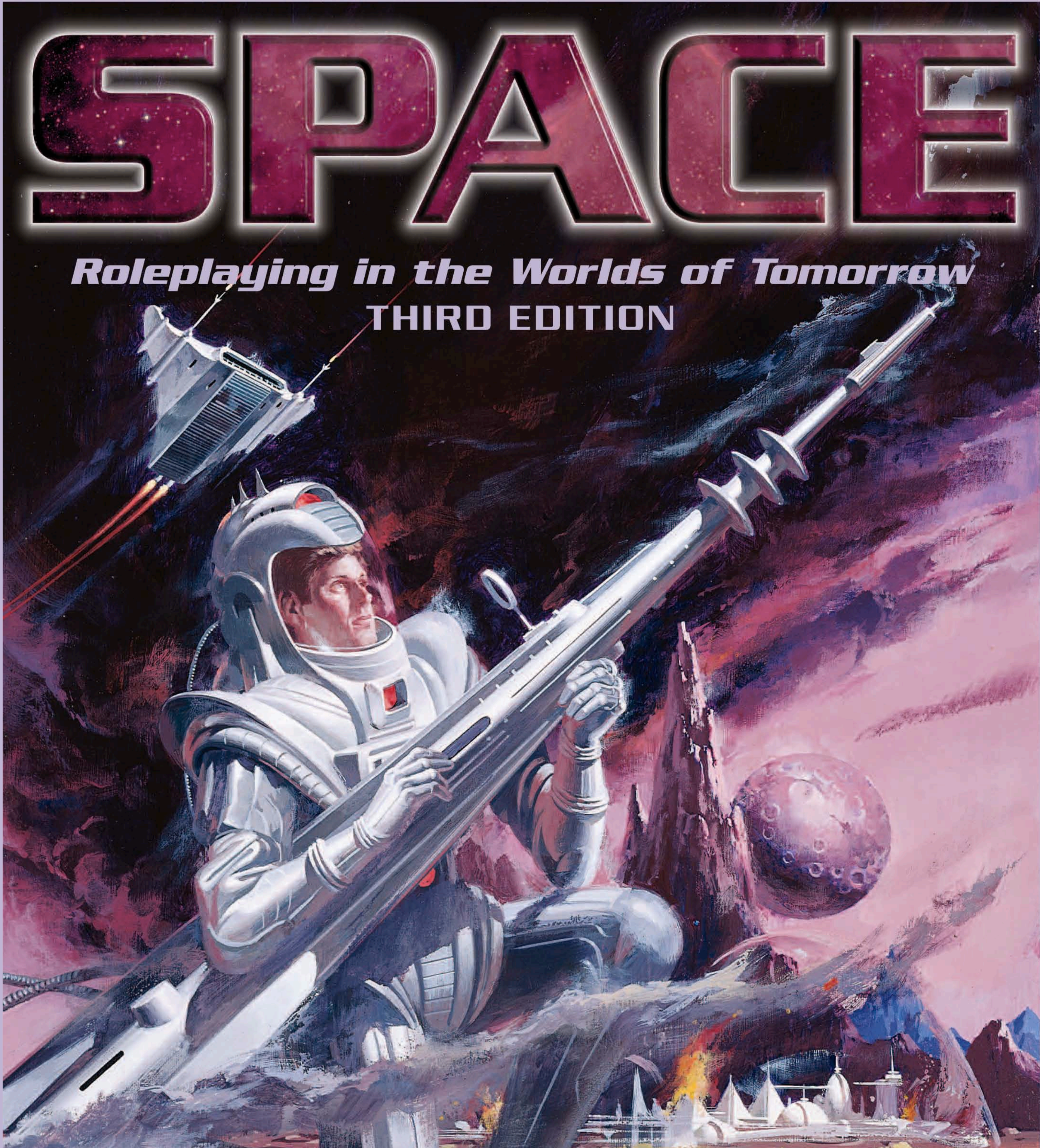
GURPS®

SPACE



Roleplaying in the Worlds of Tomorrow

THIRD EDITION

By STEVE JACKSON
& WILLIAM A. BARTON

Third Edition Revised by DAVID PULVER

STEVE JACKSON GAMES

The FUTURE Is YOURS!

