIC is full of neutral dust which passes straight through the EM shield, and the ship (especially the radiators) must be protected by physical shielding of beryllium augmented by layers of c-nanotube composite. This will vaporize the ablative C60 into plasma, to be deflected by the protective EM field. Larger obstacles must be dealt with by Dustbugs (shield vehicles) and ionizing bow lasers.

ENGINE



IGNITION
Burn 1 fuel & change speed 1 step.

To Use: Fuel minus 1, Batteries minus 1, +1 Stress to each Awake Ideology.

AEROGEL REFUEL
+1 Fuel if orbiting a Star with a gas giant.

BATTERIES



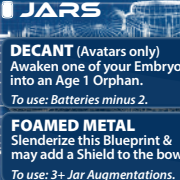
MHD RECHARGE
Advance the charge dice to 6.

To use: Worker assigned to Ignition, fuel >0.

DROPTONE
Increase hydration of the Goldilocks by 1.

To use: In Goldilocks Orbit, Fuel minus 1 step.

JARS



DECANT (Avatars only)
Awaken one of your Embryos into an Age 1 Orphan.

To use: Batteries minus 2.

FOAMED METAL
Slenderize this Blueprint & may add a Shield to the bow.

To use: 3+ Jar Augmentations.

EXAMPLE [E4c]

A Starship that has lost its first 2 Blueprints, but has slenderized its engines and batteries. Its dry mass is 160 tonnes.

➊ **EASILY MISUNDERSTOOD:** Each Ideology starts with their Shield Slot Busted by the presence of their Shield placard. What does this represent? This means that an Ideology starts with 2 Slots (at 12 tonnes mass allowance per Slot). They can increase their legal mass allowance to 3 Slots by moving their Shield to the bow after a slenderize. This simulates that they, by clever engineering, made the starship lighter, and are constitutionally entitled to make use of the mass savings to make more room. [E4a]

EASILY MISSED: If a Jars Pod is launched to a planet, any Cyborgs on Jars Workcells travel with it. Remember the Slim Pickens death scene in "Dr. Strangelove"? [E4e]

➊ **EASILY MISSED:** Anything that removes or slenderizes a Blueprint, without adding a Shield, "shortens" the Starship, representing a loss of dry mass. This can happen during LIC Erosion, braking erosion, Goo spread, or lightning. The Commander may then choose to change either speed or position. If this occurs while the Starship is moving, the change happens right after movement is finished. If the position is changed, interrupt the game to perform any effects of the new position, such as LIC, Risk Rolls, Exploration, etc. [E4a, E5a]

🔴 **EASILY MISSED:** In order to perform a Foolhardy Experiment such as "Cosm," there must be at least 1 unflipped Nugget outside the Cosmos. A successful Workcell Roll on a Foolhardy Experiment flips faceup every Nugget outside the Cosmos. Since flipping is permanent, at most there can be 3 successful Foolhardy Experiments in a game. If there are no unflipped Nuggets outside the Cosmos, Workers assigned to a Foolhardy Experiment cannot make a Workcell Roll. [E6]

The diamond "To Research" Icon indicates that this is a Foolhardy Experiment.

It needs an unflipped Nugget to make a Workcell Roll. [B2c]

Rolling a "6" in a Workcell Roll here is fatal. [B2c]

If the flipped Nuggets are mainly X, this is the success impact. [E6a]

If the flipped Nuggets are mainly O, this is the success impact. [E6b]

If the flipped Nuggets indicate no majority, a Posthuman is created. [E6c]


**Cosm
SELFISH**

To Research or Workcell Roll:







WORKCELL

X = You become Commander & steal one Medallion.

O = Steal one Nugget from another player; Flip to Competitive Endgame (king).

x o
3 2

A quark-gluon plasma wormhole, held open by negative-energy density, hypothetically leads into a new universe. Inspired by the Gregory Benford sci-fi novel.

ISE06

EASILY MISSED: After you succeed in a Foolhardy Experiment in one Dozyear, you may try for another Foolhardy Experiment in the same or subsequent Dozyears, as long as there are unflipped Nuggets outside the Cosmos. [E6]

TIP: Once the learning chit is flipped to its "redeye" side, thematically HAL monopolizes the evaluation of success and failure. Avatars become a primary means of earning victory points, with Humans only useful for research or avoiding ghost ship glitches. [E6d]



d. Playmat Slot Busting. If the Jars are Lost, this Busts the left Slot of every Playmat. If life-support is Lost, this Busts the middle Slot of every Playmat. Indicate Busting by placing a red disk in the Slot. If a Shield is Eroded, this Busts the right Slot of the Playmat of the same color, indicated by placing the Shield in the Slot.

- **Busting.** This Kills Workers and Discards Workcells, unless *Commander Rescue* is used (per previous bullet).

e. Lost Jars Placard. If the Jars are Lost, all Embryos, radio signal domes, and facedown Earth Data cards are Discarded into Soylent Green. Faceup Earth Data continue to be available for all players.

- **Jars Pod (E2f).** Embryos and Cyborgs on Jars Workcells are not Killed if they land safely on a planet.

E5. Blueprint Slenderizing & Unbusting

Several Workcells make a fat Blueprint skinny. This frees up half its mass, and the mass thus saved is, optionally, used to create a Shield. The *Chief Engineer (H1f)* who makes a Blueprint skinny chooses which color Shield to add, which moves it from that Playmat to the bow (in front of the other Blueprints). This **unbusts** that Shield Slot.

a. Decreased Dry Mass. Slenderizing without adding a Shield can change speed or position per **E4a**.⁶³

E6. Successful Foolhardy Experiments

A Workcell Card with a *Nugget* "To Research" (**B2c**) is called a **Foolhardy Experiment**. In order to either research or attempt a Workcell Roll on a Foolhardy Experiment, there must be at least one unflipped Nugget existing outside the Cosmos. If the Workcell Roll succeeds, all the Nuggets outside the Cosmos (i.e. in any Playmat or in the Starship's bow) are permanently flipped to reveal either an **X** or an **O**. The results of Foolhardy Experiments cannot be negated by the Chief Engineer. Flipping one or more Nuggets yields three possible outcomes: more **X** than **O**, more **O** than **X**, or equal numbers of **X** and **O**:

a. The Majority of Flipped Nuggets are X. The experiment indicates a subjective Reality and enacts the “**X** =” outcome on the Workcell. Possible **X** outcomes include: create a Posthuman, create a Bussard Ramjet,⁶⁴ or change the *Exodus*’ speed up to 3 steps. See glossary for details on capitalized terms.

b. The Majority of Flipped Nuggets are O. This outcome is specified on the Workcell as “**O**=”. Possible **O** outcomes include: Blueprint Restoration, exchange Blueprints for Fuel, flip faceup all *Earth Data* (**C4b**), Domesticate all Goo, Hermaphroditism, resurrect a dead Cyborg, or slenderize a fat Blueprint.⁶⁵

c. Posthuman if Neither X nor O are in the Majority. If the only two faceup Nuggets are an **X** and an **O**, and no Posthuman yet exists, then the results listed on the card are ignored but the Chief Engineer becomes irreversibly Posthuman (see glossary).⁶⁶ Furthermore, the *endgame chit* (**B14b**) is flipped to its "Competitive" (king) side, indicating that the endgame will be Competitive (**J3**).

d. Flip Learning Chit. If the results of a Foolhardy Experiment indicate to flip the *learning chit* (**B14a**), then flip this chit to its “redeye” side (if not already), meaning machine learning (ML) of Avatars has surpassed Human inductive logic.⁶⁷ Subsequent successful Workcell Rolls will yield an *Augmentation reward* (**H1g**) to all participating Avatars instead of Cyborgs. Avatar success or failure follows the initial *funding*, either isotope or übermensch (**C5a**).⁶⁸

63 DRY MASS VS. DELTA-V. A rocket's change in velocity, known as **delta-v** (footnote 52), is equal to (rocket exit velocity) times the natural log of (Wet Mass/Dry Mass). Assume **Exodus** has 6 tanks (240 t) of Fuel remaining. With an exit velocity = 24,000 km/sec, a dry mass = 400 t, and a wet mass = dry mass + tonnes of Fuel, the result is: Delta-v = $24000 \ln((400 + 240)/400) = 11280$ km/sec, or 4% c. If the dry mass is slashed to 180 t, the new delta-v = $24000 \ln((180 + 240)/180) = 20335$ km/sec, or 8% c. Losing dry mass is the equivalent of gaining one speed step!

64 OBSERVER PARADOX. One class of quantum objects drastically changes properties just by being observed by a human. If unobserved it is a wave, but if observed it appears to be a particle. It is well known that this observation is accurately and reproducibly described by the mathematics of quantum mechanics. Not so well advertised is that this mathematics gives no hint whether it is describing what is being observed, or the observer. Consider the twin slit experiment, in which electrons fly through two slits, either with interference (if unobserved) or without (if observed). This has two interpretations: **supernatural** and **natural**. In the former, the electron flies in an indeterminate (supernatural) state, and "collapses its probability wave" only if a conscious observer watches it. This fanciful interpretation violates the Laws of Identity and Causality (footnote 89), two fundamental premises needed for science and Natural Laws to work. In the natural interpretation, the illusion of a collapse is caused by the fact that the observed electron is not an objective object, but rather the subjective concept of an electron as formulated by the human observer. If you stargaze, either with your eyes or a telescope, you may notice a rainbow pattern about the star. Early astronomers were fooled into thinking this was a feature of the star, but we now know that chromatic aberration is a feature of the lens, not the star. The same confusion occurs if observing light going through two slits. The data compression software that all animal brains use to interpret what is seen has been fine-tuned by natural selection in the macroscopic world, ending up with algorithms that resemble Newton's Laws. Thus the natural interpretation, equally supported by the mathematics, is that light appears to be a particle only as an artifact of our mental software (footnote 51). If this interpretation is correct, useful devices using superposition, duality, entanglement, or other Observer Paradoxes will never work.

65 BELL INEQUALITY notes that observation of one half of a quantum entangled pair constrains the observation of the other half, even if the two are greatly separated. This is an Observer Paradox (previous footnote) and again there are objective and subjective interpretations. Physicist John Stewart Bell interpreted the observed violation of this inequality as a non-local feature of quantum particles that transfers superluminal information in violation of the Law of Causality, what Einstein called a "spooky action at a distance". The alternative subjective interpretation notes that there is a local feature, namely the consciousness of the observer who evaluates the two halves. The effect is no less real, but measures the physical manifestation of a concept, the units that comprise consciousness and are responsible for its "free will" and "statistical independence" properties. This interpretation explains how a human can become entangled by merely reading a message about an entangled object. The proper interpretation will determine whether useful entanglement devices (e.g. superdense coding or quantum teleportation) will ever be realized.

66 POSTHUMANS are human-derived beings whose basic capacities that radically exceed those of present humans as a result of emergent cybernetic technology. Transhumans are intermediate between Humans and Posthumans. See footnote 51.

67 MACHINE LEARNING. Although progress is scant towards artificial consciousness, ML (machine learning) for specific well-defined fields has progressed beyond human capacities. Machines can avoid human biases such as seeing patterns where there aren't any, giving undue weight to more recent events, and confusing chronological order with causation. But in the frontiers of technology and knowledge, humans still outperform algorithms on general pattern recognition and especially inductive logic. Humans think in abstractions.

68 **2001 A SPACE ODYSSEY** This 1968 film, directed by Stanley Kubrick with screenplay written by Kubrick and Arthur C. Clarke, inspired the "redeye" learning chit. This transcendental film has refused to show its age for the last half century. Kubrick also directed "Dr. Strangelove."

F. Political Hexagon

This diagram is found on the map. It contains a sector for each Ideology, linked ring icons, Regulations icons, and star-shaped spaces where the star token is placed to indicate who is in command. The outer perimeter contains the 6 **Trapezoids** (see glossary).

F1. Commander’s Regulations

As listed on the Political Hexagon, each Ideological Commander can enforce certain **Regulations** to reassign Workers or seize Nuggets during **Phase D2**. The list of Regulations plus their Ideologies are below:

- a. State Security (Equality, Authority, Unity):** The Commander, without a Nugget, may confiscate one from another Playmat.
- b. Arranged Marriage (Authority Commander Only):** The Commander may force a marriage (F4) or divorce.
- c. Carrot (Individuality, Equality, Authority):** The Commander may reassign any number of Workers assigned to a Workcell *subtitled* as "selfish" to any other Cell. See **B2a** for details on subtitles.
- d. Pawn (Honor, Unity, Authority):** The Commander may reassign a Worker assigned to any Cell to a Foolhardy Experiment, Maintenance Cell (if the Task is possible), or to a Goo Cell.



F2. Helm Decisions

During **Phase D5**, the Commander makes all decisions and makes Plasma Risk Rolls regarding the flightpath while moving *Exodus* (see **D5d**). Helm decisions are:

- a. Eradicate/Domesticate Decision.** Set the *alert cylinder* (C5b) to either **red alert** (eradication) or **yellow alert** (domestication). This is important for any Goo fights (H3) next Dozyear.
- b. Flare/Debris Hazard Entry.** If *Exodus* enters or ends a move on one of these icons during a move, make a *Plasma Risk Roll*, using row (2), see **H6**. Make the roll immediately after finishing the move.
- c. Oort Icebraking Decision (batteries discharged one).** If *Exodus* enters or ends a move on a *Sunlens* (B8a), the Commander may decelerate by 1 step by discharging the batteries by 1 step and rolling a *Plasma Risk*, using row (3), see **H6**.⁶⁹ Make the roll immediately after the move.
- d. Fryby Decision (batteries discharged one).** If *Exodus* enters or ends a move on a Substar (i.e. gas giant, white dwarf, or brown dwarf), the Commander may discharge the batteries by 1 step and dive into it to decelerate by 1 step.⁷⁰ Immediately after the move, roll a *Plasma Risk* using row (4), see **H6**.⁷¹
- e. Post Icebraking/Fryby Movement.** After a braking maneuver (previous 2 bullets), *Exodus* must continue to move a number of spaces equal to her original speed.⁷²
- f. Intersections.** If entering an intersection, the Commander decides the path and *final facing* (D5k),

⁶⁹ICEBRAKING. To decelerate, a starship can be steered toward vast icefields in the Oort cloud, to be vaporized by the ship's engine or lasers, then the steam is ionized by specially tuned lasers. A Mag Sail - a loop of superconducting cable kilometers in diameter - is deployed, and its milliTesla B field deflects the ions for a braking force over a distance of many AU. Neutral atoms or molecules will not be deflected and become a radiation hazard similar to cosmic rays, and larger particles, even if ionized, will not be deflected by practical field strengths. —Dana Andrews, *Interstellar Propulsion Opportunities Using Near-Term Technologies*, 2003.

⁷⁰FROSTLINE PLANETOID. Beyond a certain distance from a star, water can take on an entirely different form than the crystalline form we are used to on Earth. This distance is called the frostline, and beyond the frostline there are several forms that water can take. The most common is low density amorphous water (ASW), which forms around seeds of very cold dust, and can maintain its liquid form at temperatures between 140 and 210K. It is more viscous than normal liquid water, and is thought to explode (iceflash) if exposed to seed crystals of normal ice. Water rapidly cooled (over 10,000K/sec) below 77K forms hyperquenched glassy water, a quasi-stable form that can be stored for years. High density amorphous ice is formed by squeezing normal ice to 16,000 atm at temperatures under 77K. Even if the pressure is restored to ambient, it retains its high density form (1.17 g/cm³). This type of ice can form at temperatures of 30K but low pressure on seeds of interstellar grains, of interest to the panspermia theory. An even higher density form (1.26 g/cm³) is called very-high density amorphous ice. ASW and other forms of water are present in an unstable frostline planetoid, which can be detonated by the ship's wisp lasers or engine exhaust. This triggers runaway recrystallization, called "iceflash." If this vaporized ice is efficiently laser-ionized, starship can use it to brake and change course by its reaction upon the ship's EM shield.

⁷¹FRYBY. If a starship needs to slow down without expending fuel or reaction mass, it can use the frictional drag from first a brief pass through a stellar chromosphere followed by multiple passes in a highly eccentric orbit through the atmosphere of a substar. Because things very quickly get white hot, this is called fryby aerobraking. If the deceleration is 10 gees, the total aerobrake time is at least 16 hours and aerobrake distance is 6000 km. To avoid melting the whole ship, the heat load would need to be distributed over multiple orbits which dip into the atmosphere at periaapsis, which would take years. The initial pass would be through the star's chromosphere, then a substar's atmosphere, using an enhanced Mag Sail/EM shield to create drag with the plasma. Everything would have to be bolted down and submerged in the Jars to survive the 10 gees.

⁷²OBERTH MANEUVERS are a significant thrust-multiplying effect only for rockets of high thrust in steep gravity wells. They are not so useful for interstellar journeys, for which most of the trip traverses a flat gravitational landscape. If a starship heads directly for a star, the star's gravity will have a "reel in" effect for only the last month or so of the approach. This is not useful for stellar capture, and is lost upon exiting the system. But the Oberth thrust multiplication at the closest approach to the star is useful for course changes. The orbital velocity of a star around the center of the galaxy (230 km/sec in the case of Sol) may be exploited in a stellar Oberth flyby, if it differs from the velocity of the destination.

EXAMPLE [F1c]

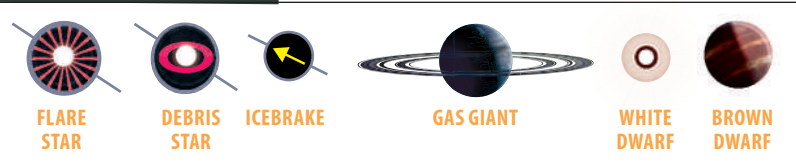
This shows the gray sector of the Political Hexagon. The individuality Commander assigns her Cyborg to research the "Pleasure Gardens" (a selfish card) during Phase D1. Then, using the carrot regulation, the Commander orders herself reassigned to fight Goo during Phase D2.



EXAMPLE [F1d]

The honor Commander (Ideology white) intends for a powered deceleration at the target Star, plus a battery recharge to ensure enough power for decanting. However, tired of being pressured to do the grunt work, the last 2 Workers to assign (Ideologies green & purple) assign to Tasks that may earn them Medallions and Augmentations. The Commander uses the pawn Regulation to reassign these 2 Workers, one to the Ignition Cell, and the other to recharge.

HELM DECISION & FRYBY SPACES [F2b,c,d]



EXAMPLE [F2e]

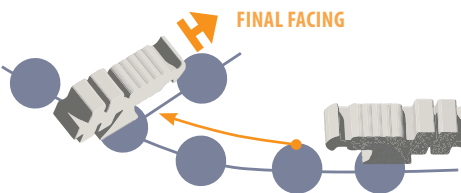
On its approach to Alpha Centauri, Exodus is traveling at speed = 2, moving first to Sunlens Luhman 16 and then to Proxima Centauri. She has Lost her engine to Goo, so her Commander orders an Oort icebrake at the Sunlens, which discharges batteries by 1 and adjusts her speed token to 1. Two risk rolls are made, first for the icebrake and then for the flare star. The icebrake risk roll is a "2," which Kills the Commander and first mate (in retrospect, ramming vaporized ice worlds with unknown cores at 24 thousand km/sec was not a good idea). The flare risk roll of "4" destroys all 4 sensitive Workcells in the Playmats of all Ideologies. There is no Substar at Proxima so no fryby by autopilot (F5a) is possible. In the next Dozyear, a new Cyborg (Hanno) is decanted and thrown behind the wheel as soon as he is old enough to fly a starship. Exodus is now at Alpha Centauri, which Hanno observes to have a Habitable Goldilocks, but is traveling too fast to go into Orbit. In the next Dozyear, Hanno is now 30. Entering the Oort Cloud at Sunlens Ran, Hanno performs an icebrake to slow Exodus to speed = 0. The risk roll is "2," which kills Hanno and Erodes the wardens away. What is left of Exodus stops at Sunlens Ran. In the final Dozyear, Avatars under ghost ship command jettison the life-support Blueprint, in order to move Exodus into Orbit around Alpha Centauri. Survivors in the Jars make Arrival at the planet.



This shows the derelict ghost ship after it launches the Jars.

EXAMPLE [F2f]

The Starship moves 3 and ends its move on an intersection. The Commander decides to face it to the right.



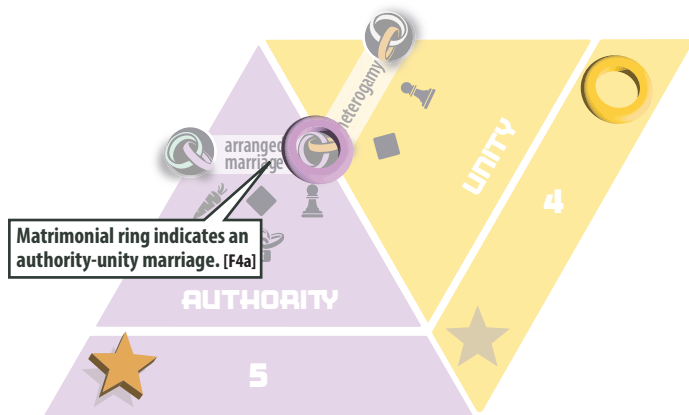
EASILY MISSED: You are not allowed to swap or donate Workcells or Tokens between Playmats (e.g. as part of negotiations during an election). [F3]

EXAMPLE [F3]

In a 3-player game, Commander Long (authority) is in command, and Arduinna (honor) and Siddhartha (unity) are also Awake. Long enforces state security in an attempt to seize a Nugget from Arduinna (honor). Arduinna protests, suffering one Stress, and an election is held. The authority-equality player has no Medallions, but does have the Commander's star. The other two players have one Medallion each. During finger-pointing, each player pointed to themselves, resulting in a 3-way tie with Long, Siddhartha, and Arduinna each getting one vote. Arduinna has the lowest Pulse Order Number (3), and so she becomes the Commander.

EXAMPLE [F4b]

Commander Long is married to Siddhartha and uses state security to confiscate a Nugget from Arduinna. Arduinna protests, and in the subsequent mutiny and election Siddhartha becomes Commander. The couple would normally stay married, but unfortunately the legal marriage is now heterogamy, which bans same-sex marriages. The Long-Siddhartha marriage dissolves, returning the ring to the owner's Trapezoid.



EXAMPLE [F4c]

At the start of the voyage, Commander Long pops the question to First Mate Pachamama, pragmatically pointing out the arduous stresses ahead. But she coyly demurs, knowing that to marry an authority Commander means that she will be forced to abide by all of his Regulations without protest for the rest of her life. So she respectfully declines. During Phase D2, Long, knowing that marriage would strengthen his position as Commander should she or her children ever mutiny, decides to use his arranged marriage Regulation to force her into marriage while she is still childless. It is useless for Pachamama to protest, because she would suffer Stress and still lose the election, since she has no votes and Long has the Commander's star worth 1 vote.

