Using Traveller space ships as ships with chemical engines

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Introduction

The Science Fiction RPG system „Traveller“, with its many iterations, has created a vast amount of spaceship deckplans suitable for role-playing campaigns. Unfortunately. the validity of these deck plans seems to depend on the Official Traveller Universe‘s rather peculiar assumptions about advanced SF physics.

But what if you want to use your Traveller deck plans for spaceships that are slighly more realistic? This document is intended to show a way for conversion of the Traveller stats to those of a more „hard science fiction“ setting.

Note that only Traveller *starships* can be converted that way. Anything that lacks a jump drive will simply not work without adding massive drop tanks or simply a (possibly multi-staged) carrier rocket – most likely both. Planetary boats will be assumed to be basically drop capsules or equipped with purely atmospheric drives.

Basic Assumptions

For the purposes of this document, the following assumptions apply:

- Ships use chemical rocket engines with a realistic exhaust velocity (or specific impulse).
- The jump drive (or whatever kind of FTL drive you are using) does not require fuel.
- To convert volume to mass, we assume an approximation of 1 ton of mass per dton of the ship. Judging by modern day rocket engines, this is true for the most important components except the fuel and cargo. (In an earlier version of this document, a simplified 1:3 relation was assumed, but further examination of real-world rocket engines and fuel cells found that to be unrealistically pessimistic.) Only hull mass reactor mass, rocket engine mass and jump drive mass are really relevant here – other masses, are comparatively light. Technically, the relation should go up a bit (up to about 1.2) for ships with a higher share of engines in their volume; but 1:1 is a good and easy-to use approximation across all types of ships, and we can just assume that smaller engines have a worse thrust-to-weight or output- to weight ratio, while bigger ones have a better one.
- After the conversion, the ship will have no more artificial gravity. The assumption is that either the side effects of weightlessness (atrophy of muscles and bones, blood pressure problems, for some people space sickness) are either accepted or prevented by readily available medication. In free fall, rhe crew could also attach a counterweight, such as

another ship, „back to back“ to their ship in order to create a replacement for gravity in the form of centrifugal force. There are ways to work around this, though: A ship might use builtin pylons to connect itself back to back with another ship of the same mass, or with a giant tank of similar mass, and rotate around their common center of gravity, with the ship‘s bottom pointing outward.

Most stats

Most of your ship‘s stats can stay largely the same.

- Your FTL drive will work how ever you want it to, the only requirement is that it does not require significant amounts of fuel on its own.
- Computer, bridge and similar components remain unchanged
- Your maneuver drive will still be able to produce the same amount of thrust. However, its endurance will be affected enormously, see „Fuel and endurance“, below.

Only two things need to change significantly: The endurance of the maneuver drive, and the ship‘s main power source.

Fuel and endurance

Traveller‘s OTU assumes that the jump drive requires 10% of the ship‘s volume in liquid hydrogen per parsec of jump distance of the ship. All OTU ships are built that way.

So we have 10% of the ship‘s volume, and want to know how much of a total speed change we could derive from that. However, that does depend on the mass and specific impulse of the fuel. Which means the higher the fuel‘s density, the better for our ship.

Here is a list of liquid rocket fuels that might be worth considering (excerpted from Wikipedia, https://en.wikipedia.org/wiki/Liquid_rocket_propellant):

Definitions

V_e Exhaust velocity.
r mass oxidizer / mass fuel
T_c Chamber temperature, °C
d Bulk density of fuel and oxidizer, t/m³

Propellants

Oxidizer	Fuel				
		V_e	r	T_c	d
LOX	H_2	4462	4.83	2978	0.32
	CH_4 (methane)	3615	3.45	3290	0.83
	C_2H_6	3584	3.10	3351	0.91
	C_2H_4	3635	2.59	3521	0.89
	RP-1 (kerosene)	3510	2.77	3428	1.03
	N_2H4 (hydrazene)	3460	0.98	3146	1.07

If we use LOX/LH fuel, we get the following conversion table for our Traveller spaceship:

Using LOX/LH fuel for conversion to a rocket engine

Old Jump Range	Share of ship‘s volume	Share of ship‘s of mass	Delta v
1	10%	14%	1,460 m/s
2	20%	37%	2,716 m/s
3	30%	39%	3,874 m/s
4	40%	50%	4,999 m/s
5	50%	60%	6,149 m/s
6	60%	87%	7,388 m/s

Let us try kerosene, because the technology to make or find it is quite conceivable for us present-day Earthlings. The conversion table will look like this:

Using LOX/Kerosene fuel for conversion to a rocket engine

Old Jump Range	Share of ship‘s volume	Share of ship‘s of mass	Delta v
1	10%	35%	3,457 m/s
2	20%	55%	5,521 m/s
3	30%	67%	7,126 m/s
4	40%	76%	8,539 m/s
5	50%	83%	9,889 m/s
6	60%	96%	11,276 m/s

SpaceX, Elon Musk‘s famous and successful space company, has opted for using „Methalox“, which is liquified Methane with LOX as oxidizer, and this has made this propellant increasingly

popular. It is a bit less dense than kerosene, but has a slightly higher specific impulse. Will that work for us, too?

Using Methalox fuel for conversion to a rocket engine

Old Jump Range	Share of ship‘s volume	Share of ship‘s of mass	Delta v
1	10%	30%	2,972 m/s
2	20%	49%	4,892 m/s
3	30%	62%	6,429 m/s
4	40%	72%	7,801 m/s
5	50%	79%	9,125 m/s
6	60%	95%	10,493 m/s

So amazingly, SpaceX‘s solution to their problem is also a good solution for our little conversion issue!