GURPS Space is the star-spanning sourcebook for ***GURPS*** – now revised and expanded for its third edition. In the 160 pages of ***GURPS Space***, you'll find:

- Scientifically accurate and *up-to-date* rules for creating star systems and planets . . . either randomly or to fit a specific campaign.
- Detailed guidelines for creating futuristic and alien governments and societies.
- An informed look at the technologies of tomorrow: what will be, what might be, and beyond!
- Character-creation resources for space campaigns, featuring 24 character types, three variant human races, and four alien races.
- A full science-fiction equipment list, including weapons, gadgets, and medical technology.
- Realistic treatments of the dangers of noxious atmospheres, crushing gravity, vacuum, radiation, and other hazards of space travel and exploration.
- A self-contained, ***GURPS Vehicles***-compatible starship construction system, covering TL8 (just around the corner) to TL13+ (superscience).
- Complete ship combat rules – no ship counters, just roleplaying – for playing out ship-to-ship battles.

GURPS Space does not tie your game to a single background. Rather, it is designed for the creative GM who wants to develop his *own* universe! This book presents a wide variety of choices and background information to let you recreate your favorite science-fiction background – or build your own.

Years in the making and now extensively revised and updated, ***GURPS Space*** is a survey of the whole space-adventure genre as it relates to roleplaying. If you're ready to create your own future . . . it's yours.

Winner of the Origins Award for Best Roleplaying Supplement of 1988!

STEVE JACKSON GAMES
www.sjgames.com

GURPS Basic Set, *Third Edition Revised* and ***Compendium I: Character Creation*** are required to use this supplement in a ***GURPS*** campaign; however, ***GURPS Space*** can be used as a sourcebook for *any* science-fiction roleplaying campaign.

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THIRD EDITION, SECOND PRINTING
PUBLISHED AUGUST 2002
ISBN 1-55634-390-6
52495
9 781556 343902
SJG02495 **6005**
Printed in the USA

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Roleplaying in the Worlds of Tomorrow

THIRD EDITION

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ISBN 1-55634-390-6

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INTRODUCTION

There's this about space: It's big. Sometimes entirely *too* big. ***GURPS Space*** was tough and long-delayed, but when it hit the stores, it was worth it. When it was named Best Roleplaying Supplement at Origins 1989, we were overjoyed. And now it is in its third edition.

Each new edition of this book has seemed to take forever, because there was so *much* to cover and more was appearing every year. In fact, the first edition "spun off" several other projects. Bill's original manuscript included over 30 complete world descriptions, enough to be a book in their own right. We solved that problem by *giving* them their own book – the first of four ***Space Atlases.***

Several other subjects that got chapters in this book deserved full-length treatment, too. We now have separate books for high-tech gadgets – ***GURPS Ultra-Tech*** and ***Ultra-Tech 2*** – not to mention technological sourcebooks like ***Vehicles,*** which covers spaceships in even greater detail than ***Space,*** and ***Bio-Tech,*** which is an indispensable guide to designing non-human races.

One common question has been "Is ***GURPS Space*** hard SF or space opera?" Actually, it's both. We have *not* included a pregenerated universe background. Instead, the book tells you how to create your own. Want detailed, state-of-the-art scientific guidelines for building star systems? They're here. Want quick random tables that give believable results? They're here, too. Descriptions of zap guns and aliens? No problem.

In some chapters, we've given detailed information on (for instance) the way the Galactic Survey works, or the politics of an interstellar federation. But, again, this is resource material . . . suggestions. We don't expect the GM to feel locked into these names, or these details, for his own campaign.

Instead, we're doing whole worldbooks for specific SF backgrounds, like ***GURPS Autoduel, Cyberworld, Planet Krishna,*** and ***Traveller.*** But this book is something else: the (pardon the expression) generic rules. It's a *general* sourcebook. You can use it to adventure in your own SF universe, or that of your favorite SF author – or even that of the SFRPG you used to play (before switching to ***GURPS,*** of course).