F3. Elections

If the Commander dies or there is a *mutiny* (D2b), interrupt the game to perform an **election** to determine a new one. A candidate can be any Awake Cyborg, and an election is unnecessary if there is but one Awake Cyborg. See F5 if there are no Awake Cyborgs. Every player (not Ideology) has a number of votes equal to the number of *Medallions* (B12) and the *Commander's star* (B1h) on all their Playmats. An election proceeds as follows:

- Initiation.** An election occurs at the end of any Phase in which either the Commander dies or there is a *mutiny*. (D2b).
- Eligible Candidate** is any Ideology with an Awake Cyborg. Each player, whether Awake or Asleep, must give all its votes to a single candidate.
- Finger Pointing Procedure.** The mutineer counts "one-two-three" out loud, whereupon all players (Asleep or Awake) simultaneously point with their finger to the player (including themselves) controlling the candidate they vote for. You may vote for any candidate (you are never forced to vote for yourself or a spouse).
- Tiebreaker.** The player with the most votes chooses the new Commander from among Awake Cyborgs they control. If the vote is tied, the tied candidate with the lowest Pulse Order Number becomes the Commander.
- Commander's Star Transfer.** The new Commander (if any) starts immediately, including deciding on the action that caused the challenge. Move one star to the new Commander's Cyborg, and the other into the Trapezoid of the winning Ideology.
- Commander's Agenda.** If playing with the optional Agenda Cards (see glossary), a new Commander receives the Agenda Card if it is still in the hand of the previous Commander.⁷³
- Democratic Mandate.** As the final step of a successful *mutinous election* (D2b), the new Commander can cancel any Regulations enforced by the previous Commander and enforce any new *Regulations* (F1). Now illegal marriages are *divorced* immediately by F4c. These actions cannot be mutinied.

F4. Marriages

You can propose marriage during the *assignment phase* (Phase D1). A marriage is only possible between two Awake Ideologies whose Ideologies are adjacent on the Political Hexagon. Unless polygamy is legal, an Ideology is allowed to be married to only one adjacent Cyborg partner. Some marriages are forbidden by legal marital practices.

- Popping The Question** (not allowed during polycule). If there is an Awake Ideology adjacent to yours on the Political Hexagon, during **Phase D1** you may propose marriage. Unless this Ideology immediately rejects you, bless this union by placing the *matrimonial ring* (B1i) of your color on the linked ring icon between the two Ideologies.⁷⁴
- Legal Marital Practices.** The Commander sets the standards of new and existing marriages under his/her command. Marriage to more than one partner is only allowed during polygamy, and if polygamy is no longer legal than the Commander chooses which polygamous unions are broken.
 - Polygamy (Individuality).** An Ideology can marry both adjacent partners.⁷⁵ Marriages to Posthumans are legal.
 - Exogamy (Freedom).** *Bliss stress relief* (D7c) is enjoyed by both partners, not just one.⁷⁶
 - Monogamy (Honor).** *Divorce* is not allowed (F4c). Those married to the Commander may not protest Regulations.
 - Heterogamy (Unity).** Same sex marriages are annulled/not allowed.
 - Arranged Marriage (Authority).** Matrimonial rings can be reassigned as a protestable Regulation by the Commander during **Phase D2**. Those married to the Commander may not protest Regulations.
 - Polycule (Equality).** All marriages annulled, but 1 reroll allowed for each *Motherhood Roll* (H5b).⁷⁷
- Divorce.** Divorce is automatic for the following Cyborgs:
 - If Affair.** A Cyborg who is already married who wishes to marry a different Cyborg.
 - If Married to the Commander.** A Cyborg who *protests* a Regulation (D2b). Protests and divorce is not possible in arranged or monogamous marriages.
 - Illicit.** A couple who are in a marriage which is made illegal by a change in command.
- Widow/Widower.** If a married Cyborg dies or divorces, return his/her matrimonial ring back to his/her Trapezoid. However a couple can be still married, with *marital bliss*, even if they live on different planets.

⁷³MISSION DRIFT. The problem of keeping individuals on task towards a desired outcome across multiple generations is faced by the founding fathers of any society. A constitution is one solution, as long as its principles are objectively defensible. Another solution, favored by illuminati-style secret societies, are secret agendas handed down from leader to leader. The secrecy and the Human fascination with the occult give such practices some clout, and may help avoid ennui by providing long-range purpose.

⁷⁴MARRIAGE is a legal contractual partnership between two conscious beings. Among humans and presumably other conscious individuals with sexual reproduction, it is part of the cultural universal, common to all known human cultures worldwide. Persons marry for all kinds of personal, political, religious, or reproductive reasons, but human mate selection is tempered by a half billion years of natural selection driven by the selfish gene, instilling us with a healthy dose of love, sexual attraction and jealousy, and other monogamous emotions. To be productive, a marriage follows the rules of any other voluntary partnership, using the guidance of honesty, freedom, honor, union, authority, and/or equality.

⁷⁵POLYGAMY is a marriage of multiple spouses. It could be a husband married to two (or more) wives, also known as **polygyny**, or it could be a wife married to more than one husband, also known as **polyandry**. From a Darwinian perspective, the best number of marital partners is two, because this matches the number of strands in DNA.

⁷⁶BLISS. Numerous studies covering 140 years show that married persons tend to live longer than their unmarried counterparts.

⁷⁷POLYCULE is a connected network of people in promiscuous relationships.

F5. Ghost Ship

If there are no Awake Workers, but there are still Embryos in the Jars, then *Exodus* runs on autopilot. Each Dozyear, the Avatars assign to Workcells, as well as librarian and Maintenance Cells, which are executed before moving or Orbiting the Starship. During the final Phase each Asleep Ideology loses a Stress, and the Starship suffers a *glitch*:

- a. **Helm Decisions** are made by the last Ideology who was in command. If any Plasma Risk Rolls are required, the risk roll must be made twice, accepting both results (reflects superiority of Human pilots).
- b. **Glitch**. During the end of **Phase D7**, each Ideology must Discard their choice of an Augmentation, Domesticated Goo, or Nugget. If they have none, there is no effect.
- c. **Mission Failure**. If no Humans remain, either Awake or in the Jars, the mission ends in failure without scoring.

G. Research & Librarian

You can assign Workers into the Market during **Phase D1**, placing them on the card. If the Worker is a Cyborg, this is a *research assignment* (**G1**), which instantly moves the card and Cyborg into a Playmat. If the Worker is an Avatar, this is a *librarian assignment* (**G2**), which instantly moves the card to the bottom of its draw deck.

G1. Research Assignment (Market Cell, Cyborgs only)

If you assign a Cyborg to a Market card, you must research it, instantly moving it as a Workcell to any Slot that is empty or contains only one Workcell. You may *trash* (**B6b**) Workcells in your own Playmat to make a Slot empty during research.

- a. **"To Research" Augmentation**. If the Market Card being researched has a "To Research" (**B2c**) shape requirement, it must be researched by an Ideology having the depicted Augmentation.
- b. **"To Research or Workcell Roll" Nugget**. This card is a *Foolhardy Experiment* (**E6**) which cannot be researched unless there exists at least 1 unflipped Nugget outside of the Cosmos (in any Playmat or in the Starship's bow).
 - **Agenda Cards**. If the Commander still has their Agenda Card (see glossary) in their hand, they may play it into any Slot, together with their Cyborg dice, as a research assignment.
- c. **Creative Stress**. Researching a Market card adds a number of Stress to the Cyborg's Playmat, as shown by the numbers in the *creative stress chits* (**C3b**).
- d. **Playmat Slot**. Place a researched Workcell into any unbusted Slot that contains space (i.e. has no more than 1 Workcell). It can be in any Playmat. You may *trash* a Workcell in your own Playmat to make space (**B6b**).
- e. **Earthbound Radio Signal**. If you research a Workcell with an Earthware icon  into a Slot, choose an available *radio signal dome* (**B1k**)⁷⁸ to place on top of that icon. This dome is launched by the first successful Workcell Roll (**H1k**) and moved per **D5a**.⁷⁹ This dome contains data about the card's novel technology, and so can be sent once, and no further domes can be placed on that Workcell.

G2. Librarian Assignment (Market Cell, Avatars only)

During assignment, an Avatar may be placed onto a Market card as a **librarian**. This immediately moves the Market card to the bottom of the draw deck of the appropriate column. This leaves a gap that will be filled in **Phase D7** and helps keep the Market from stagnating. Return the Avatar to its Trapezoid.

EXAMPLE [F5]

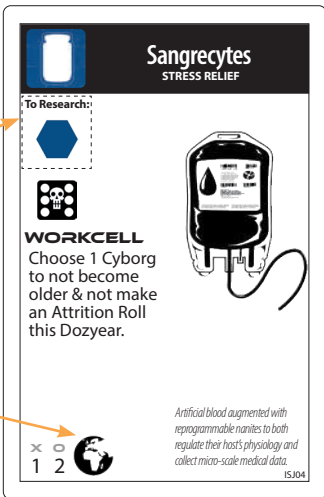
In Phase D5, a flare kills Che, the last Awake Cyborg. The Starship flies on autopilot, making an icebrake at the command of ghost Commander green. During Phase D7, all six Ideologies lose a token as a result of glitches. On the next Dozyear, an Avatar assigns to the Jars and decants a new Cyborg, Siddhartha, who takes command at Age = 1 at the start of the next Dozyear.

EXAMPLE [G1a]

As Ideology white, you research "Sangrecytes," which has a hexagon "To Research." However, you have no hexagon Augmentations. Instead, you decide to move it into a Slot of Ideology purple who has a hexagon Augmentation.

EASILY MISSED: The term "To Research" on a Workcell indicates an Augmentation requirement for research, needed to bring it into a Playmat Slot. Once in a Slot, this requirement is no longer relevant. [G1a]
The term "To Research or Workcell Roll" indicates a Nugget requirement to either research or, once it is in a Slot, to make a Workcell Roll for it. [G1b]

Earthware Icon [G1e]



EXAMPLE [G1d]

In the previous example, a Workcell is moved to the Playmat of Ideology purple. But both his available Slots are occupied by 2 Workcells, leaving no room for the new card. Ideology purple agrees that the Workcell is important, and thus agrees to trash one of his Workcells to make room for the new one.

EXAMPLE [G1e]

In the previous example, the Workcell has the Earthware icon . Since Ideology white researched it, he choses his own dome to place on this icon. A subsequent Workcell Roll on this Workcell is successful, launching the dome. Ideology white gets the broadcast medallion, regardless of who the Chief Engineer was who launched the radio signal.

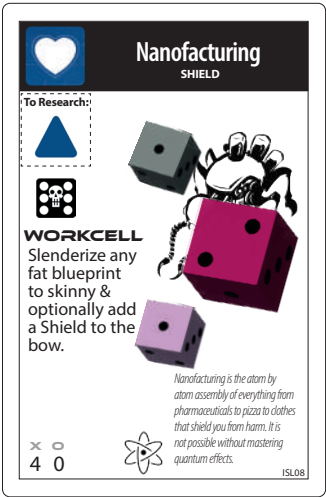
⁷⁸RADIO SIGNALS sent back to Earth can be gravity-focused by passage near Sol, so that the signal can be read by a receiver in orbit on the farside of Sol. This receiver would be at the focal point of the Sunlens. The signal also experiences a modest time dilation, because the *Exodus* crew ages more slowly than the rest of the universe. For a starship traveling at 16% c (where c = lightspeed), one Dozyear on the starship is 12.16 years back at Sol or other stars.

⁷⁹EARTHBOUND. The signals are going back, not to Earth, but to the High Frontier in the Solar System. This includes Earth, but also the spacefarers housed in dozens of Bernal space colonies.

EASILY MISSED: In order to discharge 1 step, the batteries charge must be at least 2, since the lowest batteries charge is 1. [H2a]

EXAMPLE [H1e]

Funding is "isotope" and learning is "blueeye." The life-support (heart) Workcell "Nanofactoring" is currently in the Playmat of Ideology red, with 3 Workers assigned. During the Workcell Roll, the red Cyborg rolls "2," the gray dice rolls a "1," and the purple Avatar rolls a "1." The Task is successful, since Ideology gray and Ideology purple both rolled a single success. But Ideology red has a heart Augmentation, matching the life-support "Nanofactoring," so she achieves a success as well. Only one success is necessary for Task success, so 1 fat Blueprint becomes skinny.



EXAMPLE [H1f]

In the previous example, none of the 3 Ideologies had a majority of successes, but since the Workcell lies in the Playmat of Ideology red, she can choose herself as the Chief Engineer. She slenderizes the Jars and adds the red Shield to the bow.

EASILY MISSED: The Chief Engineer can choose not to perform the success impact after a successful Workcell Roll. [H1f]

EXAMPLE [H1g]

In the previous example, the Workcell Roll was successful. However, the gray and purple Avatars do not receive Augmentation rewards because the learning is human. Ideology red had a Cyborg who participated, but this Cyborg is already Augmented in this shape.



EXAMPLE [H1i]

Two Ideologies, one with Stress = 3 and the other with Stress = 4, each assign a Cyborg to a triangle Workcell. An Avatar of Ideology white is also assigned, but is unimportant for this example because only Cyborgs cause outbreaks. If all rolls are "4," there is no outbreak. But suppose one Cyborg rolls a "2." There is an outbreak, placing a triangle Goo chit on the engine Blueprint. (H1i).



EASILY MISSED: If a Workcell Roll succeeds, do not forget to send off its radio signal dome if there is one on the card. This dome was previous chosen and placed by the player who researched the Workcell card.[H1k]

H. Workcell & Other Rolls

There are several kinds of dice rolls:

- a. Workcell Rolls.** These are rolled in the *cell rolls phase (Phase D3)* to determine the success or failure of Workers assigned to Workcells. Which Workcell is rolled for first, etc., is chosen by the Commander. The Worker dice themselves are used in the Workcell Roll. See **H1**.
- b. Goo Rolls.** Fights against Goo are similar to Workcell Rolls.
- c. Motherhood Rolls.** These are rolled in the *cell rolls phase (Phase D3)*. See **H5a** for successful child rearing.
- d. Plasma Risk Rolls.** Dangers include Pod Launches, flares, or diving into Substars. See **H6**.

H1. Workcell Roll (Phase D3)

In an order decided by the Commander, roll for each Workcell with assigned Workers. A joint roll is made to determine success or failure. Each *success impact* can succeed only once (even if multiple Workers succeed).

- a. Participation Choice.** All Workers must participate in the roll.
- b. Workcell Roll.** For each Workcell, simultaneously roll the dice of all the Workers present.
- c. Funding Row.** Use the row in the **Workcell Roll Table** according to the *funding* (isotope or übermensch, see **C5a**).
- d. Augmentation Bonus.** If a Cyborg (or an Avatar, if "redeye") is Augmented in the same shape as the Workcell, the chances for success for that Worker is improved, see the *Workcell Roll table* (map).
- e. Overall Success.** The Workcell Roll succeeds if at least one of the dice rolled is a success per the Workcell Roll Table (next page). Perform the *success impact (B2e)* once, even if there are multiple successes. Success may depend on if the Worker's Playmat has an Augmentation of the same shape as the *Workcell's Blueprint (B2b)*.
- f. Chief Engineer** is the Ideology whose Worker dice rolls a success. In case of a tie, the Ideology owning the Playmat decides. The Chief Engineer decides how the listed *success impact* is applied, and who benefits from it.
 - Hijack.** The Chief Engineer can move the Workcell into any empty space in a Slot, and may *trash* his own Workcells to make room (**B6b**).
 - g. Augmentation Reward.** An overall success rewards an Augmentation of that shape to each Ideology with a qualified Worker that rolled. However, each Ideology can have no more than 1 Augmentation of each shape.
 - "Blueeye" Learning.** If the *learning chit* is "blueeye" (**E6d**), then only participating Cyborgs are rewarded.
 - "Redeye" Learning.** If the *learning chit* is "redeye," then it is the participating Avatars (and not Cyborgs, not even the Posthuman) that receive an Augmentation of that shape.
 - Posthumanism.** If an Ideology achieves 4 Augmentations on its Playmat, it becomes the Posthuman (see glossary), assuming no Posthuman yet exists. If multiple Ideologies become Posthuman in the same Phase, then the Ideology with the lowest Pulse Order Number (see glossary) becomes the Posthuman.^{80,81}
 - h. Post-reward Stress or Accidental Death.** Next, each Cyborg rolling a "6" suffers 1 Stress on their Playmat.
 - Risky.** If the Workcell has the Risky icon , then the Cyborg is Killed instead of suffering Stress.
 - i. Goo Outbreak.** If any Cyborg Roll during a Workcell Roll is less than the number of its Stress, then place the Goo chit of the Workcell shape somewhere on the Blueprint of its shape.
 - Outbreak Cancelled** if that Goo chit is already in the Blueprint or is already Domesticated.
 - Ambushed by Goo.** If there is a Goo outbreak in a Blueprint, all Workers already assigned to Maintenance in that Blueprint are Killed. Workers on Workcells of that Blueprint are endangered on the next Dozyear per **H4**.
 - Goo Fights.** Goo fights do not occur the Dozyear of the outbreak. Make Goo fight assignments and *Goo Rolls (H3)* beginning the following Dozyear.
 - Goo Fight Assignment.** If a Blueprint contains Goo, its entire placard becomes a Goo Cell that can contain any number of Workers. Its Maintenance Cells cannot be assigned to. See **H3** for Goo Rolls.
 - j. Foolhardy Experiments.** A Workcell with the *nugget "To Research or Workcell Roll" (B2c)* is a *Foolhardy Experiment*. A Workcell Roll can be made only if there is at least one unflipped Nugget outside the Cosmos. If the Workcell Roll is successful, the Nugget(s) are flipped faceup, per **E6**.
 - k. Send Radio Signal.** If the Workcell Roll succeeds and the Workcell has a *radio signal dome (G1e)*, then the dome must be placed on the map at *Exodus'* location. It will be moved 12 spaces towards Earth during **Phase D5a**.

H2. Maintenance Cells Requirements

Maintenance Cells typically list "Requirements" which must be met in order to perform the Maintenance Task.

- a. Batteries Discharge.** Tasks requiring discharge indicate this by rotating the *charge dice (B4e)* to a lesser value. You cannot perform Tasks that would discharge the batteries under its minimum charge of 1.
- b. Engine Ignited.** Some Tasks require that the engine is **ignited**, defined as when a Worker is in the Ignition Cell plus Fuel is in the tanks (**E2i**). The Starship must expend Fuel and change speed.
- c. Augmentations.** Foamed metal Tasks require that Augmentations exist of that shape, counting all Playmats.

⁸⁰ POSTHUMAN IMMORTALITY. The advantages of biological immortality is the increased repertoire of experiences to draw upon, limited only by the still mysterious human memory and memory retrieval systems, and without reference to exosomatic sources of knowledge such as books. The downside is, with so much invested in a single life, immortal beings become conservative with an aversion to life-endangering risks. The longterm downside is that biological evolution is surrendered, in favor of technological evolution.

⁸¹ POSTHUMAN MORALITY. Humans evolved as a highly cooperative social animal, with a degree of cooperation and childcare unprecedented in the animal kingdom. Their awareness of their own mortality is the foundation of their morals and scruples. Having developed for immortality in an artificial zero-growth environment, the morality of Posthumans would change.

H3. Goo Roll (Goo Cell, Phase D3)

Every Goo chit on a Blueprint is also a **Goo Cell** that can be assigned to by a Worker starting the Dozyear after the outbreak. Resolve them in an order chosen by the Commander. If it contains no Workers, it *spreads* during this Phase per **H4**. If it contains Workers, all must roll simultaneously on **Goo Roll Table H3** (right) to see if the fight succeeds or fails. The results depend upon the *alert* status (**F2a**):

- Red Alert Status.** If the alert status is *red*, use the upper row of the Goo Roll. If successful, the Goo is Killed, Discarding its chit. The Chief Engineer receives the "champion" *hero* Medallion (**B12a**).
- Yellow Alert Status.** If the alert status is *yellow*, use the lower row of the Goo Roll. If successful, the Goo is **Domesticated** and its chit is stacked into the matching Domesticated Goo Shadow of a Playmat of the Worker rolling successfully.⁸² The Commander chooses among tied successes.
- Augmentation Bonus.** If a Cyborg or Avatar is Augmented in the same shape as the Goo, the chances for success for that Worker is improved, see the table.
- Critical Cyborg Roll.** If a Cyborg Roll (see glossary) in the Goo Roll is a "5" or "6" (red alert) or a "4," "5," or "6" (yellow alert), then that Cyborg is Killed.
- Augmentation Reward.** If Goo is Killed or Domesticated, all Cyborgs present (or all Avatars present if "redeye") receive an Augmentation of that shape if they do not already have it. If Goo is Domesticated, its Chit goes to the one successful (chosen by Commander if there are multiple successes).
- Goo Spread.** If the Goo Roll jointly fails, the Goo immediately *spreads* per **H4**.

H4. Goo Spread (Goo Cell, Phase D3)

If a Goo Roll fails to Kill or Domesticate Goo, or if nobody is assigned to the Goo, it will eat (Discard) all of the Workcells of its shape on Playmats.⁸³ This Kills all Cyborgs on those Workcells, including the ones that are fighting it. If there are no Workcells to eat, the Goo will eat the Blueprint itself:

- Blueprint Is Consumed.** If there are no Workcells to eat, then the Blueprint is *Lost* per **E4**, which Kills Workers on it. The Goo then goes extinct (starves to death).
 - Batteries Fuel-Eating Goo.** If the Goo has the battery shape and there is Fuel remaining, lose all steps of Fuel instead of losing the batteries Blueprint.
- Hero Medallion.** Any Cyborg that Kills Goo is awarded the "champion" hero Medallion per **B12a** (taken from anywhere, limit 1 per Ideology).

H5. Motherhood Roll (Pregnancy Cell, Phase D3)

A young female is **pregnant** if her own Cyborg dice has been assigned to the Pregnancy Cell of her own Cyborg placard. Pregnancy consumes the entire Dozyear because it simulates 9 months plus the childcare period. A successful Motherhood Roll allows the Mother to choose a Cyborg of any Asleep Ideology of her choice. The newborn Cyborg can come from either the Jars or the Soylent Green Pile.

- Motherhood Roll (Females of Ages 1 - 4).** Roll 1d6. This succeeds if it is among the **fertility dice faces** depicted for the young female's Age on her placard.⁸⁴ If a 6 is rolled, the mother suffers 1 Stress.
 - Hermaphrodite.** The fertility dice for a Cyborg with the Pregnancy Cell chit are always "1," "2," "3."
- Marriages.** If the female is married and the Motherhood Roll fails, a single reroll is allowed for success. If *polycules* (**F4b**) are legal, this reroll is made for all Motherhood Rolls.
- Childbirth & Apprenticeship.** The mother (or the married couple if she is married) decides which Ideology the newborn will be apprenticed in when it becomes a teen. The Ideology chosen must not already have an Awake Cyborg, and must have a Cyborg available in their Jar or the Soylent Green Pile.
 - Procedure.** Place the Cyborg placard into the Slot with a large dice covering his/her Age, as a reminder that he/she does not advance in Age this Dozyear and cannot be assigned until next Dozyear when he/she reaches Age 1 (18 years old).
 - Living Space.** The Ideology chosen must *trash* (**B6b**) Workcells if necessary to make room in their Playmat.
 - Constitution.** Per **A3g**, the mother's right to choose her child's Cyborg cannot be denied.
- Sterility.** Because the ship's artificial wombs require the endometrial cells from a woman, if all 6 females are dead, the mission needs to produce a reproductive Human (Hermaphrodite or Posthuman).⁸⁵

⁸²GOO DOMESTICATION. One way to control the growth of gray goo is with an asimov inhibitor, a contagious pathogen tailored to kill at a certain age, as depicted in the sci-fi short *Hostess*. In the sci-fi novel *Moonseed*, gray goo escaped from an alien starship on Luna destroys Venus and Earth before being domesticated by the alien's asimov inhibitor. —Isaac Asimov, *Hostess*, 1951. —Steven Baxter, *Moonseed*, 1998.

