Better Rockets through Chemistry

Chemical rockets get the shortest of sticks in the Knight Hawks rules. They can't jump. They have terrible acceleration and are more expensive to run than ion drives. For very large system ships, even atomic drives end up being more cost effective than chemical drives. The only niche that chemical rockets excel in is taking off from planets. Even there, atomic drives are cheaper to operate and better if there's no one to complain about pollution.

Quasi-Real Rockets (QRR) assumes that Frontier technology has advanced to the point that common chemical drives are three times as efficient as the Space Shuttle Main Engines. That gives them an Isp of 1353. I'm not sure that any advance in materials science or rocket motor design could actually produce an engine with that Isp but it looks quasi-realistic as long as you don't stare too close. And that's really all QRR needs.

Also, please note that QRR isn't finished and what I'm presenting here is a backport of the changes to Knight Hawks rules. This article assumes that 1 turn is one minute and that 1ADF = 1 gee acceleration for one turn (thus 600m/s of delta-V)

Rules

Ships with Chemical drives calculate their acceleration the same way other ships do. Anything that would affect the ADF or MR of a ship affects one with chemical drives in the same way.

A ship must have its full compliment of chemical engines. A ship with chemical drives may carry up to 50 ADF of fuel. A fuel load costs 250 credits per hull size. Using MR or otherwise rotating the ship does not use fuel.

Since chemical drives can not simply accelerate half way to their destination then decelerate the rest of the way, they use fuel efficient transfer orbits that unfortunately take much longer. While an atomic drive ship in orbit around a planet might reach one of its moons in a few hours, the chemical drive ship will take a few days. But a freighter captain on a chemical drive ship will have his retirement paid for by running cargo between moons before the atomic drive ship has even paid for its engines.

Some example maneuvers and their fuel cost are listed below:

Maneuver	Fuel Used	Time
Changing your speed by 1 ADF	1ADF	1 min
Landing/Taking off from an earth-like planet	15ADF (10-20)	10 min
Landing/Taking off from a mars like planet	7ADF (4-8)	15 min
Landing/Taking off from a large moon	4ADF (2-6)	5 min
Landing and taking off from a small moon or large asteroid	1ADF (1-2)	2 min
Extensive orbital maneuvers/acting as an orbital shuttle	1ADF	varies (up to days)
Transfer between moons of a planet/different orbits	1ADF	minutes to days (1d10 hours per ADF)
Transfer between 2 inner solar system planets	8ADF (4-12)	weeks to months (1d10 weeks per ADF)
Transfer between inner and outer solar system	15ADF	months to years (2d10 weeks per ADF)
Transfer between 2 outer solar system planets	10ADF (7-30)	months to years (2d10 weeks per ADF)
Transfer between the moons of a gas giant	3ADF (1-4)	hours to days

Numbers in parenthesis indicate typical ranges if referees wish to customize slightly larger or smaller planets. Ion, atomic, and advanced drive ships do not have to use this table but they may in order to save fuel.

In QRR, many ships are designed to carry less than 50 ADF of fuel. The rocket equation requires that a ship that carries more fuel must make room for even more fuel to push that fuel along until it is used. So a ship that carries 10 ADF of fuel not only buys less fuel than one with 50, it pays less for each ADF.

Orbital taxis, space tugs and work pods simply don't need more than a few ADF to complete their missions. Likewise, a shuttle that carries passengers and cargo to an orbiting station and then glides back might only carry 20 ADF of fuel. This allows them to be smaller, lighter, and cheaper to operate than if they carried a lot of extra fuel.

New Sub-skills

Sub-skills are given in Alpha Dawn format but are really intended to be used with a more substantial skill system like A Skilled Frontier (SFMan #9) or Learn by Doing.

Astrogation

Plot Gravity Assist
Success Rate: 40% + 10% per level

A Gravity Assist uses the gravity of a body along your path to speed you up or slow you down, saving fuel. Once a successful plot has been made, the pilot receives a +5% bonus to his roll for every full 20 points the astrogator succeeds by. For details of the maneuver, see the pilot skill.