We had a lot of fun developing the technical material – but reality testing had to go right out the viewport this time. Not too many blasters or stargate generators are available to test, even at Frederick's of Altair VI. So if you disagree with any of our specifications – change 'em. We've done our best to keep the science straight wherever *our* science applies, and we have updated it in each edition, but science evolves quickly and today's "facts" may be discredited next week. Until then, take it and run.

Where Credit Is Due

We were certainly influenced by previous efforts in SFRP gaming (good or bad), and even more by that vast body of SF literature that has accumulated since the golden age of the '30s.

Our own favorites include the work of authors such as Poul Anderson, Isaac Asimov, Iain M. Banks, C.J. Cherryh, Arthur C. Clarke, Philip José Farmer, Robert A. Heinlein, Larry Niven, Andre Norton, H. Beam Piper, Robert Silverberg, Jack Vance, Roger Zelazny, and many more. Overt influences from the SF gaming world would include that old favorite, GDW's ***Traveller*** (now adapted for ***GURPS***); the works of Don Rapp and Chuck Kallenbach of Paranoia Press (which published some of the best ***Traveller*** supplements); and Richard Tucholka, designer of the too-often overlooked ***FTL: 2448.***

And, finally, our sincerest thanks to the many who commented on the various stages of the manuscript. If this book holds together well, it is only because of the dedicated pickiness of all those rules-readers and playtesters. Whatever is missing is the fault of the authors . . . but let us know what you want, and we'll deal with it. After all, we've got a whole universe out there.

Hot jets!

About *GURPS*

Steve Jackson Games is committed to full support of the GURPS system. Our address is SJ Games, Box 18957, Austin, TX 78760. Please include a self-addressed, stamped envelope (SASE) any time you write us! Resources include:

Pyramid (**www.sjgames.com/pyramid**). Our online magazine includes new ***GURPS*** rules and articles. It also covers ***Dungeons & Dragons, Traveller, World of Darkness, Call of Cthulhu,*** and many more top games – and other Steve Jackson Games releases like ***In Nomine, Illuminati, Car Wars, Toon, Ogre Miniatures,*** and more. *Pyramid* subscribers also have access to playtest files online!

New supplements and adventures. ***GURPS*** continues to grow, and we'll be happy to let you know what's new. A current catalog is available for an SASE. Or check out our website (below).

Errata. Everyone makes mistakes, including us – but we do our best to fix our errors. Up-to-date errata sheets for all ***GURPS*** releases, including this book, are available from SJ Games; be sure to include an SASE. Or download them from the Web – see below.

Gamer input. We value your comments, for new products as well as updated printings of existing titles!

Internet. Visit us on the World Wide Web at **www.sjgames.com** for an online catalog, errata, updates, Q&A, and much more. ***GURPS*** has its own Usenet group, too: rec.games.frp.gurps.

GURPSnet. This e-mail list hosts much of the online discussion of ***GURPS***. To join, e-mail majordomo@io.com with "subscribe GURPSnet-L" in the body, or point your World Wide Web browser to: **gurpsnet.sjgames.com**.

The ***GURPS Space*** web page is at **www.sjgames.com/gurps/books/space/**.

Page References

Rules and statistics in this book are specifically for the ***GURPS Basic Set***, Third Edition. Any page reference that begins with a B refers to the ***GURPS Basic Set*** – e.g., p. B102 means p. 102 of the ***GURPS Basic Set***, *Third Edition*. Page references that begin with CI indicate ***GURPS Compendium I***. Other references are CII for ***Compendium II***, GT for ***GURPS Traveller***, T:BC for ***Traveller: Behind the Claw***, and so on. The abbreviation for this book is S. For a full list of abbreviations, see p. CI181 or the updated web list at **www.sjgames.com/gurps/abbrevs.html**.

Medium Thrusters. About twice as efficient. Most ships will average about 0.1 to 1 G, with ships capable of 3-5 Gs if they devote a lot of space to expensive drives.

Fast Thrusters. A quantum leap in technology – maybe a new principle. Accelerations of 1-3 Gs are easily obtained, and ships that are mostly drive can achieve tens of Gs.

Grav Drive. The ultimate reactionless drive! This generates a bubble of space-time with its own arbitrary gravity. As the bubble's occupants don't feel acceleration, grav-drive ships can safely pull *hundreds* of Gs, although the speed of light is still an absolute limit. Grav drives are similar in function to warp drives (p. 31); they may be precursors to or spin-offs from warp drive or contragravity technology.