⁸³ECOPHAGY. Nano-engineers walk a tightrope with their self-replicating molecular creations. They are programmed to create more of themselves from the energy and raw materials they consume, so as to have the numbers required for a task. Yet anything that replicates is subject to Darwinian laws of natural selection, favoring mutations that replicate more efficiently. For this reason, greater chances of task success also mean greater chances of a Goo cancer.

⁸⁴PARENTHOOD & AGE. Infertility and birth risks increase with the age of the parents. For females, increased chromosomal abnormalities (such as Downs) occurs around age 31, sterility about a decade later, and menopause a decade after that. For males, two new mutations in the DNA of his sperm are accumulated on average for every year after age 35. On *Exodus*, technology has improved these figures considerably, in spite of the high radiation flux.

⁸⁵STERILITY. It's impossible to significantly shield the crew from the extreme radiation of the engine and the interstellar environment without an unthinkable mass penalty. Even with extremely radiation-hardened Cyborgs, extinction is inevitable unless they can land on a low radiation planet within a few generations.

WORKCELL [H1b] & GOO CELL [H3] TABLE (also on map)

Use this row if funding is "isotope." [H1c]

(roll 1d6 per Worker)

= Critical Cyborg Roll!

	Success	Success if Augmented*	Failure	Failure, Critical Cyborg Roll
Workcell Roll	IF OVERALL SUCCESS: Augment* participating Cyborgs.	Augment* participating Avatars.	Augment* participating Avatars.	If rolled by a Cyborg, either gets a Stress, or (if Risky) Killed.
Goo Roll	Success: Goo is Killed.	Success if Augmented*: Goo is Killed.	Failure, If Cyborg Roll = Killed	IF OVERALL FAILURE: Goo eats all Workcells of its shape**
	IF OVERALL SUCCESS: Augment* participating Cyborgs.	Augment* participating Avatars.	Augment* participating Avatars.	
	Success: Goo is Domesticated.	Success if Augmented*: Goo is Domesticated.	Failure, If Cyborg Roll = Killed	IF OVERALL FAILURE: Goo eats all Workcells of its shape**
	Augment* participating Cyborgs.	Augment* participating Avatars.	Augment* participating Avatars.	

*Augmentations must be the same shape as the Workcell/Blueprint. **If there are no Workcells for Goo to eat, it will eat that Blueprint instead. Workers on Workcells or Blueprints eaten by Goo are Killed.

EXAMPLE [H3]

Four Avatars are assigned to fight Jar Goo in the Jar Workcell "Noosphere Cult". It is yellow alert, and none of the Avatars are Augmented. The rolls are "2," "3," "6," and "6." This is a failure, and the Goo spreads (H4). There are no Augmentations or Stress, because no Cyborgs are involved. Two Avatars are Killed, yet as immortal machines they are Discarded to their Trapezoid unharmed.

EASILY MISSED: If Goo is Killed, the Chief Engineer receives the "champion" hero Medallion. [H4b]



EXAMPLE [H4]

The Jar Goo of the previous example spreads. This Discards both existing Workcells on Playmats: "Connectome" and "Noosphere Cult." There are 2 Cyborgs on "Connectome" and both go to Soylent Green. There are 2 Avatars on "Noosphere Cult" and both go to their Trapezoid.

EASILY MISSED: Each Ideology always has exactly one active Worker, per the constitution (A3b). [H5c]

EXAMPLE [H5c]

The Commander is pregnant, and Ideology purple wishes to decant because his Ideology is Asleep. But the Commander is concerned that Exodus would become unstable with two newborns, and tries to talk Purple out of decanting. Ideology Purple agrees on the condition that he receives the child when it is born. In Interstellar language, the Commander has made a "Rumplestiltskin deal," so-called because her firstborn is promised.

PLASMA RISK TABLE [H6] (also on map)

EROSION = Replace forward Blueprint with Nugget:

LIGHTNING = Replace random Blueprint with Nugget:

NEUTRONS = Discard all Workcells with icon:

ROCK = Kill 1 random Awake Cyborg:

KILL = all Asleep, = all Awake, = all Old:

1. Relativistic Pod (landing party only)

2. Flare Star

3. Debris Disk

4. Oort Icebraking

5. Fryby (into a Substar)

roll 1d6

					3+
					5+
					3+
					6+
					6+

EXAMPLE [H6a,c,d]

Exodus enters the Ran debris disk and rolls a "1." This Erodes the Shields and wardens, all sensitive Workcells are fried, and the Commander dies at her post. Then the Exodus makes a fryby of the gas giant Aegir and rolls a "6" (no effect). The ghost ship enters an Orbit around Ran in Phase D5, and each Ideology suffers a glitch in Phase D7. During Phase D4 of the next Dozyear, Arrival is achieved and the game ends.

EXAMPLE [H6f]

There is a Goldilocks 4 spaces away with a right stuff requirement of 2 Domesticated Goo. You make a successful Workcell Roll on the "Pushrope" Pod, and as Chief Engineer, you choose the landing party for the Goldilocks per I4b. To maximize chance of success, both are females: your Cyborg of Age 5 and the other embryonic. One Domesticated Goo exists, and this is carried as a "chip" to help Terraform the atmosphere. Unfortunately, the relativistic Pod roll is "1," which Kills the Embryo. The survivor reaches the planet but since she has only half of the right stuff, she will Age and roll for Attrition each Dozyear. But fortunately next Dozyear another Domesticated Goo is created on Exodus, and this information is automatically radioed to the survivor. She stops aging (it is assumed that, even as alone and old as she is, on a Habitable planet she will be fruitful and multiply).

AIR & WATER CHITS (facedown) [I1]

AIR
YELLOW SUN
AIR CHIT

AIR
RED DWARF
AIR CHIT

H₂O
WATER CHIT

These chits are placed and revealed during an Exploration. A Goldilocks planet is defined by one air chit plus (to the right) one water chit. A Troglodyte planet is defined by a single water chit adjacent to a Substar icon.

EXAMPLE [I1b]

Ideology green is in command while exploring Tau Ceti, and the revealed chits are "No Goldilocks" and "Icy Moon Troglodyte, Goldilocks ." This means that no planet is to be found in the habitable zone around the star, but the gas giant icon is paired with the gas giant icon in the Tau Ceti system, indicating the presence of an icy moon Troglodyte. See flowchart I5, I6.



H6. Plasma Risk Roll

The Starship must roll one dice (1d6) for this risk right after she finishes a *move* (D5) that entered a *flare/debris space* (B8b), or performed either *Oort icebraking* (F2c) or a *fryby* (F2d). Two rolls are made if she is a *ghost ship* (F5a). Use the appropriate row (2, 3, 4, or 5) in the **Plasma Risk Table** to find the result. Interpret the icons as follows:

- Erosion.** Beginning with the foremost Blueprint, braking erosion removes 1 or 2 Blueprints as indicated per E4. This forms one Nugget per Blueprint Lost per E3a.
- Lightning.** The buildup of frictional charge causes a megabolt of lightning.⁸⁶ After all other results are applied, a random Blueprint is *Lost* (E4), and a Nugget is placed in the bow Blueprint.
- Neutrons.** Discard any Workcells with the "neutron sensitive" icon .
- Rock.** A meteor Kills 1 random Cyborg from any Playmat (after all other deaths are applied). If this result is from a relativistic Pod Plasma Risk Roll, the Cyborg Killed must be in the landing party.
- Human Killed.** All Cyborgs are Killed who are old, Awake, or in Jars as indicated. If this result is from a relativistic Pod Plasma Risk Roll, only the Cyborg(s) in the landing party are Killed.
- Relativistic Pod.** If Cyborgs make *Arrival* (I) at Orbital speed, they do not need a Pod and there is no risk. But if the speed is 1 or more, the landing party needs either a *Jars Pod* (E2f) or a successful Pod Workcell and then must survive a Plasma Risk Roll (row 1). The results of this roll apply only to the landing party.
- Flare/Debris Mitigation.** If a *flare/debris space* (B8b) contains a Dustbug, add 1 to the Starship's Plasma Risk Roll.

I. Exploration, Arrival, & Terraform

You can explore a distant *planet* (B11) orbiting a Star by entering *Exodus*, or a Wisp, into the Star's space, or by entering a Wisp into a Sunlens that names that Star. This **Exploration** fills its *placement spots* (B8c) with faceup Planet Chits drawn randomly. To attempt colonization, perform the following to achieve **Arrival**:

- Enter Orbit (D4b).** The Starship must slow down to speed = 0. At this speed she can face in any direction.
- Perform Terraforming (I3b)** to launch a dropstone in order to make a *desert planet* Habitable (I5a).⁸⁷
- Deploy Refueling Zeppelins (I3a)** to refuel for moving to another Star or to launch a dropstone.
- Habitable Goldilocks.** To make Arrival on a Goldilocks, it must have at least of *hydration* (I5a) and *Exodus* must have the number of Domesticated Goo and/or Nuggets specified by its air chit (I5b).
- Habitable Troglodyte.** Arrival on a Troglodyte needs a Posthuman/Hermaphrodite to be present.
- Seedship Launch.** Alternatively, *Exodus* can maintain speed to continue to the next Star, but launch a Pod (I4).

I1. Planetary Exploration (by Starship or Wisp, Phase D5)

An **Exploration** reveals all of the *air* and *water chits* (B11) of a Star. Reveal a chit by taking, at random, one from the pile with the matching icon (yellow sun, red dwarf, or waterdrop). An air chits specifies the planet's *right stuff* (I5b) and a water chit specifies how much *water* is present (I5a). An Exploration occurs if *Exodus* enters, or a Wisp, stops at a Star with unexplored planets. If a Wisp stops at a Sunlens, it also performs an Exploration of the Star named by the Sunlens called a **snapshot** (because the Wisp's camera is but an instant at the exact focal point of the gravity lens).⁸⁸

- Goldilocks Exists?** If the air chit says "No Goldilocks," then there is, unfortunately, no planet in the Goldilocks zone. If the system has a Substar, there could be a Habitable subsurface ocean world orbiting it (next bullet).
- Substar Troglodyte Exists?** If a water chit with a Substar icon (B8d) is *paired* with that Substar on the map, then it is orbited by a **Troglodyte (I6a)**. This non-atmospheric world is only Habitable by tapping the ocean deep underground, which requires a Posthuman or Hermaphrodite (see glossary). There are 3 types of Troglodytes:
 - Icy Moon (11).** This exists only if a water chit depicting a gas giant is paired with a gas giant map icon.⁸⁹
 - Carbon Planet (3).** This exists only if a water chit depicting a brown dwarf is paired with a brown dwarf map icon.
 - Phoenix (3).** This exists only if a water chit depicting a white dwarf is paired with a white dwarf map icon.

I2. Explorer Medallions

Sending your Wisp to an unexplored Planet awards your Ideology with an *explorer Medallion* (B12b), which is taken from wherever it is (either reserves or Playmat). Discard the Wisp after it makes its Exploration. Explorer Medallions are of three types, and each Ideology is limited to one (if a second is acquired, choose one to Discard):

⁸⁶ LIGHTNING. The charge separation caused by friction and triboelectric effects in a fryby of a substar poses a grave risk of a lightning strike. On Jupiter and Saturn, lightning of unknown origins has been observed in the upper stratosphere, hundreds of kilometers above the water clouds. Observed lightning bolts may be 1000x that of Earth.

⁸⁷ PRIME DIRECTIVE. Dropstone terraforming alters the natural environment. This is no different from what all life does, indeed is the very definition of life. But some ideologies have ethical concerns. "Commander, I think you killed the biosphere!" "No no Pachamama, it's just dormant." "It's not dormant Commander! It's passed on! This biosphere is no more! It has ceased to be! It's expired and gone to meet its maker! It's a stiff! It rests in peace! If you hadn't nailed it with that dropstone, it'd be making a fossil record! Its metabolic processes are now history! It's off the twig! It kicked the bucket, shuffled off its mortal coil, run down the curtain and joined the bleeding Noosphere!! THIS IS AN EX-BIOSPHERE!!" —Matthew Rozanski (apologies to Monty Python).

⁸⁸ SUNLENS is a star between a distant light source and an observer, such that its gravity bends the light towards the observer. Albert Einstein predicted in 1936 that rays of light from the same direction that skirt the edges of Sol would converge to a focal point approximately 542 AUs (0.01 lightyears) from Sol. Similarly, a starship positioned at the gravitational focal point from a star could use the star as a gravitational lens for magnifying distant objects on the opposite side. The predicted optical gain of 113 dB is enough to zoom in on potential landing sites as far out as a dozen lightyears.

⁸⁹ EXISTENCE. What does it mean to "exist" in a law-abiding universe? A existent must have two properties: **identity** and **causality**. Identity means that it has a nature and follows its nature. Causality means its actions also temporally respond to the identity of others. Supernatural concepts with neither identity nor causality, such as superposition and duality, cannot exist in a universe in which science and knowledge are possible.

- a. **Wisp Explorer Medallion.** Award this Medallion to the *latest* Ideology who uses a Wisp to take a "snapshot," thus revealing at least one new Planet Chit of a planet that *exists* (I5b, I6a).⁹⁰
- b. **Galactic Explorer Medallion.** Award this Medallion to the latest Ideology who uses a Wisp to take a "snapshot" at a Sunlens with the galaxy icon ☄, which is a feature on the map. Once a snapshot is made at a Sunlens, it may not be repeated. The ☄ icon is found in the following 8 Sunlens':
- **Galactic Center Sunlens.** This Sunlens is located outside the 40 Eridani B/C trinary, where conditions are right to see the center of the Milky Way.⁹¹
 - **Gould's Belt Sunlens.** This Sunlens is outside of Kapteyn's Star.⁹²
 - **Off-Map Star Sunlens.** There are 6 Sunlens for the 6 off-map Stars.
- c. **Detective Explorer Medallion.** Award this Medallion to the latest Ideology who uses a Wisp to take a "snapshot" of one of the 5 Planet Chits that has a magnifying glass icon 🔍. This can be a "living planet," "magnetic monopole,"⁹³ "diamond core" (phoenix planets only), "iron rain" (carbon planets only), or Siren Civilization (icy moons only).⁹⁴ This last represents a Siren (alien) civilization living in the liquid diamond oceans of the gas giant.⁹⁵
- **Peep.** The magnifying glass icon 🔍 also allows the Wisp owner to have one Peep (see glossary).
 - **Pair Rule Existence.** If the 🔍 icon is on a water chit, the planet must exist per the *pair rule* (I6a) to receive the Medallion or do any peeping.

13. Orbital Missions

To *refuel* at a gas giant, *Terraforming*, or to make *Arrival*, *Exodus* must first brake to a stellar Orbit at a speed of zero. If *Exodus* starts the Dozyear at Orbital speed, during **Phase D4** the Commander can order the following 2 missions:

- a. **Deploy Refueling Zeppelins.** If the Star has a gas giant, and any Ideology has at least 1 Domesticated Goo, then deploying a Dustbug (per **E2b** or a successful "MHD Dustbug" Workcell) adds one Shield and 1 step of Fuel (instead of regular effect). Performing *aerogel refuel* Maintenance Task (**E2j**) adds 1 step of Fuel. These simulate deploying a floating helium/deuterium refinery in the atmosphere of the gas giant. Arrival is not necessary for refueling.
- b. **Terraforming.** This assignment can be performed if orbiting a Goldilocks that has less than the ☄ of hydration (I5a) needed for habitability. Terraforming occurs by being in Orbit and either assigning to a "Dropstone" Maintenance Cell (**E2h**)⁹⁶ or succeeding in a "Deep Hot Fusion" Workcell Roll. Terraforming can be accomplished up to two times, to add up to 2 drops 💧.⁹⁷

⁹⁰WISP RECONNAISSANCE. With enough light, a telescope with a nulling interferometer or coronagraph can analyze the spectrum from the reflected light of a planet to evaluate habitability. For an atmosphere like the present Earth, water, carbon dioxide, and ozone would dominate the infrared spectra, the last a possible indicator of photosynthesis. The temperature of the lower atmosphere could be inferred. The optical spectra would indicate molecular oxygen, and a brightness in the far red would be a sign of the "red edge" of chlorophyll in vegetation.

—Jonathan Lunine, *Astrobiology, a Multidisciplinary Approach*, 2005.

⁹¹CENTER OF THE MILKY WAY is dense and chaotic region called Sagittarius A*, located 26,673 lightyears distant. It can't be seen from Earth because recently (44 to 140 kya) Sol wandered into the dusty LIC called the Local Cloud that blocked the view. This center, and the centers of other galaxies, are often interpreted as supermassive black holes. However the existence of classic black holes involves contradictory assumptions and the first starship to break free of the Local Cloud may be surprised by what it sees. If Reality is **O**, alternative models include clusters of gravastars (composed of false vacuums) or black stars. If on the other hand Reality is **X**, then galactic centers could be modeled with string fuzzballs or dark-energy stars.

⁹²GOULD'S BELT. This necklace of stars in the Orion Arm is filled with OB associations, swarms of massive short-lived stars which end their lives as supernovae. In the past the belt surrounded Sol, causing enough galactic cosmic ray influx to have triggered a cosmic ray winter on Earth. Since then Sol has since drifted 325 lightyears from the arm's center.

⁹³MAGNETIC MONOPOLE. A hypothetical elementary particle with a net north or south "magnetic charge" analogous to the electric charge found on electric monopole particles such as the electron.

⁹⁴DIAMOND RAIN. The ammonia (NH₃), methane (CH₄), and water (H₂O) that dominate in so-called "ice giants" (such as Uranus and Neptune) may form hot dense liquid mantles, according to mathematical models. The outermost pressures of about 6 bars (6 time the atmospheric pressure of Earth) could break methane molecules apart and release carbon, forming long chains that squeeze together to form crystalline patterns that resemble diamonds. Then these dense diamonds drop through the layers of mantle until they are subjected to extreme temperatures, where they vaporize to repeat the diamond rain cycle.

—D. Kraus et al., *Formation of diamonds in laser-compressed hydrocarbons at planetary interior conditions*, *Nature Astronomy*, 2017.

⁹⁵BINARY & TRINARY STARSYSTEMS. A design problem is how to represent star systems with 2 or 3 stars, should these count as 1, 2, or 3 Stars? Each star in a multiple star system can have its own family of stable planets, called **interior planets**. A binary star system can also have stable planets that orbit the center of mass of the binary, and these are called exterior planets. Alpha Centauri A/B has 2 yellow suns, but the small distance between them (semimajor axis = 23 AU) means that the interior planets are marginally stable over long time periods and the exterior planets are 70 AU or more, far outside the Goldilocks zone. Thus I counted it as only 1 yellow sun. The 61 Cygni A/B system also has 2 yellow suns, but at a greater separation (semimajor axis = 85 AU), and thus it has 2 yellow suns on the map. —Wiegert & Holman, *The stability of planets in the Alpha Centauri system*, 1997.

⁹⁶DROPSTONES are rocks or ice that are deorbited so as to smash into a targeted world. They are normally deorbited from the outer planetary system, where the kinetic energy needed to deorbit is low, and the heliocentric potential energy is enormous. Most of the energy of a planetary system is stored in the potential energy of worlds in its outer reaches. A dropstone delivers not only enormous energy, but also raw materials such as water. The energy is converted into a rock vapor atmosphere, and can also (rarely) kickstart plate tectonics. Some of the energy is used to generate electricity for the pioneers (e.g. wind turbines).

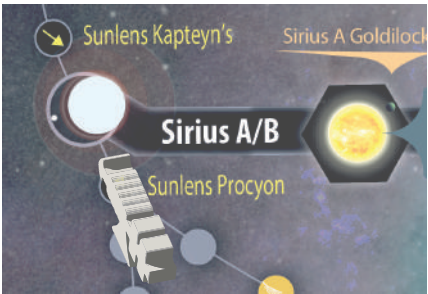
⁹⁷DROPSTONE FREE FALL. A dropstone falling from the scattered disk at 550 AU would take 2281 years in freefall to hit a target planet orbiting a Sol-sized star. We don't have that kind of patience, so there will have to be powered acceleration during the plummet.

EXPLORER MEDALLIONS [I2]



EXAMPLE [I2c]

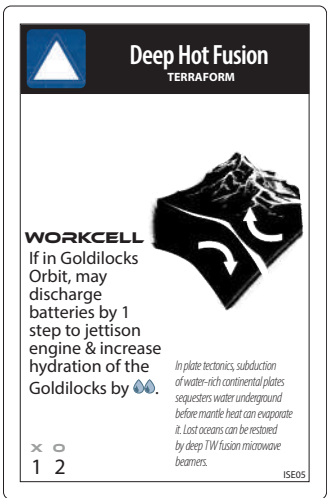
Exodus is 1 space away from "Sunlens Procyon" at Sirius A/B. You assign your Avatar to Wisp Maintenance (E2c) and, during Phase D4, move it as a Wisp to take a snapshot to reveal the 1 air and 2 water chits of Procyon. The second water chit (for the planet named "Procyon B phoenix") is revealed to be a diamond core 🔍. This awards the detective explorer Medallion instead of the wisp explorer Medallion.



EASILY MISSED: If the Starship is in Orbit and ignites its engine, it accelerates to speed 1, thus leaving Orbit. [I3]

EXAMPLE [I3b]

Tau Ceti f is the designation for the 6th planet discovered orbiting the star Tau Ceti. Its air chit shows it to be a Goldilocks, but its water chit is dry. It is a super-earth, so it ends up as a desert planet with only one 💧. To conserve Fuel, the Commander orders a fryby at Tau Ceti i ("i" means it is the 9th planet discovered; it is a gas giant). Thanks to the Wisdom of Hanno the Pilot, Exodus survives both the fryby and the debris disk, and enters Orbit at Tau Ceti. With the last step of Fuel, dropstone maintenance is used to make Tau Ceti f Habitable.

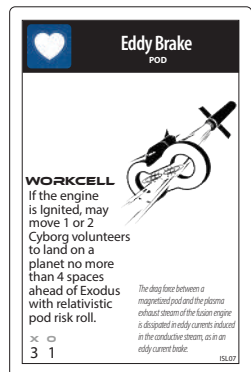


DEEP HOT FUSION WORKCELL: This Workcell is a possible alternative to the dropstone Orbital mission for adding hydration 💧 to a dry planet. [I3b]

A POD WORKCELL [I4c]

❗ **EASILY MISSED:** Most Pods (pushrope or eddy brake) require the engine to be ignited to be able to make the enormous deceleration required. [I4c]

❗ **EASILY MISSED:** The landing party will no longer Age when they get the Goo and Nuggets needed (these can be transmitted by radio) and the Starship drops enough dropstones (I3b) to bring the hydration up to 💧. [I4f]



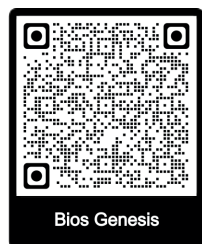
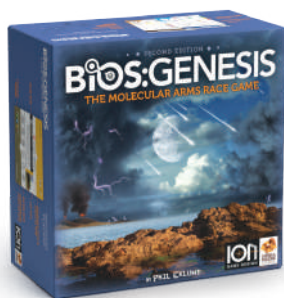
SEEDSHIP [I4g] & PANSPERMIA MEDALLION [I4h]



❗ **EASILY MISSED:** A Pod Launch to a Goldilocks with less than 💧 of hydration is doomed unless the Exodus stops there to Terraform. A Pod Launch to a Troglodyte without a Posthuman/Hermaphrodite is also doomed. [I4f]

EXAMPLE [I4g]

Exodus has lost its braking technology to Goo and is 4 spaces from the 61 Cygni binary. The Commander orders a relativistic Pod, even though nothing is known about the system's planets. Upon the arrival of Adam and Eve, the 4 chits are revealed to have no Goldilocks around either star, and only a Troglodyte icy moon orbiting the gas giant of 61 Cygni B. The landing party has no Posthuman Cyborg needed for Habitability (I6b), and so Adam and Eve perish.