Plot Hohmann Transfer
Success Rate: 30% + 10% per level

A Hohmann transfer uses the amount of fuel listed on the table above but with careful plotting the destination can be reached quicker. Plotting a transfer requires 1d10 hours + 1 hour per ADF. On success, the time required to travel is cut in half. A critical success not only reduces the time to half, the transfer also takes 10% less fuel (Min 1 ADF) On failure, the plot is unusable while a critical failure actually increases the time by half.

Plot Interplanetary Transit Transfer
Success Rate: 100%

The Interplanetary Transit system is a set of transfer orbits that use very little fuel but take much more time than usual transits. To use this transfer, spending 2d10 hours and calculate the time for a normal transfer and increase it by two steps (hours become weeks, days become months, weeks become years, and months and years are doubled or tripled respectively.) The actual amount of fuel required is 1/4 the listed amount for a normal transfer. Storage class or freeze field equipped accommodations are recommended for passengers who do not wish to suffocate.

Spaceship Engineer

Recharge Life Support
Success Rate: 60% + 10% per level

Chemical engines (and some advanced engines, listed in their descriptions) use liquid oxygen to ignite their fuel. A skilled engineer can safely withdraw a bit of oxygen to extend life support. If using liquid hydrogen as most ships do, water may also be produced. This does not recharge food or other elements of life support but it does allow a stranded or damaged ship to keep its occupants alive longer, as long as the original (but not backup) system could or one week, which ever is shorter. The first time this is done, the amount is small enough not to affect the ship's performance. Each time thereafter, it costs 1 ADF of fuel. If using criticals, a critical success means a minimum of one week's life support or the original system's capacity, whichever is longer. On a critical failure, 1 ADF is wasted with no life support provided due to oxidizer leaking prior to entering the life support system.

Spaceship Pilot

Aerobrake
Success Rate: 70% + 10% per level - 10% per ADF point saved

When traveling to a planet with an atmosphere, a ship can dip into the outer parts of the atmosphere to slow down instead of using so much fuel. A ship must either be aerodynamic or have an aerobraking shield to perform this maneuver. With success, the cost of the transfer is reduced by the amount of ADF selected. On a failure, the craft suffers 1d2 hull points per hull size as thermal damage occurs and fragile exposed equipment burns or tears off and the transfer takes the standard fuel. A thin atmosphere lowers the success rate by 20%. Some atmospheres may be too thin to allow effective aerobraking.

Execute Gravity Assist
Success Rate: 20% + 10% per level

Performing a gravity assist requires both an astrogator to plot the maneuver and a pilot to execute them. In addition, there must be another planet, large moon, or star along your path to use for the assist. If successful, the cost of the transit is reduced by half but the time taken increases as if the cost was 1 higher. On a failure, the cost remains the same but time is increased as if the cost was 1 ADF higher.

Example: The Lucky Star is traveling from Gran Quivera to Morgaine's World. Since Morgaine's World has a large moon, the astrogator has prepared a gravity assist plot. The fuel cost for the trip is 8 ADF. The time for the trip will be calculated as if the cost was 9 ADF but the ship will only expend 4 ADF of fuel if the pilot makes his roll, 8 ADF if he does not.

New Spaceship Equipment

Aerobraking Shield

20,000 credits + 10,000 per hull size, QRR 1% of the mass of the ship

An aerobraking shield protects a craft from the heat of moving through an atmosphere at orbital speeds, allowing it to aerobrake or land by parachute. In Standard Knight Hawks, an aerobraking shield can be damaged on Defense hits. Light hulls in QRR can not use an aerobraking shield.

External Booster

15,000 credits + the cost of 15 units of chemical fuel for the attached ship (rental)

External boosters are available at most planetary construction centers. They enable a ship to be built on the ground, launched into orbit, and immediately leave on a trip without refueling. Since most planets have orbital refueling stations, using a booster is generally a matter of saving time, not money. They also allow ion powered ships to be constructed at ground based facilities.

Just after reaching orbit, the booster separates from the craft and deorbits itself so that it will come down near its launch facility. Most boosters have a parachute system but some can glide or descend under their own power.