The standard ***GURPS*** TL progression has slow thrusters at TL9, medium thrusters at TL10, fast thrusters at TL11, and grav drives at TL12-13. Optionally, instead of grav drives, "mega thrusters" (a high-thrust but expensive improvement on fast thrusters) may appear at TL13+. The GM is free to vary this progression.

Stardrives (FTL Drives)

The basic problem facing any FTL drive is Einsteinian theory, which makes the speed of light an absolute that nothing can exceed. This has not discouraged people from trying to find a way around it: a bewildering variety of FTL drives exist in scientific speculation and science fiction. The same name is often used to describe different methods of travel, but most science-fiction FTL drives – regardless of the "theory" on which they operate – fall within one of the following categories. Usually, only one type of FTL drive exists, but that does not have to be the case. It may be that one type has made the other(s) obsolete, or each type might have unique advantages and disadvantages, or appear at different TLs.

Hyperdrive

The theory behind hyperdrive is that there is another "dimension" where physical laws or topology allow the speed of light to be exceeded. The starship somehow enters hyperspace (or "subspace" or whatever), travels at speeds which seem faster than light from within our normal universe, and reenters "normal" space at its destination. Ships in hyperspace are wholly isolated from each other and the normal universe; they can perceive nothing, and cannot be perceived, until they emerge. A "slow" hyperdrive takes weeks or months to travel between the stars. If a hyperdrive is fast enough or the trip short enough, the ship simply pops from *here* to *there* – like a jump drive (below) that requires no special jump points.

Entering hyperspace usually takes a lot of energy, and the ship's course must be set ahead of time. If something happens to the drive or power plant during the voyage, the ship could emerge *anywhere.* Hyperdrive ships need maneuver drives unless the hyperdrive is *very* finely controllable.

Often, a rest time of some sort is required between hyperskips. This is automatic if the ship requires energy banks which must be recharged. Other reasons for the rest time might be to calculate the next skip, to let the crew recover from the unpleasant side effects of hyperspace, or to let local hyperspace itself relax from the stress of being crossed.

Hyperdrive alters space warfare dramatically. Battle lines don't exist. Any ship can escape battle if it has time to engage hyperdrive (so the amount of time this requires is a vital decision for the GM). Battles are not fought in deep space but around vital planets, when attackers appear to meet a defending fleet.

Variant forms of hyperdrive include:

Hypersails. What if hyperspace is like an ocean, with energy currents (and reefs, and storms) on which a starship can ride? Such a starship might need *hypersails* (perhaps energy fields rather than physical sails) to take advantage of the ether's flow.

Tachyon Drive. Tachyons are imaginary particles that always travel faster than light. A tachyon drive converts the starship into a beam of tachyons which then hurtles across space. A ship that is converted into tachyons might require a receiving station to restore it to its original condition.

Bussard Ramjets

One of the biggest problems with interstellar flight using any of the reaction drives described on pp. 27-28 is that accelerating to a decent fraction of light speed requires an incredible amount of reaction mass – and slowing down again takes more. The Bussard ramjet gets around this by not carrying any fuel. Interstellar space is not empty: there are stray atoms of hydrogen and other elements floating about. The Bussard ramjet uses a huge magnetic field – a "ram scoop" – to suck in interstellar hydrogen, which is used as fuel for the ship's fusion reactor, heated, and expelled for thrust.

When the Bussard Ramjet was first proposed (in the 1960s), it seemed to be *the answer* to interstellar travel. Much science fiction was written in which Bussard ramjets combined with relativistic time dilation allowed humanity to explore and colonize the galaxy or beyond (see Poul Anderson's *Tau Zero* and many stories by Larry Niven).

Sadly, more recent research suggests insurmountable technical problems exist with the concept. For example, the interstellar medium seems not to be as dense as had been first believed (especially in the vicinity of our solar system), making ram scoop sizes impractically large, while the necessary proton-proton fusion reactions that a ramjet would need to use appear to be difficult to achieve.