EXAMPLE [I5a]

The Goldilocks planet "τ Ceti f Super-Earth 2012" orbits the Star Tau Ceti. The "2012" is the year of discovery (for information only). With the Planet Chits shown below, this super-earth planet is a Waterworld. An icy moon Troglodyte also exists.



14. Relativistic Pod Launch

Three of the game's Workcells and one Maintenance Cell are **Pods**. If there is a successful Pod Workcell Roll in **Phase D3**, then the Commander chooses 1 or 2 Cyborgs or Embryos from among volunteers for a landing party. The target Star system can be up to 4 spaces ahead of *Exodus*. A launch reveals all of the air chits and water chits of the Star, and an uninhabited planet is chosen to land on.⁹⁸ Immediately make a Plasma Risk Roll (**H6f**) to see if they soft-land safely on this planet. Each Cyborg landing safely is awarded a *seedship Medallion*. If the planet is not *Habitable* (**I5, I6**), then the landing party cannot reproduce and will grow old until the *Exodus* crew takes action to make the planet Habitable. *Exodus*, having seeded this world with Humans, can proceed on her journey to the next Star system.

- Pocketed Right Stuff.** The landing party do not remove any Nugget(s) or Domesticated Goo, since their pockets they carry them as chips, regardless which Ideology owns them. If this is insufficient, see **I4f** below.
- Choosing Adam & Eve.** The landing party must (if possible) consist of 2 Cyborgs, at least one a female or Posthuman. They can be either Asleep or Awake and of any Age. The Chief Engineer of the Pod Workcell chooses Adam and Eve from among willing volunteers. See example **H6f**.
- Pods.** There are 4 types of Pods, depending upon the Workcell or Maintenance Cell used:
 - Microwave Sail Pod.** This Pod is found in the wardens deck and uses the ship's batteries-powered microwave beamers to accelerate the Pod away from the Starship. This requires the batteries to be discharged by a number of steps equal to 1 plus the Starship's speed.
 - Pushrope or Eddy Brake Pods.** These are found in the Jars and life-support decks respectively. They require engine ignition, since these Pods use the engine's contrail to magnetically decelerate.
 - Jar Pod.** The entire Jars Blueprint can be Jettisoned as a Pod in a Maintenance Task (**E2f**). In this case, all Embryos plus Cyborgs on Jars Slots and Workcells are the only ones to leave with the Pod, and the Chief Engineer chooses up to four to receive Medallions (**I4g**) from among the oldest of the appropriate gender.
- Relativistic Pod Risk.** Adam and Eve make a joint Plasma Risk Roll (**H6f**).⁹⁹ This may Kill every old Cyborg in the Pod, or everyone Asleep in the Pod. Place survivors into the "Adam & Eve" spot on the map. They make no further assignments or actions but if they have not died by the end of the game they count VP per **J3a**.
- Seedship Plasma Risk.** The seedship makes another Plasma Risk Roll if entering a *flare/debris space* (**B8b**).
- Adam & Eve East of Eden.** If a landing party does not have the *right stuff* (**I5b, I6b**) to make the Goldilocks/Troglodyte Habitable, or if the *hydration* 💧 is too low (**I5a**), then they must grow older and make Attrition Rolls (assuming zero Stress) each Dozyear that they lack the right stuff. If they lack Domesticated Goo or Nuggets, they obtain it once anyone on *Exodus* domesticates Goo or gains a Nugget (the programming instructions are sent by radio). If they lack sufficient water (**I5a**), they obtain it once *Exodus* enters Orbit around the Goldilocks and *Terraforms* (**I3b**). Once the plucky couple has the right stuff, they stop Aging or Attrition Rolls and start leaving descendants. If they do not die, they count VP per **J3a** at the end of the game.
- Seedship Medallions.** Each member of a landing party who survives the Plasma Risk Roll is permanently awarded one of these 4 Medallions (**B12f**). Only males are awarded Adam, and only Females/Posthumans are awarded Eve. If there are not enough Medallions for all, the Chief Engineer decides.
- Panspermia Medallion.** If an Ideology is the first to send a Dustbug to an uninhabited Goldilocks world, that player is awarded the *panspermia Medallion* (scientist). The Dustbug lands extremophile microbes (this optionally starts a game of *Bios:Genesis* on the planet).

15. Habitable Goldilocks

A Goldilocks planet is defined by two chits: its *air chit* (black hex with red or yellow star) and its adjacent *water chit* (square). If a Goldilocks planet exists, it is **Habitable** if its *water chit* plus default has at least 💧, and the landing party has the *Goldilocks right stuff* (a toolkit of Domesticated Goo and/or flipped Nuggets as listed on the air chit).

- Hydration.** The lower part of a water chit indicates the number of drops (💧) of **hydration** (surface water cycle) on the Goldilocks. Use this data only for Goldilocks planets, not for Troglodytes.
- Earth/Super-Earth.** If a Goldilocks has a drop icon 💧 following its name on the map, it has extra hydration, as indicated.¹⁰⁰
- Habitable.** The total 💧 (from water chit plus the bullet above) must be at least 2 in order for the Goldilocks to be Habitable (0 or 💧 = uninhabitable desert world, 💧💧 = Habitable water cycle, 💧💧💧 or 💧💧💧💧 = Habitable Waterworld). If it is too dry, use *Terraforming* (**I3b**) to bring it up to 💧💧 (or more).

⁹⁸ CONSERVATION OF MOMENTUM. This might be the most abused Law in the world of science-fiction. There are no known exceptions to this Law of Physics, making such tropes as warp drives or pure energy drives impossible. This Law means that any vehicle in empty space needs both mass and energy to change its course, and needs to transfer momentum to part of itself that is expended as reaction mass in order to maneuver. As applied to a Pod launched at a few percent of lightspeed that must slow to orbital speed in a dozen years, a featherweight payload is assumed and with imaginative sources for the required reaction mass, such as particle beams and engine contrails that are many lightyears long.

⁹⁹ SEEDSHIP is a starship that flies through several systems without slowing down, dropping off a bit of humanity at each one. So much energy is needed to accelerate a starship up to relativistic speeds, that instead of slowing down, it jettisons a featherweight Pod that uses "pushrope" or "eddy brake" technology to decelerate into an extreme-elliptical capture orbit. A doughnut-shaped "Pushrope" Pod uses the Starship's own tightly collimated exhaust as a rope, using superconducting magnets to push the charged particles in one direction for a deceleration in the other. In this manner, it climbs down the plasma highway. The final maneuvering uses a high-efficiency electric rocket. Using a "Pushrope Pod" to decelerate from 16% c at 10 gees (barely plausible for augmented humans), in less than 100 AU and in 6 days Adam and Eve can make Arrival with little more than seeds of plants, Nuggets, and gray goo in the pockets of their crash suits. And on the 7th day they rested.

¹⁰⁰ EARTHS & SUPER-EARTHS. The named planets with a year of discovery have already been detected by Earth or space telescopes. If they are labeled "Earth" or "Super-Earth," then their estimated mass is about the same as Earth or 2-3 times that of Earth, respectively.

- b. Goldilocks Right Stuff.** The air chit specifies the **right stuff**, the number of flipped Nuggets and Domesticated Goo needed for Habitability. Thematically, it reinforces thin atmospheres (on Mars-like planets)¹⁰¹ or sequesters excess atmospheres (on Venus-like planets).¹⁰²
- **Nuggets.** The Nuggets can be in the bow, but they must have been flipped by a Foolhardy Experiment.
 - **No Goldilocks.** If the air chit says "No Goldilocks," no landings or Medallions are possible.
- c. Living Planet Exobiology.**¹⁰³ The air chit "Living Planet" indicates a Goldilocks green with plants,¹⁰⁴ blue with oceans (at least  of water), and alive with exobiology.¹⁰⁵ It needs no Terraforming or right stuff to become Habitable. The *Arrival* game will explore the interaction of an invasive earthling species with the native lifeforms.¹⁰⁶ Perhaps the flamethrower would be helpful.

16. Habitable Troglodyte

A water chit paired with a Substar icon gives a chance of a **Troglodyte**, i.e. an airless world with a Habitable water-cycle beneath its surface. A Troglodyte exists if the upper part of its water chit has a **Substar icon (16a)** that matches the icon it is paired with on the map. This Troglodyte is Habitable if the landing party includes a Posthuman/Hermaphrodite.

- a. The Pair Rule.** *Substars (B8d)* come in 3 types: *brown dwarfs*, *white dwarfs*, or *gas giants*. Substar icons indicated by a water chit do not exist unless *paired* with the same icon on the map:
- **Brown Dwarf.** If the water chit has a brown dwarf icon and it is paired with the brown dwarf icon on the map, there is a Troglodyte *carbon planet*.¹⁰⁷

101 HYPOBARIC PRESSURE is a pressure much less than the 1 bar at sea level on Earth. For comparison, the atmospheric pressure on top of Mount Everest is 250 millibars, the lowest pressure in which humans can breathe is 111 millibars, the lowest pressure that humans can exist in without their blood and bodily fluids boiling away is 62 millibars, and the Martian air is 6 millibars.

102 SEQUESTERING ATMOSPHERIC CARBON. Planets with hyperbaric pressure (much greater than 1 bar, which is Earth-normal) include Titan (1.5 bars), Mesozoic Earth (2 bars), water cloudtop Jupiter (4 bars), Venus (93 bars), cloudtop Uranus (100 bars), and Mariana Trench in Earth's ocean (1086 bars). Humans have worked at pressures as high as 70 bars, and may survive much higher, but are susceptible to hallucinogenic effects. If the hyperbaric pressure is rich in carbon dioxide, it can be lowered with solar-powered algal goo, which uses photosynthesis to convert the CO₂ into hydrocarbons and more goo. When it dies, assuming there is no bacteria around to make it rot, the carbon is sequestered and the atmospheric pressure is lowered. Thus this goo is performing a function no different from an ordinary Earth plant. A similar massive sequestration happened on Earth during the Cenozoic. The freshwater fern *Azolla* blossomed profusely in the Arctic waters, at a time when the Arctic ice was completely melted and dead *Azolla* sank, sequestering its carbon rather than rotting. This one species, over a few millennia, dropped the carbon dioxide pressure from a bar to a few millibars, driving the Earth from greenhouse hot to ice age cold. The process was only interrupted when the Arctic froze over, making it uninhabitable for *Azolla*.

103 SCARCITY OF LIVING PLANETS. Earth-sized Goldilocks planets will often have thick hot atmospheres composed mainly of carbon dioxide. Examples in our own Solar System include Venus and the early Earth. But how did the Earth lose its carbon dioxide, dropping from 60 bars to 0.04 bars of partial pressure? The answer may be the Big Whack, a fortuitous collision between Earth and a Mars-sized planet. This not only removed much of the Earth's crust to form Luna, our celestial companion, but the crust left behind was thinner and less stable, which jump-started plate tectonics. Plate subduction caused Earth to gradually eat its own carbon dioxide, a steady process that continues today. Venus, having dodged the Big Whack, kept its thick stable crust and its 92 bars of carbon dioxide. The Big Whack was a rare serendipitous event, which suggests that Earths and Super-Earths throughout the galaxy will have thick uninhabitable atmospheres. Even the rare habitable Earths have a brief lifespan as they eat their precious carbon dioxide in less than 5 billion years.

104 ALIEN PLANTS. Under a red, white, or brown dwarf, photosynthetic foliage would appear black so as to absorb the most long wave radiation. In a pitch-black submarine world, the primary producers would be chemo-autotrophs such as chemosynthetic bacteria and archaea. Humans can possibly survive in such frigid gloomy places, but it seems the biosphere would be rather limited and sluggish compared to Earth.

105 EXO BIOLOGY refers to life that has naturally evolved in other planets, perhaps on Goldilocks worlds. If a microbe, insect, or human made *Arrival* on such an alien world, what chance would they have, competing against creatures that may have evolved a billion years to that precise environment? It would be as if a pig were thrown into the ocean, where it can't breathe and has no defenses against sharks. And yet, an artiodactyl (an even-toed hoofed mammal) actually splashed into Earth's ocean 50 Mya and was not eaten by sharks. Instead it evolved to replace megalodon sharks as today's apex marine predators (sperm and killer whales). What happened? Sometimes evolving in an alien environment gives an advantage over the natives. Breathing air allows whales to have a higher metabolism than sharks, which must breathe a medium with much lower oxygen content. A lot of the native evolution is wasted in Red Queen adaptations, which is entirely bypassed by immigrants.

106 INVASIVE SPECIES. How does an ecosystem react to an invasion of a foreign species? Species are much tougher than generally given credit for, and an invasive species normally increases biodiversity without causing extinctions. The species lifetime of Earth's mammals is a million years, and almost always leave descendant species behind. Species robustness is partly due to competition with other species and parasites, and partly due to the Achterbahn (roller-coaster), the unstable and wildly swinging nature of Earth's environment. In the last 500 years on Earth, the number of documented extinctions has been very low, likely no more than the natural fallout rate. Introduced continental species have increased biodiversity by about 10% worldwide, and this has likely increased the speciation rate as well, at least on the mainland. On small predator-free islands, introduced predators can wreak havoc, including extinctions (the so-called dodo effect). Over 95% of extinctions in the last 500 years have been on islands. The last major extinction event was the loss of Pleistocene megafauna in the Americas, Eurasia, Australia, and Madagascar. These extinctions seem to correspond with the arrival of humans, suggesting that the megafauna were doomed by their naivety when confronted with alien bipedal hunters armed with fire and ranged weapons. I argue that the human Pleistocene hunters were not yet subjectively conscious. Thus, unlike a starship crew, they could not voluntarily restrain their expansion.

107 CARBON PLANET is a planet that contains more carbon than oxygen, a condition thought to be true in the protoplanetary disk around brown dwarfs and very low mass stars. A carbon planet can appear similar to Earth, but the core would be iron or steel surrounded by molten silicon carbide and titanium carbide. The outer layers could be graphite and diamond, and the surface may feature mountains of diamonds and silicon carbide ejected by volcanoes. If the surface temperature is below 77 °C, an atmosphere of carbon dioxide or carbon monoxide featuring a weather cycle of oils, tars, methane, or other hydrocarbons may exist. However, water cannot form because any oxygen delivered by comets (or dropstones) will react with the carbon-rich surface. Human crops would need to be maintained under subterranean greenhouses that recycle the precious water.

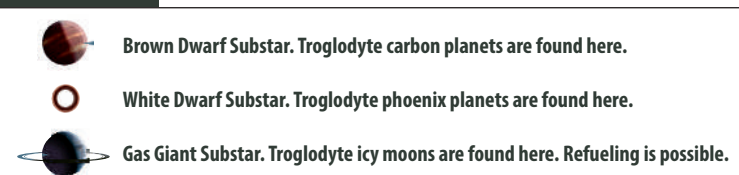
PLANET CHITS FOR EXAMPLE [15b]



EXAMPLE [15b]

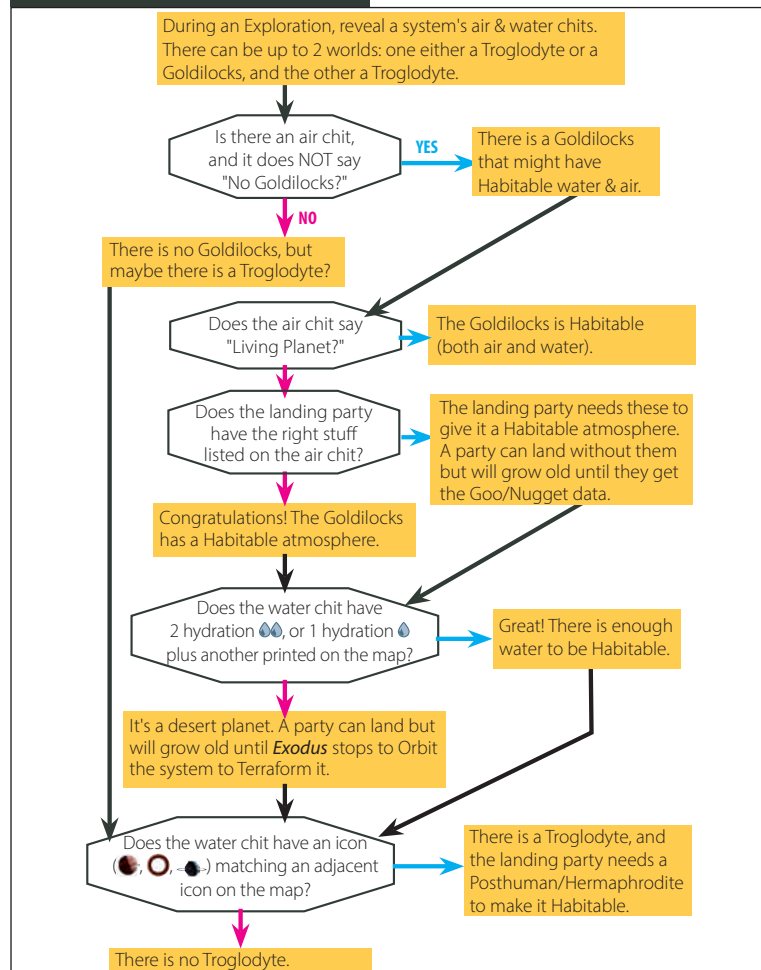
An Exploration of Barnard's Star flips the 2 Planet Chits shown above. The planet's right stuff is 2 Domesticated Goo plus 3 Nuggets. The water chit reveals the white dwarf icon (this icon is ignored since Barnard's Star has no white dwarf), plus  of hydration. Since the planet (Barnard b super-earth) has a default  of hydration, the additional  revealed in the water chit is enough to make the Goldilocks a Habitable Waterworld to a landing party with the right stuff.

SUBSTAR ICONS [16a]



EASILY MISSED: If the water chit of a potential Troglodyte does not have an icon that matches the icon shown on the map (either brown dwarf, white dwarf or gas giant), it does not exist and any attempted landings perish. If a water chit reveals any added Goldilocks hydration (on the bottom of the chit), it never applies to a Troglodyte. [16]

FLOWCHART [15, 16] IS THE PLANET HABITABLE?



EXAMPLE [I6a]

Exodus reaches the binary T-dwarf system of Epsilon Indi Ba/Bb, and its water chit is revealed to be a “Troglodyte Carbon Planet”. This water chit has a brown dwarf to the left and a gas giant to the right, and so the gas giant has no icy moons but the brown dwarf has a Troglodyte carbon planet.

EASILY MISSED: If a Troglodyte exists, by definition it has subterranean liquid water. Water drops on a water chit have meaning only for a Goldilocks, not for a Troglodyte [I6a]



EXAMPLE [I6b]

You discover a carbon planet around the brown dwarf at Luhman 16A. Since Ideology Red has a become Posthuman, the Troglodyte right stuff is available and Exodus stops and makes Arrival.

EXAMPLE [J1a]

Exodus enters Orbit around Barnard’s Star in Example I5b. If, among all the Ideologies on Exodus, there are at least two Domesticated Goo chits plus all three Nuggets, during Phase D4 the game ends with a Arrival on Barnard’s Star b.

TIP: If Arrival is stopped for lack of the right stuff, but the Star has a gas giant and Exodus has at least 1 Domesticated Goo, then consider refueling (I3a). [J1a]

EXAMPLE [J2]

The endgame is cooperative. Counting Cyborg VP (J3a), Workcell VP (J3b), and chit/token VP (J3c), the scores are 16 (gray), 25 (red), 30 (white), 25 (yellow), 27 (purple), and 28 (green). The cooperative victory = 151 VP, enough for a victory. However, there was only one world colonized, and no successful Foolhardy Experiments, so the overall victory level is only breakeven.



MATTHEW’S COMPETITIVE GAME: In this variant suggested by a playtester, if a cooperative victory is achieved, calculate a “ruling coalition” of 3 Ideologies as follows: of each Archemy pair, the ideology with the more VP becomes part of the coalition, with the Commander deciding ties. You win if at least one of your Ideologies is part of the ruling coalition. [J2c]

STARSHIP MINI: As an extra, you can order a miniature plastic starship, suitable for both Interstellar & Module 4, at www.iongamedesign.com.

- **White Dwarf.** If the water chit has a white dwarf icon and it is paired with the white dwarf icon on the map, there is a Troglodyte *phoenix*.¹⁰⁸
- **Gas Giant.** If there is a gas giant water chit paired with a gas giant icon, there is a Troglodyte *icy moon*.¹⁰⁹
- **Non-existence.** If there are no icon pairings between the map and the water chit, then there is no Troglodyte.
- b. Troglodyte Right Stuff.** A Posthuman or Hermaphrodite (see glossary) in a landing party have the right stuff to make a Troglodyte Habitable.
- c. Dual Habitable Worlds.** It is possible for a the upper part of water chit to indicate a Troglodyte and the lower half to indicate Goldilocks hydration. The Commander decides which one the landing party lands on.

J. Endgame & Victory

J1. Endgame Conditions

The game can end in the **endgame check** at the end of **Phase D4**. If any of the following are true, the game ends immediately, followed by *scoring* per **J3**.

- a. Arrival Endgame.** All surviving Cyborgs (either Awake or in Jars) must make a risk-free Arrival in **Phase D4**, assuming the Starship is in one of these two Orbits:
 - **Goldilocks Orbit.** *Exodus* is in Orbit (speed = 0) at a Star with a *Goldilocks* and the *Goldilocks right stuff* (I5b) specified on its air chit is available. Furthermore, the water cycle (I5a) of the Goldilocks is or more (counting Terraforming).
 - **Troglodyte Orbit.** *Exodus* is in Orbit (speed = 0) at a Star with a *Troglodyte* (i.e. the image on the water chit matches its adjacent Substar icon), and the Starship contains a living Posthuman/Hermaphrodite (see glossary).
- b. Mission Abort Endgame.** If there is a consensus, the players can elect to end the game in failure.
- c. Exit Local Neighborhood Endgame.** The game ends if you fly off the map (**D5h**), or are trapped in Orbit.
- d. Return to Sol Endgame.** The game ends if you return to Sol Orbit. If the Commander wants to enter Sol Orbit, Earth will send tugboats to slow the Starship into Orbit if it is moving too fast. You can even use the setup rules to restart the mission with new Cyborgs, but transferring the Ideology's chits and tokens.
 - **Posthuman War.** *Exodus* will be attacked using **Plasma Risk Table** row (5) if there are Posthumans aboard.