Parachute Landing system

25,000 credits + 5,000 per hull size, max hull size 4

A parachute system consists of drogue chutes and other air braking systems that help slow a craft without using fuel when landing on a planet with an atmosphere. To use chutes, a ship must be streamlined or have an intact aerobraking shield. The fuel cost of landing on a planet with a normal atmosphere is halved, 1/4 with a thick atmosphere and 3/4 with a thin one. The system for a hull size 1 ship includes main parachutes allowing such a ship to land without using any fuel at all. Note that a parachute system can be installed on a hull size 4 craft. This includes oversized parachutes that allow a ship to land on thick or normal atmospheres for 3/4 the cost but not in thin atmospheres.

After each use, parachutes must be repacked. This takes 1d10 being hours per hull size.

Streamlining

No cost, hulls size 3 and smaller. QRR 1% of the mass of the ship

Streamlined ships may land on planets under power. The fuel cost is the same as taking off the same planet. Streamlined ships can also aerobrake without needing an extra shield as the streamlining incorporates enough shielding.

Glide capable

10,000 per hull size, must be streamlined QRR 1.5% of the mass of the ship, including streamlining.

A Glide capable ship can land on a planet with a normal or thick atmosphere while using no fuel. They may also use their engines to fly like airplanes. In a thin atmosphere, a glider still needs to spend 3/4 the normal fuel. A glider with a parachute system can land in a thin atmosphere for only 1/2 the fuel.

Fighter Acceleration Couch

QRR Only 35,000 credits 300kg

This chair is more like a cocoon than a traditional acceleration couch. The pilot sits inside of a gel filled chamber that controls pressure and motion. Inertial fields in the gel along with contractions along the extremities allow the pilot to survive minutes of exposure to gee forces as high as 9 gee without losing consciousness or suffering damage. All controls and displays are replaced by controls inside the chair and heads-up displays. Each chair requires its own 6 FP program to coordinate gel stiffness and pressure, inertial field strength and orientation, and the ship's maneuvering. This is a very processor intensive process and must be done in real time. Therefore a computer can control no more than 2 chairs for each of its levels.

In simple terms, if all crew have acceleration couches, the ship can be designed with a higher ADF. A ship with a crew of 1 can have an ADF up to 9, 2 members can have an ADF of 8, 4 an ADF of 7, and 6 member crew ships can have an ADF of up to 6.

Rotating Sections

3,000cr and 1,000kg per simultaneous occupant

Ships with chemical drives that are occupied for more than a few minutes spend most of their time not accelerating, thus the occupants experience zero gravity. Even as little as 1/10 of a gee makes such a ride more comfortable and more healthy. Thus chemical drive ships sometimes carry internal rotating sections. These are small and often cause nausea when first used but most beings quickly adapt. Larger sections are sometimes deployed on 30-40 meter tethers. In an emergency, thrusters cancel the rotation and the sections are pulled in 1 turn later.

Ships of hull size 12 or larger with chemical drives often orient their decks so the long axis is parallel to the long axis of the ship and that outside the ship is down. Then when the ship is coasting, it spins around the long axis every 40 seconds, producing about 1/10 a gee. When the engines are running, everyone is tied down and anything that might fly around stowed. By rotating this way, they gain the benefits of gravity without having a rotating section.

Sidebar: Chemical Drives and the Void

In standard Knight Hawks, chemical ships are unable to jump. In QRR, it is possible but very rare to find a chemical drive ship with a jump device. The best jump profile for a chemical ship is to spend 20 ADF points accelerating, then coast for 4 months. At that point, they should be far enough away from any gravitationally significant mass to activate the jump drive. After that, the ship can make transit jumps at 1 light year per day like any other ship. Upon jumping into the destination system, the ship would coast for 4 months and then decelerate by 20 ADF. Thus a chemical drive ship can jump anywhere in the Frontier in 8 months + 1 day per light year traveled.

This should be regarded as more of a curiosity than a practical travel method. Still, if players want to make a jump rocket, they can do so. Obviously, if using the standard Knight Hawks or Star Frontiers jump explanations, a chemical ship cannot jump even using the rules here.