There are some situations where a fusion ram scoop system may be useful, though. One is for a culture operating in a region of space where the interstellar medium *is* dense – for instance, in a nebula or near the galactic core. As long as the starship kept to such areas, a fusion ramjet may be a practical (if very high-tech) form of STL starflight. Another is to use a ram scoop to augment a conventional fusion drive, effectively gathering extra reaction mass for it.

Despite real-life the problems with this technology, we have included two Bussard ramjet designs in Chapter 8 for those who like the idea – including a "super" model that reflects early, optimistic concepts.

Designing a Ship

First, come up with a general concept and mission for the ship. Who's building it and for what purpose? Is it an interplanetary craft or a starship? A merchantman or a warship? The ship should fit the GM's assumptions about technology in his universe, such as which space drives are available and which superscience technologies exist, if any. This system can also be used for space stations and satellites; just read "ship" as "station" and do not install a space drive.

Next, decide on the ship's TL. This design system allows ships to be built at TL8 and up.

EXAMPLE: The GM wants to design a fast interstellar freighter suitable for a party of adventurous space merchants or smugglers. The ship is built to carry passengers and cargo from one star system to another, and can be operated by a small crew. The superscience technologies used are hyperdrive, reactionless thrusters, and artificial gravity. The GM decides the ship is built at TL10: the "*Tanstaafl*-class star freighter."

Design Sequence

The following is a step-by-step spacecraft design process. Calculations are simple and can easily be done on scrap paper. A calculator is useful but not essential. Before beginning, refer to *Units and Abbreviations* (sidebar) for the terminology used in this design system.

Step 1: Design the hull and record its characteristics.
Step 2: Designate turrets.
Step 3: Select armor tonnage. Calculate its cost, cDR, and PD.
Step 4: Consider sensor masking features.
Step 5: Determine internal spaces.
Step 6: Estimate mass.
Step 7: Fill all internal spaces with component systems.
Step 8: Calculate basic statistics.
Step 9: Calculate performance.
Step 10: Finalize design.

As design choices are made, keep a running total of the ship's mass (in tons) and cost (in M$).

Units and Abbreviations

cDR: A measure of spaceship Damage Resistance. One point of cDR equals DR 100.
cf: A cubic foot. Hull size and cargo capacity are measured in cubic feet.
cHP: A measure of hull hit points. One cHP equals 100 hit points.
Gravity (G): A measure of acceleration equal to the surface gravity of Earth, or 9.8 meters per second per second (about 21.9 mph per second). Earth gravity is "1 G."
ksf: A measure of hull or turret surface area equal to 1,000 square feet.
M$: A "megabuck" or "megacredit"; one million $.
MW: A megawatt, a unit of power. Used for power requirements or power output. Equal to 1,000 kilowatts (kW).
MWs: Megawatt-second, a unit of energy equal to the output of a 1-MW plant for 1 second. Used to describe the amount of energy held by energy banks.
Space (Spc).: A unit of 500 cf; a convenient measure of internal volume.
Ton: A measure of mass and weight; 2,000 pounds.

A "k" following a number indicates thousands, an "M" indicates millions, and a "G" indicates billions (be careful not to mistake it for G for "gravity"!). Thus, "16k" means 16,000, "25M" means 25 million, and "7G" means seven billion (but "7 Gs" means seven gravities).

Suggested Hull Sizes

What one background may call a "destroyer" another may refer to as a "battleship" – terminology is up to the GM. Here are a few suggestions:

Lifeboat	5,000-10,000 cf
Fighter	5,000-20,000 cf
Shuttle	5,000-50,000 cf
Scout	20,000-100,000 cf
Light Freighter	50,000-500,000 cf
Patrol Boat, Corvette	100,000 cf+
Destroyer/Frigate	500,000 cf+
Passenger Liner	500,000 cf+
Bulk Freighter	1 million cf+
Cruiser	2 million cf+
Colony Ship	.5 million cf+
Battleship	20 million cf+
Carrier	50 million cf+
Dreadnought	100 million cf+

How Big Is My Hull?