J2. Cooperative/Solitaire Victory Point Goals

Assuming at least one female (or Posthuman, assuming a solitaire game) from any player survives Arrival, all 6 Ideologies combine their VPs (Victory Points, see **J3**) to see how well humanity has done collectively. Additionally, a minimum number of worlds must have living colonists plus a minimum number of flipped Nuggets (from successful Foolhardy Experiments, either on Playmats or in the bow) are needed to attain a particular victory level.¹¹⁰

COOPERATIVE VICTORY LEVEL	COOPERATIVE/ SOLITAIRE OUTCOME	COMBINED NUMBER OF VPS	WORLDS COLONIZED	NUMBER OF FLIPPED (FACEUP) NUGGETS
a. Minor loss	Immediate survival, but eventual exohuman extinction.	60 - 100 VPs	1 or more	0
b. Breakeven	ZPG (zero population growth), neither win nor lose.	101 – 140 VPs	1 or more	0
c. Victory	Linear population growth of at least 2 colonies. ¹¹¹	141 – 160 VPs	2 or more	1, 2, or 3
d. Major victory	Exponential growth, unstoppable exohuman presence. ¹¹²	161+ VPs	2 or more	2 or 3

¹⁰⁸WHITE DWARF is a stellar remnant of what once was a red giant, a star big enough to have swallowed and vaporized all of the Goldilocks of its tiny descendant. So how could such a small and cooling cinder even have planets in its small habitable zone? There are 3 possibilities: **survivors** (planets that somehow survived being inside a star), **intruders** (planets that wandered in from interstellar space or possibly as an ejected moon from one of the system’s gas giants), or **phoenixes** (planets formed from the ash and rubble of vaporized planets). —Terraforming Wiki

¹⁰⁹TIDAL FLEXURE PLANET/MOON. An icy planetoid orbiting a gas giant or white dwarf may exhibit sufficient tidal flexing to melt subsurface ice and form habitable subterranean oceans. This tidal effect would be particularly strong around a white dwarf, with a size comparable to Earth and a mass comparable to Sol. The planet or moon would be tidally locked, such that one side always faced the star or substar.

¹¹⁰COLLECTIVISM VS. INDIVIDUALISM. On nature shows about ants or other colonial animals, it is common to hear “for the greater good” or similar collectivist propaganda. In reality, even worker ants work for the sake of their own genes, and not for the queen. There are times, such as when choosing which workers will become queens for a nuptial flight, the interests of the worker conflict with that of the queen. Careful statistical studies show that the workers choose in a way to favor their own genetic spread, despite the fact they are essentially royal clones. In fact, every eusocial insect is exploiting the hive and its cooperative efforts for its own selfish ends. The “greater good” is a myth, at least among animals.

¹¹¹WHEN AD ASTRA? In *High Frontier* time scales, TW thrusters capable of starflight come on line at the end of a 7 Dozyear game, maybe 100-120 years from now. There is a difference between handwavium and unobtainium, the former is fundamentally impossible to the limits of our knowledge, and the latter is theoretically possible but we don’t know how. I have avoided handwavium game elements such as warp drives. Unobtainium elements include controlled magnetic fusion, magnetic spin polarization fuel processing, artificial blood, exocortex Cyborgs, high temperature superconducting nozzles, and Nuggets. Could these be developed in 120 years? Think back to 120 years ago, circa 1900. No plastics, atomic power, electronics, aircraft or space vehicles, refrigeration, or practical radios.

¹¹²LIFE & MORALITY. In the course of natural selection, life consumes resources and pollutes its surroundings without regard to other life extinguished in the process. Mass extinctions occurred during the oxygen crisis (see *Bios:Genesis*) and the *Azolla* crisis (see footnote 102). Yet it is this very mercilessness which makes life so complex, diverse, and durable in the face of natural disasters. Homo sapiens is the only known being with a consciousness able to bypass the dictates of its selfish genes, and thus uniquely capable of the conceptual understanding required to evaluate the long-term consequences of their decisions. Moral concepts answer quandaries such as which entities are worth preserving when, for instance, when a Commander must destroy the biosphere on a planet that must be terraformed for mission success.

J3. Competitive Endgame Victory Points

If the game ends with the *endgame chit* (B14b) flipped to its "king" side, and at least one female or Posthuman from any player survives on a planet, there is a **Competitive Endgame**. Each player receives victory points (VP) for their Cyborgs, Workcells, Medallions, Nuggets, Domesticated Goo, and Augmentations on their Playmat, plus Cyborgs in their Jar. If you control multiple Playmats, choose the one with the most VP.

- Cyborg VP.** Each living Cyborg is worth 4 VP (including Embryos Asleep in the Jars, the Posthuman, and surviving members of landing parties).
- Workcell VP.** First, all unflipped Nuggets are revealed, so that the quantum Reality is shown to be either **XXO** (Reality = **X**) or **XOO** (Reality = **O**). Each Workcell in your Playmat counts VP according to the **X** or **O** VP, as listed on the card. The first VP is counted if quantum Reality = **X**, and the second VP is counted if quantum Reality = **O**.
- Chit/Token VP.** Each chit (Domesticated Goo chit (B9) or Medallion (B12)) or token (Augmentation, Nugget or Commander's star) on a Playmat is worth 4 VP to the Ideology of that Playmat. An ideology can only hold one chit/token in each of its Playmat Shadows (except the Combined Game Medallions).
- The Winner** has the highest VP. Tied players share victory, in the spirit of a (partially) cooperative game.

K. Example 3-Player Game

K1. Dozyear 1 (Mission years 0 to 12). A Hazardous Course.

Commander: Meskhenet (freedom). First Mate: Hanno (individuality).

- Fuel & Funding Cylinders (C5a,c):** Commander chooses fuel and funding = "isotope" (190 tanks).
 - Starship Facing:** After reviewing the Market, the Commander chooses galactic south, which has nearby stars but is bedeviled with LIC. To build Shields, she prioritizes engine research, noting that this will allow research of a shield card in the Market ("Nanofactoring").
 - Secret Agenda:** Commander's eyes only: Waterworld (Goldilocks with 3+ hydration are Habitable).
- Sam explains his course: *"Galactic south has many possibilities, including super-earths which are possible Waterworlds. To counter LIC Erosion, I will have had the crew gain engine augmentations using the Reber Nozzle. This will allow the research of Nanofactoring, which can slenderize the ship. The mass saved will be used to build Erosion Shields."*
- First Assignments:** Hanno researches "Reber Nozzle Telescope," an engine workcell card without requirements (1 creative stress). The Commander proposes an exogamy marriage to the first mate, quickly accepted, and assigns to the Wisp Maintenance Cell, hoping for an easy Medallion while the batteries are recharged. Two Avatars assign to Maintenance (engine ignition & MHD batteries recharge), and two to the newly researched Reber Nozzle.
 - Regulations/Mutinies:** With no Regulations to enforce, the freedom Commander runs a loose ship.
 - Cell Rolls:** Individuality also has one Workcell (the telescope), populated by a Cyborg and two Avatar dice, and these dice are rolled: "5," "5," "1." Therefore, unity is the Chief Engineer. The success impact does not send any radio signals (as there are none available) but it does give an engine (triangle) Augmentation to individuality (but not to unity since isotope funding only augments Cyborgs). The unity Avatar takes advantage of its status as Chief Engineer to hijack the Workcell into its own Playmat.
 - Maintenance:** Ignition lowers Fuel 1 step (to 112 tanks), and advances the speed to 4% c ("c" means lightspeed). The Playmats of the Commander and first mate suffer a Stress from ignition, and the charge dice drops from 6 to 4. Then it drops to 1 as the Wisp is fired, moving the yellow Avatar dice to the map. The Commander chooses the MHD recharge to go last, moving the charge up to 6. Note that the MHD recharge is only possible since the engine is ignited.
 - Move:** The red Wisp flies to the nearby sunlens for 61 Cygni, and reveals the Planet Chits there, awarding freedom the Wisp Medallion. However both Goldilocks there require too much Domesticated Goo to be interesting. The Commander announces the Starship's destination to be Barnard's Star, while privately noting that the Barnard Super-Earth might be a Waterworld. *Exodus* moves to Sunlens Achird.
 - Attrition/Aging:** Commander Meskhenet & Hanno move to Age 2 (30 years).
 - Refresh:** The Commander has 1 Stress and first mate has 2 Stress (creative stress plus ignition stress), and because of exogamy both remove one as the result of marital bliss. Fortunately, there are no Archenemies.

The Market is refreshed.

Matthew explains his Sleeping Strategy: *"With both my Cyborgs in the Jars, the bad news is that I will be missing out on Augmentations and Workcells. The good news is that my Cyborgs are safe for a while and I can focus on scanning for a Habitable planet and Medallions. 'Entanglement Meme' (next page) just came out, which means there are 2 Foolhardy Experiments with the possible outcome of machine learning, which would allow my Avatars to gain Augmentations."*

EXAMPLE [J3]

During the endgame, Reality is X, which gives you 0 VP for your single Workcell. You have an Embryo, a seedship medallion, an explorer medallion, an Augmentation, and a Domesticated Goo. Each are worth 4 VP, so your total is 20 VP. This is less than one of your opponents, so not enough for a competitive win, but you have the satisfaction that your surviving Embryo made Arrival.

EXAMPLE [J3a]

Your female Cyborg survived a Pod Launch onto a Goldilocks. Later your embryonic male survived Arrival onto another Goldilocks. Assuming Arrival contained at least 1 female/Posthuman, your total Cyborg VP = 8.

EXAMPLE [J3b]

At the endgame you have 2 Workcells in your best Playmat: "Reber Nozzle Telescope" with VP = 3/1, and "Nanofactoring" with VP = 4/0. You are hoping that Reality is subjective, for a Workcell VP = 7. Unfortunately the 3 Nuggets are revealed to be X, O, & O, so your Workcell VP = 1.



PLAYTHROUGH [K]

In a 3-player game, every player controls 2 Ideologies:

Petr = freedom Commander (red) + honor (white)

Samuel = individuality first mate (gray) + unity (yellow)

Matthew = equality (green) + authority (purple)

We need this Augmentation... →

Warning: Risky icon! →

... because the Starship needs this Shield. →

Nanofactoring
SHIELD

To Research:

WORKCELL
Slenderize any fat blueprint to skinny & optionally add a Shield to the bow.

Nanofactoring is the atom by atom assembly of everything from pharmaceuticals to pizza to clothes that shield you from harm. It is not possible without mastering quantum effects.

VP
4 0

NANOFACTURING WORKCELL: Why did we shoot this albatross? (Apologies to the Ancient Mariner). [K1a]

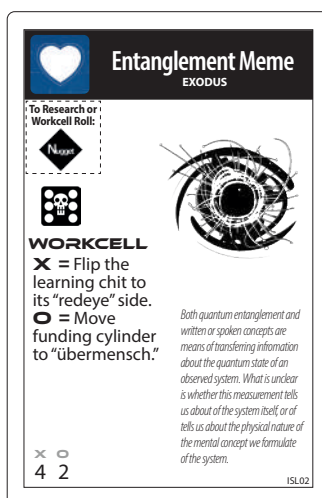
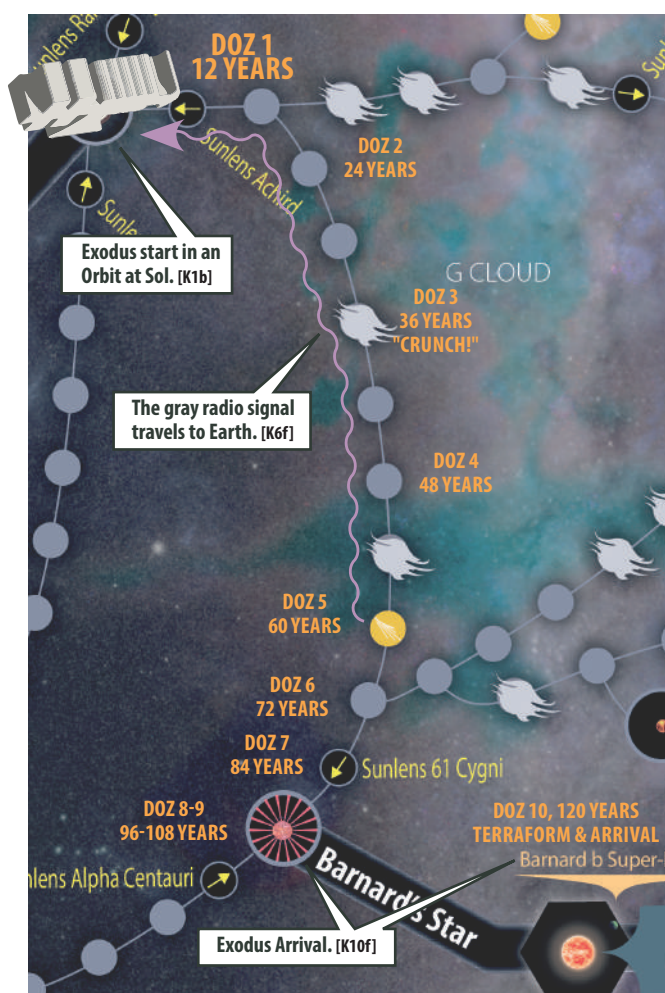
Reber Nozzle Telescope
EARTH DATA

WORKCELL
If engine is not Ignited, move any radio dome on a Workcell to Exodus' location to be sent to Earth.

This deployable radio antenna uses the ship's hemispherical nozzle as its central element.

VP
3 1

REBER NOZZLE TELESCOPE WORKCELL: This engine Workcell card allowed the first mate to gain the valuable engine Augmentation reward. [K1c]



ENTANGLEMENT MEME WORKCELL:
A Foolhardy Experiment that can either give the Avatars the power to gain Augmentations, or allow Cyborgs the power of "übermensch" enhanced Augmentation rewards. [K4b]

K2. Dozyear 2 (Mission years 13 to 24). Astrological Fail.

Commander Meskhenet (freedom) married to First Mate Hanno (individuality). Both are Age 2 (30 years).

- a. **Starship:** Speed = 4% c, Fuel = 112, location = Sunlens Achird of Sol, heading galactic south.
- b. **Assignments:** Hanno, enabled by his Augmentation, researches "Nanofactoring." Commander Meskhenet attempts pregnancy. Avatars assign to ignition and recharge, and the rest to the mission-critical Nanofactoring Workcell.
- c. **Regulations/Mutinies.** None possible under a freedom Commander.
- d. **Cell Rolls:** The 3 Workers on "Nanofactoring" fail, and Meskhenet's pregnancy fails (including her reroll for marriage). The crew should have consulted their horoscopes (do those even work between stars?).
- e. **Maintenance:** Ignition lowers Fuel 1 step (to 65 tanks), and the speed advances to 8% c. The Playmats of individuality and freedom suffer ignition Stress, and the charge dice drops before getting recharged to "6." Matthew grumbles: "*Janitorial work in the batteries for nothing!*"
- f. **Move:** *Exodus* moves 2 spaces (1 lightyear), setting a course spinward toward Barnard's Star.
- g. **Attrition/Aging:** Meskhenet & Hanno move to Age 3 (42 years).
- h. **Refresh:** With exogamy marital bliss, the married couple each remove a Stress. The Market is refreshed.

K3. Dozyear 3 (Mission years 25 to 36). The Crunch.

Commander Meskhenet (freedom) married to First Mate Hanno (individuality). Both are Age 3 (42 years).

- a. **Starship:** Speed = 8% c, Fuel = 65, location = 4.5 lightyears (9 spaces) from Barnard's Star.
- b. **Assignments:** Meskhenet again attempts childrearing. The 5 remaining Workers assign to "Nanofactoring," because Shields are needed to protect *Exodus* when she strikes the LIC.
- c. **Regulations/Mutinies.** None.
- d. **Cell Rolls:** Meskhenet has a healthy daughter, Pachamama. When she comes of age, after some intense negotiation, mom decided her daughter will be trained as an ecologist in the equality ideology. In the labs, however, the secret of "Nanofactoring" eludes the crew, yet again.
- e. **Maintenance:** None.
- f. **Move:** *Exodus* moves 2 spaces (1 lightyear), slamming into the LIC. The bow of the Starship is pounded into slag, taking the wardens (and the warden Workcells) with it. But embedded in the slag is a shiny Nugget.
- g. **Attrition/Aging:** Meskhenet & Hanno move to Age 4 (54 years). Pachamama becomes age 1 (18 years).
- h. **Refresh:** The Market is refreshed. Hanno removes his last Stress.

K4. Dozyear 4 (Mission years 37 to 48). First Lab Accident.

Commander Meskhenet (freedom) married to First Mate Hanno (individuality) and a young daughter (equality).

- a. **Starship:** Speed = 8% c, Fuel = 65, location = 3.5 lightyears (7 spaces) from Barnard's Star.
- b. **Assignments:** Hanno and everyone else assigns to "Nanofactoring," except Pachamama who researches "Entanglement Meme" (taken for no creative Stress) and the authority Avatar, who joins Pachamama. Matthew explains his decision to join the "Meme": "*If I become the Chief Engineer, I gain a Medallion and an Augmentation. If the experiment turns the learning to redeye, this helps the Avatars, and if it goes übermensch, this helps the overall mission.*"
- c. **Regulations/Mutinies.** None.
- d. **Cell Rolls:** Pachamama/Hanno fail their Workcell Roll. Not only does the "Nanofactory" Workcell team fail, but Meskhenet rolls a "6" and (since "Nanofactoring" has the Risky icon [Skull]) dies in a tragic laboratory accident. The Commander's body goes into the Soylent Green Pile. In the post-death election, Hanno is elected, with a campaign promise to make public the Agenda taken from the previous Commander.
- e. **Maintenance:** None.
- f. **Move:** *Exodus* moves 2 spaces (1 lightyear),
- g. **Attrition/Aging:** Pachamama turns Age 2 (30 years). Hanno turns Age 5 (66 years), and gains his Wisdom (pilot). Since Attrition Rolls are made before aging, Hanno does not risk death by old age until next Dozyear.
- h. **Refresh:** The Market is refreshed.

K5. Dozyear 5 (Mission years 49 to 60). Life-Support Failure.

Commander: Hanno (individuality) and his daughter, Pachamama (equality).

- a. **Starship:** Speed = 8% c, Fuel = 65, location = 2.5 lightyears (5 spaces) from Barnard's Star.
- b. **Assignments:** Nuptials: Hanno (Age 66) marries his daughter Pachamama (Age 30). Such is life on a ship where every gram matters! Since polygamy is legal, expanding the marriage to include freedom or authority is possible, should more humans be born/decanted. All Workers assign to "Nanofactoring" since more LIC's loom dead ahead. Insert "Titanic" theme music here.
- c. **Regulations/Mutinies.** None.
- d. **Cell Rolls:** The "Nanofactory" Workcell team fails again, but this time Pachamama rolls a "6" and dies at age 30.
- e. **Maintenance:** None.
- f. **Move:** A repeat of K3f, except this time the life-support is lost. All cards with the heart shape are discarded, and all the middle slots in the Playmats are busted (including "Entanglement Meme" and the jonah

"Nanofabricing"). *Exodus* continues its move, ending on an amat jet 🚀. This allows a Peep at one of the two bow Nuggets, and Hanno sees that it is **X** (subjective).

Sam's Quantum Reality Check: *"One of the available Nuggets is **X**, so if the second Nugget is **X**, then Waterworlds such as (hopefully) Barnard b Super-Earth 2018 are beach-front paradises. If it is **O** the Foolhardy Experiment will produce a Posthuman who will make Troglodytes such as Luhman's Rogue Planet Habitable."*

Petr's Assessment: *"We lost our life-support research, including "Entanglement Meme," "Pleasure Gardens" and the cursed "Nanofabricing." A big blow. The only one left conscious is Hanno the Pilot – the worst Commander ever."*

g. Attrition/Aging: With 1 Stress, Hanno has an adjusted age of 6 and survives his Attrition Roll by rolling a "4." He then turns 78 (Age 6). He is twice widowed.

h. Refresh: The Market is refreshed, revealing "Hyperspectral Telescope."

K6. Dozyear 6 (Mission years 61 to 72). On Immortality.

Commander: Hanno (age 78) is alone at the helm of a ship with only Jars, batteries, and the engine remaining.

a. Starship: Speed = 8% c, Fuel = 65, location = the amat jet 🚀 1.5 lightyears from Barnard's Star, and 2.5 lightyears from Luhman's Rogue Planet, a brown dwarf.

b. Assignments: Noting the 2 unflipped Nuggets in the bow, the Commander researches the Foolhardy Experiment "Hermaphroditism," gaining 1 creative stress. He moves it into the unity Playmat as his own Playmat has its only Slot occupied (note that each Slot can hold 2 Workcells). Because it is an Earthware 🌍 Workcell, Hanno places a radio dome on it, which he chooses to be his own color (gray). In a bid for Posthumanism, freedom, equality, and authority each add their Avatar to this experiment. The honor Avatar goes to Jars Maintenance (decant) and unity Avatar goes to engine Maintenance (ignite).

Petr explains the Race to Posthumanism. *"The bungled mission needs to get a Posthuman on board, otherwise there will be not enough VP to produce anything but a cooperative defeat. A Posthuman can be created in a Foolhardy Experiment, and there are two possible available in the second Market row – "Cosm" and "Hermaphroditism." But "Cosm" is both worthless in effect and Risky (two previous funerals are still in fresh memory). "Hermaphroditism" looks better – better effect, not Risky and can also send Earth Data. And a chance to get Augmentations. But becoming the Posthuman gives a significant advantage in the competitive endgame."*

c. Regulations/Mutinies. None.

d. Cell Rolls: Rolls on "Hermaphroditism" are "1," "4," "4" and "4" – success. This gains Hanno the Jars Augmentation, and launches the card's radio dome. It also flips the two Nuggets at the bow – **O** and **X**. Thus the true nature of the universe is unresolved and the Workcell text is ignored. The Chief Engineer (freedom) becomes Posthuman - an immortal heavily-Augmented Human Cyborg, and the endgame chit on the map is flipped to its "King" side. Freedom receives the Posthuman placard and black dice. The experiment Kills the embryonic freedom Cyborg Brokk, who retires into the Soylen Green Pile (thematically he is transformed into the Posthuman Prometheus). Freedom also receives the *mad scientist Medallion* (latest Foolhardy Experiment success).

Petr pontificates on immortality: *"With the game no longer cooperative, my Posthuman is motivated to kill all the pesky mortals to strip their points. But in respect for my human Playmat (honor), I decide to give humanity a chance."*

e. Maintenance: Engine ignition slows *Exodus* to speed = 1. Hanno gets an ignition Stress. The honor Avatar in the Jars decants Arduinna (honor). She has no childcare, and so, is born an Orphan. Both activities drain batteries to nearly empty (charge = 2). But that is a problem for next Dozyear.

f. Move: The gray radio dome (with exciting new "Hermaphroditism" discoveries) travels 12 spaces towards Sol and reaches it in this Dozyear. So the Earth Data in the gray Jar is flipped faceup - permanent benefit "Hypertumor Silver Bullet." This is life-prolonging for females, but not males like Hanno. Individuality is awarded the *broadcast Medallion*. *Exodus* moves to the intersection and points towards Barnard's Star.

g. Attrition/Aging: Hanno makes an Attrition Roll, with 2 Stress he has an adjusted age of 8. However, he rolls the "3" and survives, and becomes 90 (Age 7). The test tube Orphan Arduinna turns 18, with no Stress. Prometheus the Posthuman does not Age.

h. Refresh: The Market is refreshed.