To convert your ship‘s jump range into delta V on the rockets, use the appropriate table for the rocket propellant of your choice, or create your own.

Conclusions for your game universe

What do these delta V values mean? You need about 1,000-2,000 m/s for a successful soft landing (without using parachutes and the like), so for a streamlined ship that wants to simply land, the available fuel should always be sufficient. The last phase of the landing will be „on the tail“, with the bow pointing directly away from the gravity source, but you can probably land softly in vertical position (using a single burst from your maneuvering thrusters) once all of your speed has been negated by the combination of aerobraking and your main rocket engine.

What about lifting off? That is usually not possible with converted Traveller ships. For lifting off, you will have to assume that all starports offer reuseable, multi-staged launch rockets for payloads of up to 3,000 mass tons. That is certainly massive by today‘s standards, but an interstellar society will probably be able to do this cost-efficiently. If you set your fuel costs at 1 Credit per ton or less, and assume that to rent a rocket will cost no more than 5 Cr per ton of payload, you can lift off a for about 65 Credits per mass ton or 200 Credits per dton (or Cr. 40,000 for the whole ship). This is only possible if you allow for extremely cheap and widespread production facilities, and properly long-lived reuseable rockets that land on their own power once the payload is delivered. On-planet energy cost would have to be less than 1 Cr. per 40,000 KWh. In other words, electrical energy must be basically free in your game universe, for example because it is made in large quantities by cheaply produced solar cells that have a lifetime of hundreds or thousands of years, or can simply be sprayed upon any surface for negligible amounts of Credits and in a fully automated process. If that is the case, everything in your game universe (including spaceships!) will be cheaper, except labour that cannot be done by robots. Divide all non-labour prices by 10.

If power is less cheap, space travel (and thus interstellar trade) will be accordingly more expensive. In prices that are more equivalent to today, at about Cr 1,000 per mass ton of Methane, you end up with launch prices in the range of 65,000 Credits per mass ton of payload, still assuming fully resuseable, long-life carrier rockets.

Conclusions for space combat

Traveller‘s spaceship combat assumes that ships constantly accelerate and have no issue with unlimited amounts of delta V. Obviously, that cannot be the case after a conversion to chemical rockets. One space combat round, or 360 seconds, at 1 g (which is equivalent to one thrust point) equal about 3,600 m/s of delta V, more than many ships will have in total.

Instead, you have to keep track of an additional stat in space combat: Speed.

You start combat with a certain speed, in m/s, relative to your opponent. If the situation does not suggest a particular relative speed, determine it randomly: Default relative speed is 3D6*100 m/s, with the direction determined by an additional D6: 1-3: range increasing, 4-6: range decreasing.

Your range changes by a rate of 36 km per combat round per 100 m/s relative speed.

If using the alternative rules for movement from book 2, a speed of 1 range band (1,250 km) per round equals a speed of roughly 3,600 m/s. Do keep track of fractions.

To change that speed into the direction of your liking, consume delta V from your ship‘s fuel at a maximum of 3600 m/s per g of acceleration per combat round. Don‘t do it all too often, for your fuel is limited, and you have to resume your previous course after the encounter!

As you can see, space combat will consist mostly of artillery duels, with evasion or even significant change of speed playing no major role. Instead, employ countermeasures and sand casters.

Reactor

The Official Traveller Universe assumes cheap and lightweight fusion power. This is simply needed for giant gravity drives (in fact, going by basic physics, the Official Traveller Universe‘s reactors are still too weak for that, even if we ignore the mere impossibility of the whole concept).

However, we have just converted our ship to a chemical engine, which means we do not need all that power – the power for the drive is stored in its fuel. Then again, fusion power may end up as a pipe dream anyway, and fission reactors are much heavier per watt of output even in the most optimistic of realistic assumptions. On top of that, getting rid of all the waste heat was always a problem that Traveller simply ignored for the sake of convenience.

So we will instead assume that our ship will use a fuel cell, a battery, or some kind of chemically-driven power plant, and as we will need a lot less power, that is still quite acceptable. However, the power output will be more like per 30 KW per dton (or 200 kWh per dton of battery), not the fantastic values some Traveller sources offer. The added advantage is that it is much easier this way to cool the ship, as far less waste heat will accumulate. Note however, that energy weapons are now

no longer an option. It is suggested that you replace your lasers with missiles or projectile weapons when using this option.

Finished

That‘s it – you are done! You now are proud owner of a spaceship obeying the laws of physics as we know them, if you ignore the FTL drive.

A universe filled with such converted ships will have a significantly different „feel“ than the Official Traveller Universe, not only in space combat. It will feel a lot more real, though, as you only require a single exception to the physical laws of the world as we know it (and that is your FTL drive.

You might even consider a „single solar system“ campaign for maximum realism. In tat case, however, your setting will either be rather small in spacial scale (limited to Earth orbit, the moon and the space stations in their immediate surroundings), or extremely stretched on the temporal scale, with travel times of, for instance, 100-250 days to Mars, unless you use booster rockets or some kind of catapults to help your ships with the journey.

Summary

To summarize, convert a given OTU ship to using hard science fiction chemical rockets with the following checklist:

1) Choose a rocket propellant appropriate to your game world. See page 3 for stats. Write down the delta V for your fuel tank.
2) Change the ship‘s reactor to a fuel cell, battery, or similar device. Reduce power output to 30 KW per dton of reactor when using some kind of fuel cell or chemically driven motor, or 600 kWh per dton when using a battery.
3) Optionally, reduce the price of the ship to 1/10th.