A ship's actual dimensions can vary greatly. For a rough idea of the hull's length, look up its Size Modifier in the Size column on the table on p. B201. This assumes a fairly average cylindrical ship, or a collection of disks, pods, and cylinders. Length may be 1.5 to 3 times that if it is long and skinny, dartlike, or a flattened disk or wedge. Diameter will be 2/3 that if the ship is ovoid or spherical.

Star Mapping

The type of map to draw depends on the scope of your campaign and especially on the type of FTL travel used in your universe.

If starships move by "jumplines" or a similar system, space can be mapped just by drawing the jumplines. A star (or anything else) that isn't on a jumpline may be ignored; it can't be reached except by a generation ship! If travel is instantaneous, only the connections are important. If travel along jumplines takes time, the length of each line must also be shown.

If ships move through hyperspace, the distance between stars is important, but intervening features may be ignored.

If FTL ships use a warp drive to move through normal space, possible hazards like nebulae should be mapped. In general, any area that could harbor foes or slow travel should be shown on a map.

Map Scale

Map scale will depend entirely on the frequency of important worlds (not just habitable ones). If useful worlds average 3-5 parsecs apart, for instance, a ¼″ square grid, with each square representing a parsec, will be convenient. If worlds are closer together, as in a cluster, use a smaller scale.

The Third Dimension

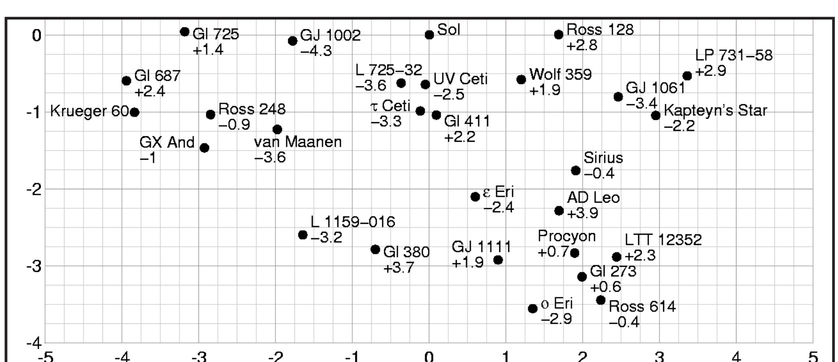
Maps (at least the convenient kind) are flat, but space is not. You may simply ignore this and place all your star systems in the same plane. But it is more realistic to use a three-dimensional grid system. The map surface itself represents a "height" of 0. If you are mapping a whole galaxy, zero height indicates the "galactic plane."

A star above the galactic plane should be mapped with a "+" sign, followed by its distance above the plane in parsecs. If it lies below the plane, note it with a "-" sign and the distance. Stars on the galactic plane need no designation. Thus, if Lestrade's Star lies 4 pc below the galactic plane, this should be noted on your map with (-4).

To find distances between stars when using 3D coordinates, use the formula $x^2 + y^2 + z^2 = d^2$. That is: square the distance, on each of the three axes, between the two stars. Sum the squares. The square root of the sum is the straight-line distance between the stars.

3D Terminology

A spacer uses standard directions to describe star locations. When he says "north," he means *galactic* north, unless he is groundside. Galactic north is perpendicular to the plane of the galactic disc; looking "down" from the galactic north pole, the galaxy rotates counterclockwise around the observer. Galactic east is the direction of galactic rotation. The remaining dimension is described as "in" toward or "out" away from the galactic core.



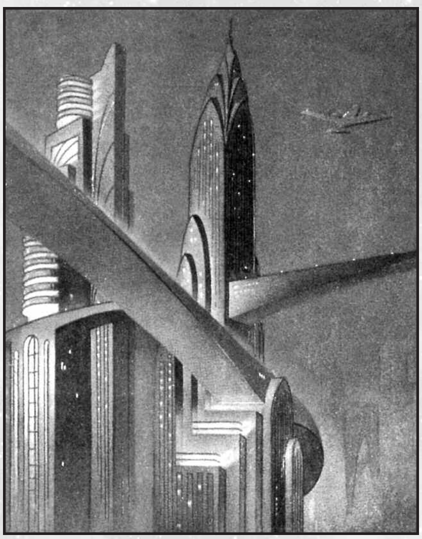
Astronomical Measurement

Three measures of distance are used on the stellar and interstellar scale:

The *astronomical unit* (AU) is approximately 93 million miles. This is the distance from Earth to the sun. Orbital distances from a star are expressed in AU in this book. In our own solar system, Earth lies 1 AU from the sun, Mercury is 0.4 AU from the sun, and Uranus lies 19.2 AU out.