K7. Dozyear 7 (Mission years 73 to 84). The Telescope.

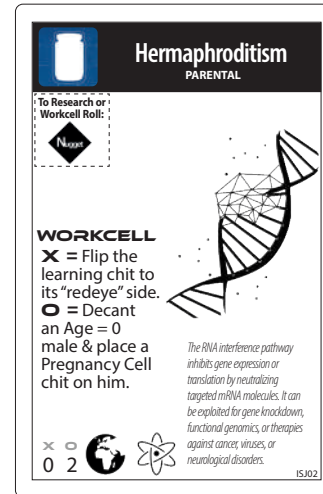
Commander: Hanno (age 90), also Awake are the Orphan Arduinna and a scary Posthuman.

a. Starship: Speed = 4% c, Fuel = 35, location = 1 lightyear from Barnard's Star or 2 lightyears from Luhman's.

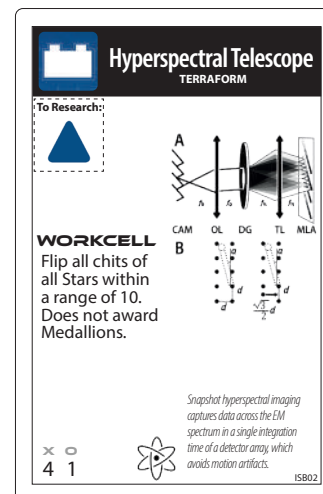
b. Assignments/Regulations: Hanno researches "Hyperspectral Telescope" to the equality Playmat (with permission) for no creative stress. Everyone else joins there, which would be able to detect if there is a Goldilocks at Barnard's or a Troglodyte at Luhman's. To reach Luhman's, *Exodus* would have to be brought to a dead stop since the Starship is pointed in the wrong direction plus survive another LIC passage.

c. Cell Rolls: Seven dice are rolled for the joint roll on "Hyperspectral Telescope," since the Posthuman rolls two dice and chooses one. The roll is successful, since Individuality rolled a "1."

d. Telescope Success: The success means that the 3 Ideologies with Cyborgs there (individuality, freedom & honor) gain a battery Augmentation reward. Furthermore, the Planet Chits of two Stars are revealed. At Barnard's Star, the planet's right stuff is 2 flipped Nuggets and its 🌌 is zero. At Luhman's Rogue Planet, the pair rule indicates that an "iron rain" Troglodyte exists, which is made Habitable by the Posthuman on board.



HERMAPHRODITISM WORKCELL: The success of this experiment was neither an "X" nor an "O," but instead an "XO," which generates a Posthuman in any Foolhardy Experiment. [K6d]



HYPERSPPECTRAL TELESCOPE WORKCELL: Provided telescopic exploration of Barnard b Super-Earth 2018. [K7d]

EXPLORATION [K7d]

This shows the 2 planet chits flipped at Barnard's Star, and the 1 planet chit flipped at Luhman's Rogue Planet, as a result of the Exploration accomplished by the successful Workcell Roll by the "Hyperspectral Telescope." The "Diamond Core Troglodyte 🌌," revealed at Barnard's b Super-Earth 2018, unfortunately didn't exist because the pair rule (16a) specifies that it exists only if paired with the correct Substar, in this case a white dwarf. Barnard's Star has no white dwarf, and thus no diamond core. However, the water chit at Luhman's Rogue Planet has a brown dwarf icon matching the icon at Luhman's, indicating a Habitable carbon planet orbiting that Substar. Furthermore, the carbon planet has "iron rain 🌌," which allows a Peep (but nothing to peep at). Also, the 🌌 does not award the detective Medallion (12c), because the "Hyperspectral Telescope" used specifies "Does not award Medallions."

APPROACH TO BARNARD'S [K8c]

This is a flare star, so as soon as the Starship enters it, a Plasma Risk Roll is rolled on row 2. Its 2 Planet Chits were previously revealed in example above.

The water chit at Luhman's Rogue Planet:

EASILY MISSED: It is not allowed to assign to "dropstone" Maintenance in Dozyear 9, because the requirement for dropstones is that the Starship must be in Orbit, and it was not yet in Orbit at that point. [K9b]

APOLOGIA: In this mission, a desert planet is made into a Habitable planet by bombarding it with icy planetoids. But it is not realistic for Arrival to occur in the same Dozyear as a dropstone is dropped. For one thing, it likely takes a decade just for the ice to fall. After impact, it would likely take another decade for the oceans to stop boiling. The biosphere would be altered for at least a million years. The next planned game in the series, "Arrival," will deal with issues such as what happens if the impatient Starship crew makes Arrival even before the icefall. [K9b]

EASILY MISSED: Nanshe (individuality) calculated that, by apprenticing her child in equality, a Workcell worth 4 VP would be transferred out of equality and into authority. This was a factor in Matthew coming in last place. [K9d]

EXODUS UPON ARRIVAL [K10f]

ENGINE

IGNITION

Burn 1 fuel & change speed 1 step.

To Use: Fuel minus 1, Batteries minus 2, +1 Stress to each Awake Ideology.

FOAMED METAL

Slenderize this Blueprint & may add a Shield to the bow.

To Use: 3+ triangle Augmentations.

BATTERIES

DECANT (Avatars only)

Awaken one of your Embryos into an Age 1 Orphan.

To use: Batteries minus 2.

FOAMED METAL

Slenderize this Blueprint & may add a Shield to the bow.

To use: 3+ Jar Augmentations.

JARS

DECANT (Avatars only)

Awaken one of your Embryos into an Age 1 Orphan.

To use: Batteries minus 2.

FOAMED METAL

Slenderize this Blueprint & may add a Shield to the bow.

To use: 3+ Jar Augmentations.

MHD RECHARGE

Advance the charge dice to 6.

To use: Worker assigned to Ignition, fuel >0.

DROPSTONE

Increase hydration of the Goldilocks by 1.

To use: In Goldilocks Orbit, Fuel minus 1 step.

THE GRAY SHIELD

THE GRAY SHIELD JETTISONED IN K9e.

Dry mass is 200 tonnes, half of what she started with.

FINAL SCORING [K10h]

Each player counts only the higher of his two Ideologies, which turn out to be honor, individuality, and authority. The game is Competitive, and honor and individuality share victory.

- Petr (honor): 2 living Cyborgs (4 VP each), 2 Augmentations (4 VP each), 2 Medallions (4 VP each) = 24 VP.
- Samuel (individuality): 1 living Cyborg (4 VP), 3 Augmentations (4 VP each), 2 Medallions (4 VP each) = 24 VP.
- Matthew (authority): 2 living Cyborg (4 VP each), 2 Workcells (7 VP on X side) = 15 VP.

- Petr's Appraisal: "Our cursed mission is headed for Barnard's. It is too dry but we can launch a dropstone. It requires 2 flipped Nuggets, and we have those in the bow."
- e. Medallions & Peeps:** The discovery of "iron rain" at Luhman's awards the Chief Engineer (Individuality) a Peep, but unfortunately there are no unflipped Nuggets outside the Cosmos to peep at.
 - f. Goo Outbreak:** Since the successful Cyborg Roll ("1") is less than the Stress on that Cyborg (2), a battery Goo outbreak (H1i) is triggered. The battery goo token is placed upon the telescope Workcell.
 - g. Maintenance:** None. The nearly-dead batteries can't be recharged without engine ignition.
 - h. Move:** Exodus moves to the Oort of Barnard's. Commander sets Red Alert because of the Goo outbreak.
 - i. Attrition/Aging/Refresh:** Hanno the Pilot dies of old age and the 30 year old Arduinna is elected as the new Commander. The Posthuman lost the election since it was felt that, since he can't die of old age, and, being freedom, can't be mutinied, as Commander he would become unstoppable in a Competitive game.

K8. Dozyear 8 (Mission years 85 to 96). The Champion.

- Commander: Arduinna (honor), also Awake is the Posthuman Prometheus (freedom).
- a. Starship:** Speed = 4% c, Fuel = 35, location = Sunlens 61 Cygni outside Barnard's Star.
 - b. Assignments & Cell Rolls:** The individuality Avatar assigns to foamed metal on the batteries, which is possible now that there are 3 batteries Augmentations. This slenderizes the batteries, and installs the gray Shield into the bow. Arduinna begets Nanshe (individuality female). Everyone else joins the Goo fight. With his twinned dice, the Freedom Posthuman successfully murders the Goo and gains the champion Medallion (B12a).
 - c. Move & Plasma Risk Roll:** Exodus moves to Barnard's Star. This is a flare star, so the Commander rolls a Plasma Risk Roll (wishing Hanno the Pilot was still alive). The roll is a "5," so nothing bad happens. Whew!
 - d. Attrition/Aging:** Arduinna turns 42. Her newborn daughter Nanshe turns 18, moving her dice to the gray Trapezoid.

K9. Dozyear 9 (Mission years 97 to 108). Barnard's Approach.

- Commander: Arduinna (honor). Also Awake is her daughter Nanshe (individuality) and the Posthuman (freedom).
- a. Starship:** Speed = 4% c, Fuel = 35, location = Barnard's Star. The game may end in the next Dozyear.
 - b. Assignments:** MHD recharge, pregnancy (Nanshe), Workcell (Posthuman), engine ignition, library, and decant. Petr's Overcrowding: "My freedom and honor Playmats have no room for more Workcells, so it's better to go for Augmentations."
 - c. Regulations/Mutinies:** The Commander decides to use her "pawn" regulation to reassign Nanshe, hoping to deny her additional VP. This backfires, as she mutinies for the right for maternity leave, and the Posthuman wins the election. He uses his special power to reassign the Avatar in ignition into Shield jettison instead (this Maintenance Cell is on the Shield Blueprint E2k).
 - d. Cell Rolls:** Nanshe chooses to apprentice her child in equality (green) as Che the Communist. Because they have but one Slot already occupied by "Hyperspectral Telescope," Nanshe makes room for Che's arrival by moving this Workcell to an empty Slot in authority (B6b). The Posthuman fails his twinned Workcell Roll.
 - e. Maintenance:** The gray Shield is jettisoned (with gray's permission), which reveals the "DRY MASS: 200 tonnes" and allows the Commander to bring Exodus to a halt, entering Orbit at Barnard's Star. Because the Commander reassigned the ignition Avatar, the batteries could not be recharged and authority's decant failed for lack of power. All part of the intense power struggle between Prometheus and Nanshe.
 - f. Endgame Check:** Exodus orbits a Goldilocks, but at one of water the planet is too dry for Arrival.
 - g. Move:** None; Exodus is in Orbit.
 - h. Attrition/Aging:** Arduinna turns 54, and her daughter Nanshe, also a mother, turns 30.
 - i. Refresh:** At the end of the Dozyear, Nanshe's son Che turns 18, moving his dice to the green Trapezoid. Beginning next Dozyear, this mother and child become Archenemies.

K10. Dozyear 10 (Mission years 109 to 120). Terraforming & Arrival.

- Commander: Prometheus (Freedom), also Awake is Arduinna (honor), her daughter Nanshe, and her grandson Che.
- a. Starship:** Speed = 0, Fuel = 35, location = orbiting Barnard b Super-Earth 2018, a desert Goldilocks.
 - b. Assignments:** Nanshe (individuality) assigns to dropstone (skinny batteries). To support this, an Avatar assigns to ignition and another to MHD recharge. The other Workers crowd onto the "Reber Nozzle Telescope," hunting for Augmentation VP. Nuptials: Che marries his mother Nanshe, to help reduce Stress.
 - c. Regulations/Mutinies:** None. A freedom Commander has no Regulations to impose.
 - d. Cell Rolls:** The "Reber Nozzle Telescope" succeeds and all 3 participating Cyborgs gain an engine Augmentation reward. Che, as Chief Engineer, hijacks this Workcell into an available space on the authority Playmat.
 - e. Maintenance:** Batteries are recharged and engines are ignited. The ignition allows the launch of a dropstone (E2a), dropping a planetoid of ice onto the Goldilocks and raising its hydration from (because it is a super-earth) to . It is now Habitable! This maneuver reduces the Fuel by one step (from 35 to 17 tanks).
 - f. Endgame Arrival:** The 9 surviving Cyborgs, including the Posthuman and 5 Embryos, make Arrival to Barnard b Super-Earth 2018. This ends the game. Scoring is Competitive, since the endgame chit is "King."
 - g. Nugget Reveal:** The final unflipped Nugget in the Cosmos is revealed. It is X, and the universe is XXO.
 - h. Determining the Winner:** Final scores show that honor and individuality share victory at 24 VP each. The Posthuman (freedom) achieved 20 VP. Individuality lost 8 VP in the mutinous change of command and the loss of the telescope Workcell in Dozyear 9.

Glossary (Capitalized terms are defined here)¹¹³

Ability is an effect listed on Earth Data, Wisdom, and Workcell cards. It is no longer available if the card is Discarded, but Tokens that are flipped or removed by an Ability remain unchanged upon Discard. Abilities on Workcells are valid only on the Dozyear of a successful Workcell Roll.

Age. The Orientation of a Cyborg indicates its Age in Dozyears. The young side of the Cyborg has four Ages: 1 (18 years), 2 (30 years), 3 (42 years), 4 (54 years). The old side of the Cyborg has four more Ages: 5 (66 years), 6 (78 years), 7 (90 years), 8 (102 years). A Cyborg at Age 8 does not grow older (**D6b**). In the Phase it is born/decanted, a Cyborg is a preteen (age group 0) and starts at Age 1 on the next Dozyear.¹¹⁴ Age is relevant for *Wisdom* (**B3c**), *Attrition Rolls* (**D6a**), and *Motherhood Rolls* (**H5a**).

Agenda Card (Optional). Give one of these 5 cards randomly to the Commander during setup (**C2f**), who keeps it secret from the other players. It represents highly classified technology conferred by the Starship's financial sponsors. He is allowed to reveal it only by researching it. A Commander with a hidden Agenda could save the mission, but it could cause the crew to mistrust the Commander as a "Captain Ahab."

- **Research (G1b).** A living Commander can research an Agenda in their hand during the *assignment phase* (**Phase D1**), which places it into a Slot along with the Commander's Cyborg dice. Once on a Playmat, an Agenda is treated just as a Workcell.
- **Succession (F3f).** If a new Player becomes Commander, they claim the Agenda Card if it is still in the old Commander's hand.

Archenemy. Two Ideologies are Archenemies if their colors lie opposite to each other on the Political Hexagon (e.g. freedom and authority). During **Phase D7**, both Archenemies suffer 1 Stress per **D7b**.¹¹⁵ Newborns (Cyborgs just born earlier in the Dozyear) can never be an Archenemy.

Arrival (I). If *Exodus* is in Orbit at a Habitable planet, the crew lands without risk during **Phase D4**, ending the game.¹¹⁶

Attrition Roll. An old Cyborg must roll during **Phase D6a** to see if he/she dies of old age. Roll 1d6, and the Cyborg survives if it matches one of the survival dice faces depicted for the old Cyborg's *adjusted age*. The adjusted age is the actual Age, plus 1 step for each Stress of the Ideology, to a maximum of 8.

Augmentation. These tokens come in 5 Blueprint shapes: engine (triangle), batteries (battery), Jars (jar), life-support (heart), or wardens (hexagon). They are acquired per **H1h** or **H3e**. Augmentations help the chance of success in Workcell Rolls of that shape (**H1e**), for both Cyborgs and Avatars. If a Workcell specifies a "To Research" icon (**G1a**), an Augmentation of that icon is required to research it. A Playmat can hold only one Augmentation of each shape, and each is worth 4 VP in the endgame. Achieving 4 or more Augmentations creates a Posthuman.

Avatar. This robotic proxy is always available to any Asleep Ideology. It is represented by a small dice of the Ideological color. It may be assigned to Cells and vote but cannot enjoy Augmentation rewards (except during "redeye" learning) or research. Since each Ideology is allowed only one Worker, if an Ideology Awakens (by birth or decant), its Avatar is retired into the Jars. An Avatar is immortal and returned to its Trapezoids if Killed.

¹¹³ **DEFINITION** means a statement that identifies the nature of its conceptual units, that distinguishes that concept from all other concepts. Subjective feelings do not create facts and are not definitions; they are the deliberate avoidance of definitions, useless in all communication including self-communication and particularly useless in a game with rules. "The winner is whoever asserts to have won" is not a game rule, it is the avoidance of rules. Justifying a lie by saying "it's not a lie if people believe it" is an evasion of justice by undefining truth and falsehood. If a person accuses another of harassment, saying "it's harassment if I feel harassed," this is an evasion of definitions not admissible in any objective court of law. A "subjective definition" is a contradiction in terms that defeats the purpose of definitions.

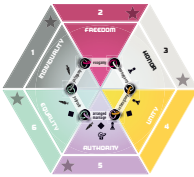
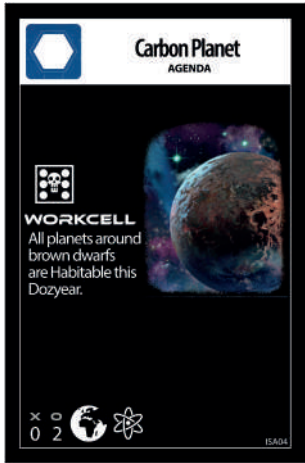
¹¹⁴ **HUMAN COMING OF AGE.** In her youth, a female Cyborg is fitted with an exocortex to augments her computation and logic. A young male Cyborg is fitted with a piezoelectric exoskeleton which gradually supplants his muscles and organs as they atrophy. Eventually he will need only liquid nourishment and oxygen for his powerplant. Both types of Cyborgs depend upon artificial nanite blood for radiation protection.

¹¹⁵ **OPPOSED IDEOLOGIES.** The 6 Ideologies are arranged on the Political Hexagon such that opposed pairs lie opposite to each other: freedom versus authority, individuality versus unity, honor versus equality. **Freedom** - the idea that humans are organized best in a social setting if they are free to pursue their own goals and live their own lives - is fundamentally opposed to **authority** - the idea that humans flourish best if told what to do by a central military authority. Likewise, **individuality** - the idea that human societies flourish and evolve when their diversity in religion and beliefs are preserved - is fundamentally opposed to **unity** - the idea that society prospers if everyone has the same beliefs. **Unity** is associated with right-wing theocracies featuring regulated speech and religious beliefs. Finally, **honor** - the idea that humans are distinguished by their ideological loyalties - is fundamentally opposed to **equality** - the idea that human workers are indistinguishable cogs on a wheel, and should be paid and treated equally. Many labor unions are organized according to equality ideals. The differences between opposed Ideologies is so deeply grounded that an advance in one necessarily constitutes a concession in the other.

¹¹⁶ **POWERED LANDING.** To land on a planet using rockets, the vehicle needs both enough propellant for the necessary delta-v (10 km/sec for Earth) plus a thrust at least equal to the ship's weight. This latter requirement is a problem for *Exodus*. A 200 tonne starship has a weight of 2 million Newtons on Earth, so the thrust of its fusion engine must develop at least 2 MN thrust to land unassisted. However, the actual thrust of its mighty 3.9 terawatt engine is a feeble 0.25 MN, not enough for a powered landing (unless assisted by parachutes, wings, and boosters). This is because her fusion engine is built for fuel economy, not thrust.

AGENDA CARD EXAMPLE

The starship accelerates to speed = 4, traveling anti-spinward, towards the giant star Sirius. At the first LIC, the wardens are sacrificed in return for a Nugget. The crew speculates that the Commander's Agenda is phoenix, and the Commander confirms this by playing the phoenix into her Playmat. If the Foolhardy Experiment of the phoenix is successful, no matter which outcome, Sirius B phoenix will be Habitable. There are no amat jets on the route to Sirius, and without the wardens the value of the unflipped Nugget is indeterminate. Thus nobody is sure if the game will end competitively or not. The Commander orders all available Workers to the phoenix Foolhardy Experiment, but the first mate objects and the Commander uses her pawn regulation to force Workers to the phoenix. The first mate successfully mutinies, hopeful that as the new Commander he will become Posthuman. The experimental delay means that the Exodus flies past Sirius without being ready to launch a Pod. The new Commander sets a course for the planet Procyon B phoenix.



EASILY MISSED: Two colors that are opposite to each other on the Political Hexagon, such as individuality (gray) and unity (yellow), are Archenemies. [Archenemy]

ATTRITION ROLL EXAMPLE

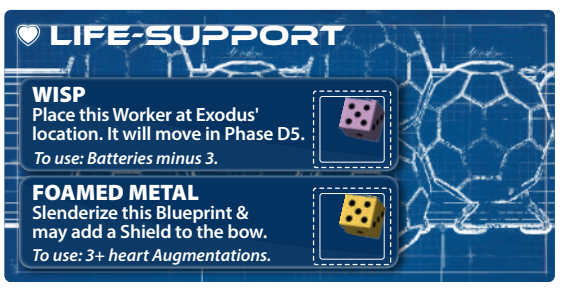
Pachamama the Ecologist is Age 5 (66 years) and equality has 2 Stress. During Phase D7, Pachamama's adjusted age is 5 + 2 = 7. At this Age, she survives her Attrition Roll only with a "1," "2," or "3."



AUGMENTATION TOKENS

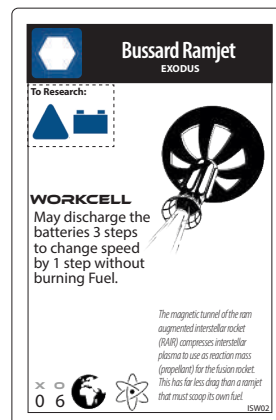


TWO AVATARS ASSIGNED TO MAINTENANCE



BUSSARD RAMJET WORKCELL

IN POPULAR CULTURE: Ever since it was first proposed in 1960 by the physicist Robert W. Bussard, the Bussard ramjet has been the science fiction staple for plausible non-rocket Starship propulsion. It is used in Poul Anderson's novel *Tau Zero*, Larry Niven in his *Known Space* series of books, Vernor Vinge in his *Zones of Thought* series, and referred to by Carl Sagan in the television series and book *Cosmos*.



EASILY MISSED: Since Avatars are merely returned to their Trapezoid if Killed, they are effectively immortal. [Busted]



ENDGAME CHIT IN A COMPETITIVE ENDGAME



CYBORG PLACARD, 102 YEARS OLD



Awake/Asleep. Each Ideology is constitutionally limited to 1 Awake Worker at a time. A Cyborg is Awake if its placard is in a Slot (excluding newborns), Asleep if in the Jars, and dead if in the Soylen Green Pile. An Avatar is Awake if its dice is not in the Jars. An Ideology is Awake if it has a Cyborg in any of its Slots (excluding newborns) and Asleep otherwise.

Blueprint. A rectangular placard that represents one of the 6 locations of the ship: Shields, wardens, life-support, Jars, batteries, or engine. They all have two Maintenance Cells. Except for the Shields, they may be *slenderized* (E1c), which makes that Blueprint one step lighter and optionally adds a Shield to bow. They can also be *Lost* (E4).