The *light year* (ly) is some 5.9×10^{12} miles – the distance light travels in one year. This is a common measure of distance in science and science fiction. One ly equals 63,271 AU.

The *parsec* (pc) – a *par*allax of one *sec*ond, or 206,265 AU – is approximately 3.26 ly. This is roughly the distance from Sol to the nearest star, Alpha Centauri. The parsec is the standard unit of interstellar measurement in this book.



Random Star Location

Assuming three-dimensional grid points one parsec apart, and a general separation between stars of about 4 parsecs, the GM may roll 2d to determine what lies at each grid point. Add 1 to the roll in a cluster or core area.

2-9 – Empty space.

10 – Possible unusual item; roll one die. If the result is a 6, go to the *Unusual Stellar Objects* table (p. 149). Otherwise, there is nothing here.

11+ – Star system.

Note that this is a very time-consuming method of building a star map, unless you program a computer to do it for you. See p. 148 for an alternate method of placing worlds.

Population

The GM may assign population as he chooses, or calculate it based on the world's history and environment. The Population Rating (PR) is the "order of magnitude" of the world's population. Increasing the world's PR by 1 multiplies the actual population by a factor of 10.

There are three good ways to set PR. For a random determination, just roll 2d-2.

To assign PR according to campaign needs, base it on the following:

0: Less than 10. Research team, shipwreck survivors, etc.
1: 10-99. As above, or a very small startup colony.
2: 100-999. The smallest likely startup colony, or a military base.
3: 1,000-9,999. A fairly small colony (equivalent of a small town).
4: 10,000-99,999. A growing colony or very large military base.
5: 100,000-999,999. Equivalent to the population of a small city.
6: 1 million-9,999,999. Equivalent to a single large city.
7: 10 million-99,999,999. A huge city, like New York; a large colony.
8: 100 million-999,999,999. A very large and successful colony.
9: 1 billion-9,999,999,999. A long-settled world or homeworld.
10: 10 billion-99,999,999,999. A severely overpopulated world.

Calculating the Population of Colony Worlds

It is also possible to calculate PR mathematically, based on the history of the world in your campaign. The initial PR might be anywhere from 2 (a very small colony) to 5 (a huge colony ship or fleet). Growth of the original colony depends on how hospitable the world is. On a wholly earthlike world, with medical technology of at least TL5, a human population will increase by a factor of 10 every 100 years, up to the maximum population for the planet (see below).

Non-earthlike environments will reduce this *increase factor,* as shown below. If the increase factor is 0, population on the planet is static; if the increase factor is negative, the world is so hostile that population is in decline.

Gravity: For gravity significantly different from the species' native gravity, subtract 2 × the number of G-increments of gravity difference; e.g., humans on a 1.4-G world (two G-increments' difference) would subtract 4, while humans on a 0.4-G world (three G-increments' difference) would subtract 6. Races (or variants) with the Improved G-Tolerance advantage can tolerate a wider range of gravities.

Composition: Subtract 4 if the world is metallic. Subtract 2 if it is high-iron or silicate.

Climate: Subtract 4 if the climate is 40° too hot or 100° too cold (very hot or frozen for humans), or 2 if the climate is 30° to hot or 80° too cold (hot or very cold for humans). Racial Temperature Tolerance will extend these ranges.

Atmosphere: Subtract 2 if the atmosphere is thin or less, or if it is polluted; subtract 3 if it is both, or if it is exotic or corrosive. Certain racial and biotech adaptations presented in ***GURPS Bio-Tech*** would eliminate these penalties: Low-pressure Lungs would remove the penalty for thin atmospheres, while Filter Lungs would remove the penalty for polluted atmospheres.

Other factors: Continual war, savage or toxic native life, disease, etc., will also lower the increase factor. Deliberate attempts to increase the population (mass cloning, etc.) will have a meaningful effect only if a significant portion of the world's resources go toward the effort!