Bussard Ramjet. If successful, this Workcell allows *Exodus* to scoop its own Fuel out of the interstellar medium. If the batteries are discharged 3 steps, a ramjet *Exodus* accelerates or decelerates by 1 step without spending Fuel.¹¹⁷

Busted. Adding a *red disk* (B1j) or a Shield Blueprint into a Slot indicates that it is Busted. This happens during *Blueprint Loss* (E4). Busting Kills the Slot's Workers (unless saved by *Commander Rescue* (E4c) during Shield Erosion or jettison) and Discards its Workcells per B6e. Store Shields in the right Playmat Slot on their "Busted" side.

Cell is a Workcell, placard, or chit where you can assign Workers during **Phase D1** (assignment). This enables you to make a Workcell/Goo Roll during **Phase D3** or perform its listed Task during **Phase D4**. There are 5 types of Cells:

- **Workcell** (in a Playmat). Must succeed in a Workcell Roll during **Phase D4**. If the "To Use" listed on the Workcell is not met (H2), you can assign there but will not be able to make a Workcell Roll. Each Workcell corresponds to a *Blueprint* (B2b) (e.g. Workcells with a triangle are located in the engine room).
- **Goo Cell** (on a Goo chit in a Blueprint). Workers assigned here fight per H3 during **Phase D3**.
- **Pregnancy Cell** (on a young female or Hermaphrodite per D1f). With a successful Motherhood Roll (H5a) during **Phase D3**, a child is born from the Jars or Soylen Green.
- **Maintenance Cell** (on a Blueprint). Performed during **Phase D4** per E2. Each is limited to 1 Worker.
- **Stadium Cell** (C4b). Any Worker assigned here during D1e removes all but one Stress on their Playmat during **Phase D4**.

Chief Engineer. For a successful Workcell or Goo Roll, this is the color with the successful roll, with the Playmat owner breaking ties, see H1f. For a Maintenance Task, the single Worker color there is always the Chief Engineer. In case of 2 or more Workers tied for the most successful rolls, the Ideology owning the Playmat decides.

Combined Game. This game is continued from *High Frontier*, with *Modules 0, 1, 2, & 4*. For *setup*, see C8.

Commander is the last Cyborg to have won an *election* (F3). One *Commander's star* (B1h) is placed on the Cyborg and another is placed in the Trapezoid of their color in the Political Hexagon. The Commander makes the *helm decisions* (F2) and his/her Ideology sets the marriages and Regulations enforced on the Starship.¹¹⁸ Can *rescue* (E4c).

Competitive Endgame. If the *endgame chit* (B14b) is flipped to its "king" side, endgame victory points are scored per J3.

Cosmos. The area in the center of the map where the Nuggets are kept (C4), until accumulated by Erosion on the ship's bow. The Cosmos starts with 3 facedown Nuggets which cannot be Peeped.

Cyborg. Because pure humans would never survive the voyage's radiation levels, the ship's crew are hybrids of humans and machines, represented in the game by a Cyborg card and its Cyborg Dice. As Workers, Cyborgs differ from Avatars in that they Age, can research, and their Workcell Roll (during blueeye) can cause Augmentation reward, Stress, or death. Cyborgs can be male, female, or Posthuman. If in the Jars, it is called an **Embryo**.

Cyborg Roll is the value showing on a Cyborg dice (if any), after a Pregnancy, Workcell, or Goo Roll. It determines *additional Stress* or *accidental deaths* (H1g) and *Goo outbreaks* (H1i),

¹¹⁷BUSSARD RAMJET is a propulsion concept in which the vehicle scoops hydrogen with a huge electromagnetic field as it flies through space. A protium fuel engine uses the scooped hydrogen as fuel, using the catalyzed CNO cycle found in the fusion of larger stars. The idea of gaining fuel directly from the interstellar medium is an appealing way to get around the rocket equation. Unfortunately, the magnetic drag created by any field large enough to capture a useful amount of hydrogen fusion fuel would create more drag than the engine could produce as thrust. Thus a Bussard ramjet could only be used in deceleration. Moreover, the magnetic scoop would need a funnel of 100 km diameter to generate the 250 kN thrust of the *Exodus*, and an axial Fishback solenoid of unreasonable length to generate such a funnel. The only known scheme to make an interstellar ramjet concept plausible is to prelaunch fuel along the spacecraft's trajectory using something like a magnetic rail-gun. —Robert Bussard, *Galactic Matter and Interstellar Flight*, 1960. —Schattschneider & Jackson, *The Fishback ramjet revisited*, 2022.

¹¹⁸COMMANDER. "The human animal wants a father-mother image but, at the same time, resents being disciplined. You can get stability like this: The ultimate authority source is kept remote, god-like, practically unapproachable. Your immediate superior is a mean son-of-a-bitch who makes you toe the mark and whom you therefore detest. But his own superior is as kind and sympathetic as rank allows ...Therefore she adds benignity to the attributes of Ultimate Authority." Charles Reymont, the ship's Constable on-board the fictitious colonization Bussard ramjet *Leonora Christine*. —Poul Anderson, *Tau Zero*, 1970.

Discard. A Workcell or Agenda Card is voluntarily Discarded by moving it to the bottom of the *draw deck* of its shape (**C3a**). This can happen during a Plasma Risk Roll or during *trashing* (**B6b**). Voluntary Discard (during jettison) returns Workers on affected Workcells or Blueprints to their Trapezoid, while involuntary Discard (*Erosion* (**D5e**), *Goo Spread* (**H4a**), or *lightning* (**H6b**)), Kills Workers (with no permanent effect on Avatars). Discarded chits and Blueprints go into an "available" pile, except Discarded Shields go into the rightmost Slot of their Playmat. Discarded Nuggets go into the Starship bow.

Domesticate. Converts dangerously cancerous Goo into Domesticated Goo during a Goo Roll (**H3b**).

Domesticated Goo. An Ideology that Domesticates Goo per **H3b** or in a Foolhardy Experiment places that goo chit upon their Playmat in the appropriate Shadow. It is often needed for the *right stuff* (**I5b**) to make a Goldilocks Habitable, during *Terraforming* (**I3b**), or *refueling* (**I3a**). Furthermore, it is worth 4 VP.

Dozyear. Short for "dozen years"; the 12-year turn corresponding to the 12-year Sunspot Cycle in *High Frontier*.

Dustbug. This bug-shaped token (**B1I**) is a space vehicle deployed per **E2b** or the "MHD Dustbug" Workcell. Once deployed, it moves up to 4 spaces maximum then loiters in that space. It is used to convert an LIC into an ordinary space (**D5e**), *flare/debris mitigation* (**H6g**), or for the *panspermia Medallion* (**I4h**).

Earth Data. These 6 cards represent the latest biological/technological ideas from Earth. They are setup facedown into the Jars per **C4b**. You can announce (and lie about) your facedown Earth Data to other players (but cannot show the card). If your *radio signal dome* (**G1e**) reaches Sol per **D5a**, flip your Earth Data faceup on top of your Jar. Each revealed card becomes public knowledge with benefits that you cannot exclude from any player. Faceup Earth Data is preserved even if the Jars are Lost.

Earthware Icon (**B2g**). When a Workcell with the  icon is researched, place a radio signal dome on it (with a color as chosen by the Chief Engineer). This indicates that data with a trade value to Earth/Sol is ready for broadcast.

Embryo. A Cyborg placard and dice stored in the Jars. It is considered Asleep and is worth 4 VP.

Erosion. The Loss (and replacement by a facedown Nugget) of the bow Blueprint by sandblasted (**H6a**) or *lightning* (**H6b**), during *entry of LIC* (**D5e**), *flare/debris space* (**B8b**), *Oort icebraking* (**F2c**), or *fryby* (**F2d**).

Exploration instantly flips all unrevealed air and water chits at a Star, see **I1**. Thematically, this is a telescopic exploration. It occurs if either *Exodus* or a Wisp enters a Star, or if a Wisp enters a Sunlens (**D5b,g**). Also some Workcells can Explore.

Foolhardy Experiment. A type of Workcell that requires an unflipped Nugget to exist outside the Cosmos, both to *research* (**G1b**) and to make a *Workcell Roll* (**H1k**). A successful Workcell Roll permanently flips all Nuggets outside the Cosmos faceup, and the effects of the experiment depend upon if **X** or **O** is the majority on all faceup Nuggets. See **E6**. These effects are listed on the card. If neither is in the majority (i.e. there are 2 faceup Nuggets, and one is **X** and the other **O**), a Posthuman is created per **E6c**.

Fuel. The number of tanks of He³-D Fuel remaining on the Starship is indicated by the Fuel strip (map).

Goldilocks. A rocky planet that is "not too hot" and "not too cold" for a water-cycle biosphere, which is solar-powered by either a yellow sun or red dwarf.¹¹⁹ A Goldilocks needs the specified right stuff and enough hydration  to be Habitable.¹²⁰ It has a yellow pointer and is defined by exactly two Planet Chits: one air and one water. Together these chits specify *existence* (**I1a**), *water cycle* (**I5a**), and the *right stuff* (**I5b**). The water cycle of a Goldilocks can be further bolstered by a  icon after its name on the map (**I5a**).

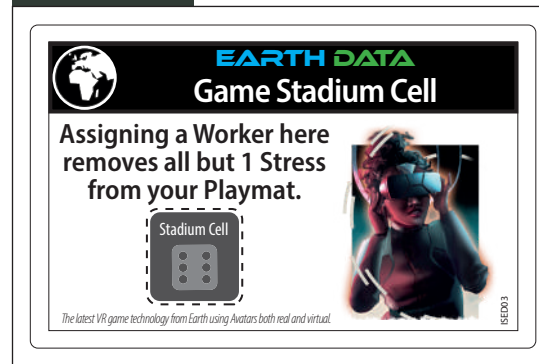
DOMESTICATED GOO CHIT (JARS)



DUSTBUG TOKEN & PANSPERMIA MEDALLION



EARTH DATA CARD



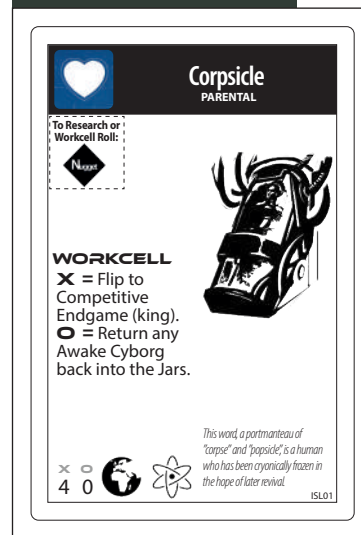
EARTHWARE ICON



EASILY MISSED: If your Shield suffers Erosion, you receive one of these two Medallions. [Erosion]



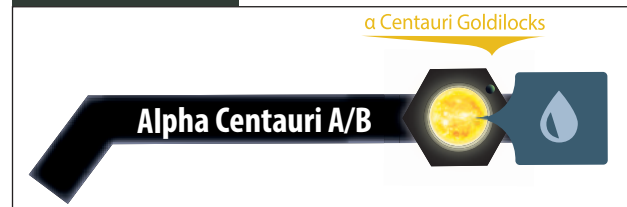
FOOLHARDY EXPERIMENT WORKCELL



EASILY MISSED: The Chief Engineer of a successful Foolhardy Experiment gets the "mad scientist" Medallion. [Foolhardy Experiment]

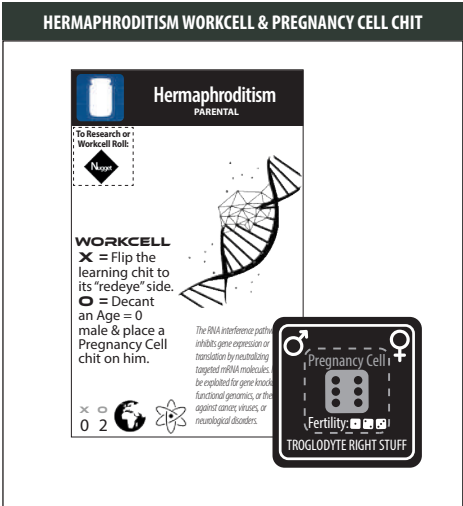
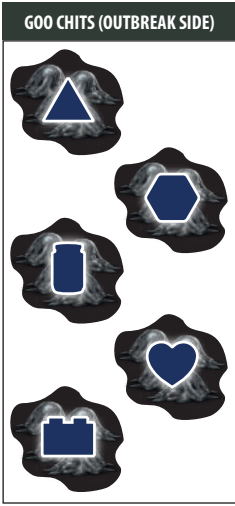


GOLDILOCKS PLANET



¹¹⁹ **GOLDILOCKS ZONE** is the range of orbits around a star within which a planetary surface can support liquid water given sufficient atmospheric pressure. It is also called the **habitable zone**. The Goldilocks zone is from 0.8 to 3 AU around a G class yellow star, 0.27 to 0.03 AU around a M class red dwarf, 0.01 AU around a white dwarf, or 0.005 AU around a T-class brown dwarf.

¹²⁰ **TERRAFORMING MARS.** The planet Mars lies at the outer edge of the Sol Goldilocks zone. To make it habitable, it might need two solar-powered species of Domesticated Goo to thicken the atmosphere. Furthermore it is a desert planet, with insufficient water frozen in its icecaps to make it habitable even if all the ice was melted with nuclear energy. If there is sufficient permafrost in its crust (this remains unknown), deorbiting one of its moonlets, Phobos or Deimos, would kickstart a water cycle that would last for millennia. Yet even with a terawatt starship engine able to refuel regularly in Saturn's helium-rich atmosphere, it would take centuries to deorbit Phobos. Much quicker to dislodge marginally held balls of ice in the LaGrange points of Jupiter or Saturn, to fall into the orbital path of Mars.



IGNITION CELL EXAMPLE

The batteries are at charge = 2, and the Starship is at Tau Ceti. However, at speed = 2, she is much too fast to enter Orbit. An Avatar assigns to Ignition in order to decelerate the Starship. The engine is on its fat side, so the batteries must discharge by 2 steps. Unfortunately, the nearly-empty batteries (at charge = 2) can only discharge by 1 step. So another Avatar must assign to the MHD Recharge Cell in the batteries. The sequence in Phase D4 is: the batteries charge to 6, then Ignition discharges the batteries from 6 to 4. Only then can other Maintenance that drains the batteries (such as Wisps or decanting) be performed. A double delta-v is needed to decelerate by 2 to an Orbital speed = 0. The Starship has 35 tanks of fuel, low enough for a double delta-v that burns 2 steps of Fuel.



MOTHERHOOD - A GAME THESIS

As long as humans reproduce and spread genes in a Darwinian fashion, their focus will be on individuals and individual diversity. The primal Darwinian unit - that is, the entity expressed by and holding the evolving genetic code - is the individual (and not the species or group). Darwinism dictates that isolation and small populations breeds diversity and speciation; these same factors also breed radical new ideas and technologies.

But what sort of being will humans become if they manage to transcend motherhood, mortality and Darwinian reproduction? This question is explored in the Posthuman rules. It is hard to say if such a being will be an individual or some composite. But the universe is a rational place and so must any survivors within it. It is certain that the pursuit of rationality and the knowledge of science will remain as the core of morality and survival.

—Phil Eklund, 2023.

Goo. Short for "gray goo." *Exodus* cannot function without her army of reproducing machines and neogens (life tailored from existing species), from nano- to macro- in size. These operate with various sources of energy, consuming worn machinery or the dead of their kind. But occasionally, under the stern ambient radiation, a cancerous mutation develops that overrides the reproductive protocols and thrives like a virus, reproducing for the sake of reproduction. A Goo outbreak occurs per **H1i**, *spreads* per **H4**, and is *fought* or *Domesticated* per **H3b**.

Goo Roll (H3). This is jointly made by Workers on a Goo chit and resolves a Goo fight, see **Table H3**.

Habitable. A planet upon which a Cyborg does not Age or make an Attrition Roll (presents a self-perpetuating colony). A planet is Habitable if the Cyborgs present have the *right stuff* (**I5b**, **I6b**). A Goldilocks must additionally have at least 💧 of *hydration* (**I5a**) to be Habitable.

Hermaphroditism. A Foolhardy Experiment that, if successful, may decant an embryonic male from the Jars, and change him into a reproductive Orphan. Place a *Pregnancy Cell chit* (**B14c**) to indicate the change.¹²¹ This chit follows the rules for *Motherhood* (**H5**) and also indicates that this Cyborg acts as the *Troglydyte right stuff* (**I6b**). The fertility dice of a Hermaphrodite is "1," "2," and "3," for all Ages.

Ideology. A political premise on how exohumanity should be socially organized for prosperity and survival.¹²² Each has a color equivalent to the six BSU's (basal societal units) in *High Frontier*. Some BSU's are opposites:

- **Individuality (Gray)** BSU = diverse group, is the Archenemy of **unity (Yellow)** BSU = unified group.
- **Freedom (Red)** BSU = self, is the Archenemy of **authority (Purple)** BSU = benevolent dictator.
- **Honor (White)** BSU = personal distinction, is the Archenemy of **equality (Green)** BSU = society.

Ignition Cell (E2i). Assignment to this engine Maintenance means that the engine is **ignited**, assuming at least 1 step of Fuel. Furthermore, the battery must be discharged the number of steps indicated (2 steps if fat side, 1 step if skinny side). If the battery charge is too low, the engine may be ignited by assigning both to the Ignition Cell and the *MHD recharge* (**E2g**) Cell, which sequentially charges the batteries to 6, then must drain the steps specified for ignition.

Jars (B4d). These 6 containers hold the embryonic Cyborgs (placards & dice), inactive Avatar dice, and Earth Data cards. It also contains the radio transmitter, and its Loss Discards all radio signal domes and facedown Earth Data Cards.

Kill. If a Cyborg is Killed, its placard goes into Soylent Green Pile. If Goo is Killed, return its chit to the reserves. If an Avatar is Killed, move its dice to its Trapezoid (indicating that it is quickly repaired and ready for assignment in the next Dozyear).

LIC (Local Interstellar Cloud). Spaces on the map containing neutral particles and grit that cause Erosion (**D5e**).¹²³

Loss, Lost (E4). Discarding a Blueprint, which destroys part of *Exodus* and its contents. Lost Jars Busts the left Slot of each Playmat, plus Kills everyone in the Jars. Lost life-support Busts the center Slot of each Playmat. Lost engine dumps all the Fuel. A Lost Shield is not Discarded, but instead added to that color Playmat, Busting the Shield Slot per **B6e**.

Maintenance Cell (E2). Each has a listed Task which is automatically successful if a Worker assigns there. See Cell.

Market. This matrix has 5 columns and 3 rows. Thus there are normally 15 ideas visible in the Market. During your pulse in the *assignment phase* (**D1**), you may assign your Cyborg to a Workcell in the Market to research it into a Playmat (**G1**), or assign your Avatar into the Market to move that Workcell to the bottom of it draw deck.

Medallion. Each of these chits is worth 4 VP and is awarded per **B12**. There are 6 classes (plus *Combined Game* (**B12g**),

Motherhood Roll. If a young female assigns to her own *Pregnancy Cell* (**D1f**), during **Phase D3** she rolls per **H5a**. This rolls 1d6 and consults the fertility dice printed on the female's placard to see if she successfully bears a child. If married, may make one reroll of this roll (**H5b**). The newborn is chosen from either the Jars or the Soylent Green Pile.

Neutron Sensitive. The ☄ icon appears on Workcells and Agenda Cards that are relatively sensitive to radiation, and thus are Discarded during "NEUTRONS" *Plasma Risk Rolls* (**H6c**).

¹²¹ SEQUENTIAL HERMAPHRODITE is a macroorganism that, at different life stages, changes between a male producing male gametes and a female producing female gametes. If an organism conceived as a male changes into a female, as described here, the hermaphroditism is called **protandry**. This capacity is common among plants, invertebrates, and fish, but not known in other vertebrates such as birds or mammals. Hypothetical hermaphrodite biotechnology would not change the sex chromosomes (that would be impossible) but would allow an XY male to express the endometrial and other cells necessary for corporeal or extracorporeal reproduction. Such speculative technology might be useful for those now in the LGBT community.

¹²² IDEOLOGUES. Each ideology promotes its particular principles for the most beneficial social system. This excludes pragmatists, persons who follow no set principles or scruples. A pragmatist enjoys the advantage of unscrupulous flexibility, guided only by the emotions of the moment. It is assumed that the tiny community on board the *Exodus* cannot afford such lack of scruple.

¹²³ DETECTING LIC. "It is not possible to determine the properties of interstellar dust grains in the cloud around the solar system using remote astronomical techniques. This is due to the low total column densities in the LIC cloud (a column density is space density times cloud length, and has units of 'per centimeter squared'). In-situ observations from spacecraft are the only way to obtain data on the full mass distribution of the dust grain population in the cloud surrounding the solar system." —NASA, *Interstellar Science Technology, Mission Roadmap*, 1998.

Nugget (E3a). A token representing exotic matter that accumulates on the Starship's bow during Erosion.¹²⁴ By using the wardens (**E2a**), it can be prospected and stored on a Playmat (worth 4 VP). A Nugget exists in two states: *unflipped* (facedown), or *flipped* (faceup). Once flipped faceup, it can't go back to facedown. Peeping does not change its state. If unflipped outside the Cosmos, it enables Foolhardy Experiments. Flipped or unflipped, it can serve as *Goldilocks right stuff* (**I5b**) or *cooperative VP* (**J2**).

Oort Cloud Comets. These icy bodies are always found in a Sunlens space, see Sunlens.

Orbit. If *Exodus* is at speed = 0 on a Star's space, she orbits that Star. At an orbital speed of about 30-42 km/sec, she can face in any direction.

Orientation. A Blueprint can be in two Orientations, either **fat** or **skinny**. Fat has a dry mass (80 tonnes) twice that of skinny (40 tonnes). A Cyborg can be in four Orientations, to designate his/her Age in Dozyears.

Orphan. Place this chit upon a Cyborg that is decanted rather than born. It indicates that it was raised by a robotic nanny rather than mom. When it becomes old, this chit is a reminder that its Wisdom is inactivated.

Peep. This allows a player to privately look under an unflipped Nugget, which must be either in the bow or on another Playmat.¹²⁵ A Nugget always remains unflipped after a Peep. You may always look at a Nugget in one of your Playmats. Peeping is activated by certain Abilities, entering a planet jet spaces on the map (the Commander does the peeping), or revealing a Planet Chit with the  icon (**I2c**) and the planet exists per the *pair rule* (**I6a**). If a Wisp is used to reveal a Peep Planet Chit, the Wisp owner does the peeping.

Phase. The *sequence of play* (**D**) for each Dozyear is 7 Phases. After all players have completed a Phase, go to the next, indicated by moving the *phase cylinder* (**Da**) down one step.

Plasma Risk Roll. A risk resolved by rolling one dice (1d6) on the *Plasma Risk Table* (**H6**). This can be modified (**A4I**). There are 3 occasions to make this roll: when making a Pod Launch (row 1), when entering flare or debris Star systems (rows 2 & 3), or when violently braking the Starship (rows 4 & 5).

Planet Chit. These chits are randomized until revealed by an Exploration. There are 2 types: air and water. See **B11**.

Playmat (B6). There are always six Playmats, one for each Ideological color. Each player can control up to 3 (**C1a**) in which to store Workcells, Stress, Nuggets, Commander's star, and chits. You may not swap Cyborgs, tokens, chits, or cards between your Playmats. In solitaire games, the player controls all playmats.

Pod is a lander that allows a landing party consisting of 1 or 2 volunteers (either Cyborgs or Embryos, with at least one female or Posthuman) to bail out via a *Pod Launch* (**I4**). This allows *Exodus* to continue its flight to other planets. If *Exodus* is not in Orbit, a Pod must make a Plasma Risk Roll (row 1) (**H6f**), reflecting the hazards of extreme deceleration.

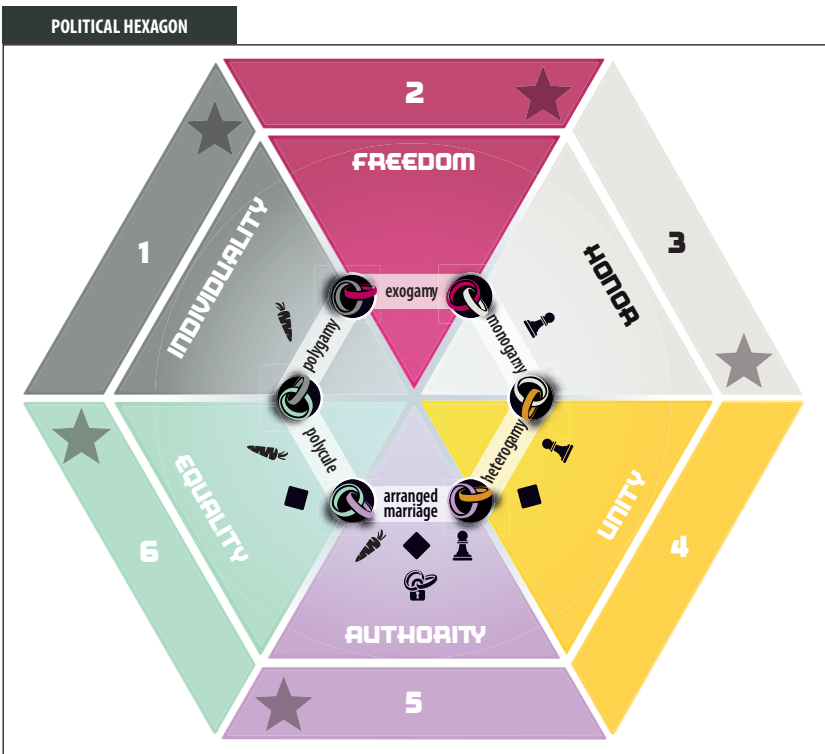
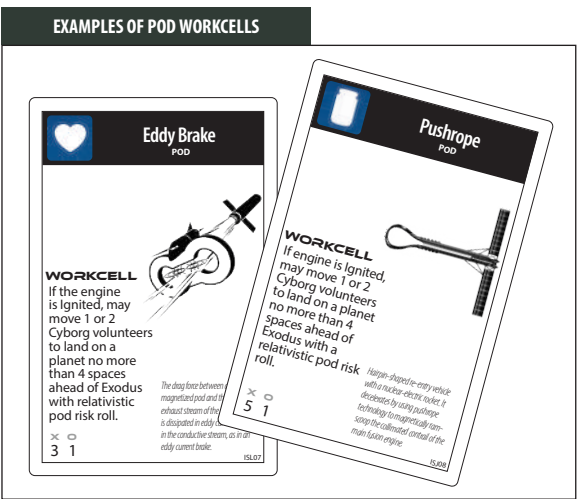
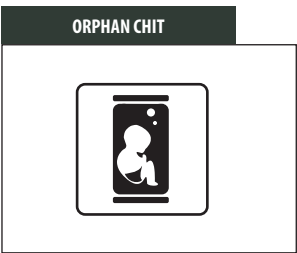
Pod Launch (I4). A Pod containing a landing party can be launched either by Maintenance (**E2f**) or a successful Workcell Roll on a Pod Workcell. The destination must be an uninhabited Star system no more than 4 spaces ahead of *Exodus*. If the launch is greater than Orbital speed, make a Plasma Risk Roll (**H6f**) to see if the Cyborgs land safely, awarding *seedship Medallions* (**B12f**) to the survivors. A Pod Launch is not Arrival and the game continues if there are still living Cyborgs on *Exodus*.

Political Hexagon. This diagram on the map shows the game's six Ideologies.¹²⁶ The geometry indicates which are adjacent and which are opposite. On the perimeter are the six Trapezoids with numbers to indicate the pulse order (**D1**). A star token here indicates who is in command, and Regulation icons indicate the Regulations. Rings on this diagram indicate which Ideologies are married to each other.

¹²⁴ NUGGETS are hypothetical metastable grains of true vacuum, based upon the leading theory and observations of the electroweak vacuum and its stability landscape. Discovery of the top quark in 1995 and the Higgs boson in 2012 have validated the state of the universe as a false vacuum, at a higher energy than the true vacuum (which, despite its name, is not empty but filled with quantum fields). The barrier height separating the two vacuums is not known. If it can be surmounted by bubble nucleation, the false vacuum decays into the lower-energy true vacuum. Given a Higgs mass of 125 GeV, and a possible pole mass of the top quark of 173 GeV, the nucleation would yield a true-vacuum "Nugget" that is metastable. —Markkanen, Rajantie, & Stopyra, *Cosmological Aspects of Higgs Vacuum Metastability*, 2018.

¹²⁵ HOW TRUE ARE OUR PERCEPTIONS? "Perception apparatus providing false information about the outside world is just as incompatible with survival as a false enzyme or a defective heart valve. The monkey, who had no realistic perception of the branch he jumped for, was soon a dead monkey. ... We are the first and only living beings on this planet who know that there must be a real, objective world. A world whose objective qualities exist independently of ourselves: the "world itself" in the language of the epistemologists. What is more, our minds are only enough to realize that we are not in a position to see this objective world in any way. The ultimate step in our common sense is to recognize that we, too, are still living in a subjective reality. ... Also in the subatomic sphere, where we are dealing with proportions and standards that are just as far removed from those of our world of experience as those of outer space – just as it were in the opposite direction – the laws of our logic and perceptions no longer exist. A light quantum turns out to be a wave or a particle at the same time, depending solely on the method of observation." —Himar von Ditfurth, *Der Geist fiel nicht vom Himmel* (translated), 1976.

¹²⁶ POLITICS is defined as the science of how persons should treat each other in a mutually profitable social system. This is consistent with other games in the *Bios/High Frontier* series.

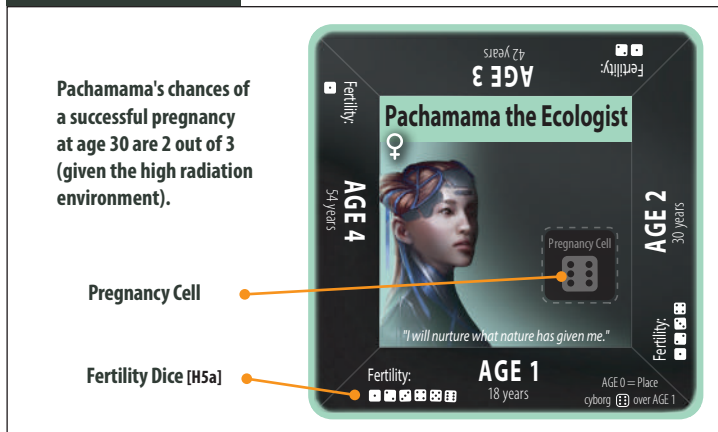


POSTHUMAN EXAMPLE

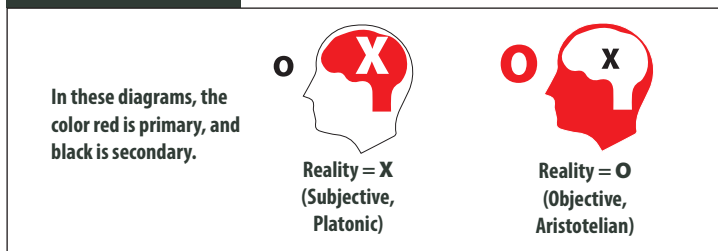
The Starship calamitously lost 2 Blueprints in the LIC traveling towards Bernard's Star. Wisp reconnaissance shows no Habitable planets at Barnard's, but there is a carbon planet Troglodyte at the nearby system of Luhman's Rogue Planet. Because of the loss of so many Workcells (making a cooperative victory unlikely), and because the bow contains two unflipped Nuggets, the crew decides that their best chance is attempt a Foolhardy Experiment, which has a 50% chance of creating a Posthuman capable of making the Troglodyte Habitable. Everyone crowds onto this foolhardy Workcell, hoping to become the Posthuman and thus have the edge for a Competitive Endgame.

EASILY MISSED: The Posthuman placard has a male and a female side, and either side may be chosen when created. A Posthuman of either gender can reproduce only on a Habitable Planet, not on the Starship. The Posthuman, if the Commander, gains the "pawn" regulation. [Posthuman]

PREGNANCY CELL



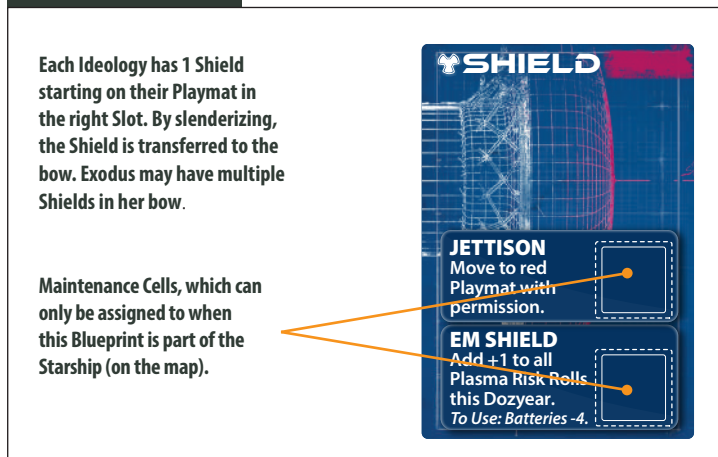
TWO THEORIES OF REALITY



REGULATION ICONS



THE FREEDOM SHIELD



Posthuman. An immortal heavily-augmented Cyborg. It can be created by being the Chief Engineer during a Foolhardy Experiment (E6c), if afterwards there are two faceup Nuggets: an X and an O. A Posthuman is alternatively created by accumulating 4 Augmentations (H1h). Use the Posthuman placard to replace the Cyborg(s) of the new Posthuman Ideology, and twin its Cyborg Dice. A Posthuman changes a Cooperative game to Competitive, indicated by flipping the endgame chit (B14b) to its Competitive "king" side, see J3. Further:

- Cyborg Assimilation.** If you become the Posthuman, Kill both of your Cyborg placards (if they are alive, without gaining founder Medallion). Place the Posthuman placard in a Slot on your Playmat, trashing Workcells if necessary.
- Twinned Cyborg Dice.** The Posthuman gains one extra (black) Cyborg dice. These two dice represent one Posthuman being and thus always stay together. During Workcell or Goo Rolls (H1,H3), both Dice are rolled simultaneously and the Posthuman chooses which one to use.¹²⁷
- Assignments, Aging, Marriage.** The Posthuman can do anything a human male can (research, cause Goo outbreaks (H1i), enter Jars, vote, become Commander, marriage (during polygamy only), collect Stress and Augmentations, etc.). But it does not Age, and can marry only during polygamy (F4b).
- Death.** A Posthuman does not age. It can be Killed by a Lost Blueprint (E4c,d), accidents (H1g), Goo spread (H4), and Plasma Risk Rolls (H6e). The game remains competitive, and the Posthuman has only its Avatar.
- Regulations & Mutinies.** Posthumans are immune to Commander's Regulations. If the Posthuman is the Commander, in addition to its other Commander Regulations, it gains the pawn regulation (F1d) over all Avatars. As with all Regulations, the Posthuman's reassignments can be protested in a mutiny with an election (F3).
- Supremacy.** Having a living Posthuman excludes any other Ideology from becoming Posthuman. If the Posthuman dies, its card is removed from the game.
- Troglodyte Right Stuff.** A Posthuman in the landing party makes a Troglodyte world (I6b) Habitable.

Pregnancy Cell. Assigning a female Cyborg's dice to this square on her own placard is an attempt to get pregnant and raise a child to become a teenager. Hermaphroditism adds the Pregnancy Cell chit (B14c). See Cell.

Pulse Order Number. As shown in the Trapezoids on the Political Hexagon. Pulse Order Numbers are: gray (1), red (2), white (3), yellow (4), purple (5), and green (6). Assigning Workers (D1) proceeds from lowest to highest Pulse Order Number. A tie during an election (F3) is decided by the Awake Cyborg with the lowest Pulse Order Number.

Reality. That which exists outside of our minds. If Reality = X, then the philosopher Plato is correct: consciousness is primary and what lies outside our minds is but a shared mental construct. If Reality = O, then the philosopher Aristotle is correct: existence is primary in which our concepts and imaginations are part and must accommodate.

Regulation (F1). These rules allow the Commander to reassign Workers or seize Nuggets during Phase D2. The rules are specific to the Ideology of the Commander, as shown by icons on the Political Hexagon.¹²⁸ Regulations include state security, arranged marriage, carrot, and pawn, see F1.

Restore. The Foolhardy Experiment "Weak Boson Physics" can restore a Lost Blueprint (on its skinny side) plus its Workcell deck (shuffled and setup per C3a). Due to conservation of mass, restoring a Blueprint must Discard a Shield.

Risky (D3a). If a Cyborg rolls a "6" in a Workcell Roll with the 6 icon (H1g), or in a Goo Roll (H3), it is Killed.

Shadow. These spaces are found on each Playmat to hold tokens (Commander's star, Nuggets) and chits (Medallions, Augmentations). Each Shadow can hold but one token/chit, worth 4 VP each.

Shield. Each Ideology has a Shield Blueprint of their color. Create it by making a Blueprint skinny (thematically it is made out of the mass saved). This moves the Shield into the bow and unbusts the Shield Slot on that Ideology's Playmat.

Slots. Each Playmat has 3 Slots. The first is Busted if the Jars Blueprint is Lost; the second is Busted if life-support is Lost, and the third is Busted if their color Shield is Lost. Each Slot can hold 12 tonnes: either one Cyborg or one pair of Workcells. A Slot is Busted per E4d and unbusted per E5. Add or subtract a card/placard from a Slot per B6.

Soylent Green Pile. A discard pile on the map for dead Cyborgs. They may be reborn by a successful Motherhood Roll.¹²⁹

¹²⁷POSTHUMANITY. The game's concept of emergent consciousness as largely language-based rather than an evolved intelligence follows the ideas of the Julian Jaynes society. Dr. Jaynes postulates the origins of human consciousness as a breakdown of a former mode of authoritarian decision-making. This breakdown has led to "quests for authority," "the need for authorization," "the power of suggestion," and many other uniquely human tendencies. In this view, human politics tends toward the authoritarian corner of the Nolan Chart (the basis for the Political Hexagon) as an artifact of how consciousness came to be. However, a conscious computer, having a different origin of consciousness ("maind" rather than mind), would not share this purely biological ilk. Furthermore, if the machine happened to be immortal, the human basis for morality would be removed. Under these conditions, speculated that a suddenly conscious machine would tend toward the upper (freedom) part of the Nolan in its dealing with other consciousnesses.

¹²⁸REGULATION. This is legal force applied to restrict a human action, including use of property. A regulation differs from a Law, which is a universal standard, the truth of which is set in human nature rather than political expediency. Laws found to be useful in all societies prohibit initiation of force such as lying, cheating, stealing, and murder.

¹²⁹SOYLENT GREEN is taken from the 1973 dystopian film set in the year (ahem) 2022.

Stadium Cell. A Cell located on the "Game Stadium" Earth Data card. See Cell.

Starship *Exodus*. A rocket represented on the map by a token with facing, and configured as indicated by the arrangement of Blueprint placards. See **A2** for its specifications.

Star. Each large *space* (**B8a**) contains a Star/binary Star, plus its system of planets (**B11**). Star types are yellow suns and red dwarfs. Rogue planets are brown dwarf Substars, but are treated as Stars in this game.

Stress are red disks placed upon a Playmat. They represent radiation dosage, the burden of responsibility, and the mental baggage of sanity-sapping misfortunes accumulated by a dynasty. Stress is important in *Goo outbreaks* (**H1i**) and *Attrition Rolls* (**D6a**). Stress occurs during engine *ignition* (**E2i**), *Archenemies* (**D7b**), *creative stress* (**G1c**), and rolling a "6" in a *Workcell Roll* (**H1g**) or *Motherhood Roll* (**H5a**). If you run out of disks, use substitutes. Stress is removed by assigning to the *Stadium Cell* (**D1e**), by marital *bliss* (**D7c**), or by the *mimarobe* (**D7e**).¹³⁰ An Ideology that is Asleep loses 1 Stress per **D7b**.

Substar. A white dwarf, brown dwarf, or gas giant, usually orbiting a Star or other Substar.

Sunlens. A space on the map containing a  icon is at the focal point of a gravitational lens focused by a nearby Star. The arrow points towards that Star. Moving a Wisp into this space allows a *snapshot* (**I1**). A Sunlens space also contains Oort Cloud Comets, enabling Oort *icebraking* (**F2c**).

Task. A listed game effect in a Maintenance or Stadium Cell. It is automatically successful.

Terraform (*I3a*). If a Goldilocks has  or less of *hydration* (**I5a**), it is too dry to be Habitable. Terraforming delivers additional water to a Goldilocks to make it Habitable, either by the "Deep Hot Fusion" Workcell, or by launching *dropstones* (**E2h**).

Token Management. Tokens and chits are limited to what is supplied, on a first-come first-served basis. However Stress and Busted disks are unlimited; use substitute red disks if you run out.

Trapezoid (F). Each Ideology has a trapezoidal area in the outer perimeter of the Political Hexagon. The Trapezoid contains the Pulse Order Number. Store unassigned Worker dice and marriage rings here.

Troglodyte. Meaning "cave dweller," it refers to a phoenix planet, carbon planet, or icy moon. It supports a subsurface water-cycle biosphere powered by natural¹³¹ and human nuclear energy. It has a blue pointer. Its existence and characteristics are defined by a single water chit adjacent to a Substar, and exists if this water chit is adjacent to the Substar specified on the chit (white dwarf, brown dwarf, or gas giant). The landing party must include a Posthuman (or Hermaphrodite) to make a Troglodyte Habitable (**I6b**).

Waterworld. A Goldilocks with  or more *hydration* (**I5a**). Possible at Super-Earths or by Terraforming.

Wisdom (*B3c*). An Ability found on the old side of Cyborgs. It is inactive if the Cyborg is an Orphan. You can negotiate the benefits of your Wisdom with other players.

Wisp. A featherweight reconnaissance probe pushed by directed energy beamed from the Starship. Launch it per **E2c** to make an Exploration (**I2**) of a Star space a maximum range of 10 spaces away.

Workcell. A card starting in the Market that can be researched into a Playmat Slot. In its corner, it has a shape showing the Blueprint it is located in. Workers on a Workcell make a Workcell Roll during **Phase D3a**. Those with a "To Research" icon (**B2c**) have a requirement in order to be researched into a Slot (**G1a,b**).

Workcell Roll. This is rolled by all Workers on a Workcell during **Phase D3a**, see **H1b**.

Worker. A Cyborg (large dice) or Avatar (small dice).

¹³⁰ MIMAROBES is the name of the operator of the *Mima*, the artificial intelligence of the accidental starship *Aniara*, as imagined by the Swedish poet and Nobel laureate Harry Martinson. The job of the Mimarobe is to relieve the ennui and existential despair of the crew and passengers by inducing dream-like trances filled with scenes from their own memories. This was depicted in the 2018 feature film *Aniara*, directed by Pella Kågerman and Hugo Lija. —Harry Martinson, *Aniara: en revy om människan i tid och rum*, 1956.

¹³¹ TROGLODYTE ENERGY SOURCES. "Tidal dissipation at the ice-water boundary provides a source of heat to warm the ice (on Europa's subsurface ocean) and maintain the liquid layer against the loss of heat through the crust to space - but little else. Radiogenic heat at the ocean base, which is on top of the silicate mantle, is a much more plausible heat source for biology, and organisms might feed off the thermal energy or the emission of reduced species to be combined with oxygen. Tidal currents themselves might serve as a source of kinetic energy, which could be harvested by organisms with movable "hairs," whose forced opening by the currents allows the flow of ions or other chemical energy sources into a cell against compositional or electrical gradients that would push the organism toward equilibrium. The induced magnetic fields in the ocean associated with passage of Europa across the magnetic field lines of Jupiter is another potential energy source. Magnetic minerals that might orient along the field lines could generate potential fields and free energy. Compared with Earth, any contemplated biosphere on Europa would be a poor producer of biomass - one quantitative estimate being no more than 10¹² g/yr biomass production with present energy sources, orders of magnitude less than Earth." —Jonathan Lunine, *Astrobiology, a Multidisciplinary Approach*, 2005.

STRESS DISKS ON A PLAYMAT



SUBSTAR ICONS



SUNLENS ICON



EASILY MISSED: The binary Star Luhman 16 A/B has two potential Troglodytes. [Troglodyte]



CYBORG "OLD" WISDOM



The Wisdom of Che the Communist allows him to steal Workcells.

TABLE J2. Cooperative/Solitaire Victory Point Goals

Assuming at least one female (or Posthuman, assuming it's a solitaire game) from any player survives Arrival, all 6 Ideologies combine their VPs (J3) to see how well humanity has done collectively. Additionally, a minimum number of worlds must have living colonists plus a minimum number of flipped Nuggets are needed to attain a particular victory level.

COOPERATIVE VICTORY LEVEL	COOPERATIVE/ SOLITAIRE OUTCOME	COMBINED NUMBER OF VPS	WORLDS COLONIZED	NUMBER OF FLIPPED NUGGETS
a. Minor loss	Immediate survival, but eventual exohuman extinction.	60 - 100 VPs	1 or more	0
b. Breakeven	ZPG (zero population growth), neither win nor lose.	101 – 140 VPs	1 or more	0
c. Victory	Linear population growth of at least 2 colonies.	141 – 160 VPs	2 or more	1, 2, or 3
d. Major victory	Exponential growth, unstoppable exohuman presence.	161+ VPs	2 or more	2 or 3

Game Credits

The Interstellar Team

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Quantum Theory: Oscar Dahlsten of Oxford

Websites. This game is indebted to:
 http://www.projectrho.com/public_html/rocket/
by Winchell Chung "Nyrath the nearly wise".

ABOUT THE COVER. Her beryllium radiators glowing, Starship Exodus flies at 16% light-speed towards another star, cocooned in its remaining fuel tanks, most of which have been jettisoned. She has just emerged from the Local Interstellar Cloud, offering a view of the center of the Milky Way galaxy not possible from Earth. Art by Anne Isaksson.



The starship Exodus under construction at an isobank located on an icy moon of Saturn in the Sol System. An isobank is a facility that mines and stores helium-3 isotope to provide clean fusion fuel for throughout the Solar System, as well as for the starship. The isotope is mined from Saturn and lifted by a space elevator. Art by Josefin Strand.



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Cover image: Anne Isaksson