Example: Saphronia has 0.75 G; that's one G-increment, so subtract 2 from the increase factor. Its composition is low-iron, and its climate is warm (no effect from either). It has a thin atmosphere: subtract 2. Its increase factor is thus (10 - 2 - 2) = 6. Thus, the population is multiplied by 6 every 100 years. If it started with a population of 1,000 and has been colonized 400 years, it will now have a population of $1,000 \times 6^4$, or 1,296,000.

Native Intelligence

When intelligent life is encountered, the GM may get basic information about it by rolling 3d on the table below. Add 3 if the planet is hostile; subtract 1 if it is earthlike. Assume that a native race is perfectly adapted to its environment unless the settlement is a colony or the world is a dying one.

4 or less – Human colony (perhaps lost).
5-8 – Cold-blooded, four limbs.
9 – Cold-blooded, six limbs.
10 – Warm-blooded, four limbs.
11 – Warm-blooded, six limbs.
12 – Insect- or crab-like.
13 – Boneless or worm-like.
14 – Plant-like.
15 – Two races living in a symbiotic relationship; roll twice more.
16 – Roll 2d on the *Psychological Oddities* table, and again on this table at a +2.
17+ – Physically very unusual; roll 2d on the next table.

Physical Oddities

2, 3 – Energy eater.
4 – Gaseous.
5 – Shapeless.
6 – Roll twice more on this table, discarding contradictions.
7 – Roll 2d on the *Psychological Oddities* table, and again on this table.
8 – Possesses a sense humans don't have, such as radar.
9 – This is an outpost; race is not native to the planet and is not adapted to it.
10 – Artificial or mechanical life.
11, 12 – Silicon-based metabolism.

Psychological Oddities

These creatures have cultures very different from the humanoid patterns described in the rest of this chapter. The GM may add details as he chooses.

2, 3 – Simply incomprehensible to mankind.
4 – Hive culture (telepathic).
5 – Hive culture (non-telepathic).
6 – Dislikes other intelligent life.
7 – Extremely short life span.
8 – *Secretly* xenophobic: dislikes other intelligent life.
9 – Ignores attempts to communicate.
10 – Secretive; avoids *all* contact!
11, 12 – Moves/thinks *very* slowly.

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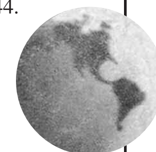

GLOSSARY

Technical and scientific terms, and some common science-fiction abbreviations used in this book:

astronomical unit (AU): The distance from the Earth to the sun, 93 million miles.
biozone: The region around a star at which the temperature allows water to exist as a liquid. This is the region in which a planet can orbit and support terrestrial life without the need for life-support structures.
c: The speed of light, 186,000 miles per second.
escape velocity: The speed at which a ship must travel in order to completely escape a planet's gravitational field. For Earth, this is 6.9 miles per second.
FTL: Faster-than-light.
gigabyte or **gig:** A unit of computer data storage. 1 billion bytes, or 1,000 megabytes.
kiloparsec (kpc): 1,000 parsecs.
light year (ly): 5.9×10^{12} miles.
main sequence: The normal course of evolution for stars. Most stars are "on the main sequence."
megabyte or **meg:** A unit of computer data storage. 1 million bytes.
parsec (pc): 3.26 light years.
rad: A unit of radiation as it affects the human body.
STL: Slower-than-light.

Four Handy Formulas:

- *Formula to determine escape velocity from a planet:*

$$V_E = 6.9 \times \text{Square root of } (g \times R) \text{ miles per second}$$

where V_E is escape velocity, g is the world's surface gravity in Gs, and R is the planet's radius in Earth radii.

See *Ground-to-Space & Space-to-Ground Performance* (p. 130) for the time required to reach escape velocity by various means.

- *Formula to determine planetary surface gravity in Gs:*

$$g = \text{Diameter (in miles)} \times \text{Density} \times 0.0000228$$

- *Formula for length of planetary year:* See *Length of Year* (p. 161).

- *Formula for time dilation as a ship approaches light speed:*

$$\text{T-ratio} = 1/\text{Square root of } [1-(v^2/c^2)]$$

where v is the speed of the ship and c is the speed of light.