NEW PLANETARY SYSTEM GENERATOR

The Planetary System Generator presented in the Gamemaster Guide enables the GM to create solar systems similar to our own, with rocky planets close to the star, gas giants further out, and smaller giants further still, where the scarcity of planet-building material has arrested the growth of large worlds. Finally, there are the icy worldlets of the Kuiper belt, and beyond that the Oort comet cloud that delineates the Solar System.

Until only a few years ago it was universally accepted that most, if not all, solar systems would follow this plan. With only one example to work from, it is hardly surprising that formation theory predicted that other systems would be pretty much like our own. The system generator in the GMG reflects this.

The truth, however, is a little more complicated.

Since the middle of the nineties, approximately twenty planets have been found orbiting a number of stars. One star, Upsilon Andromedae (which is visible to the naked eye during autumn and winter - check a star map) is host to at least three giant planets (Jovian worlds like the four giants of our system are the only planets that can be detected so far).

One of the first things noticed about these new worlds was that they don't necessarily occupy nice, circular orbits about their primary. Many of these worlds (including the Up. And. system) have distinctly elliptical orbits.

If this were the only revelation to be had, a simple note at the bottom of the page could fix it. But this wasn't the only difference. The first planet detected, back in 1995 by groundbreaking new methods, was a giant planet in orbit about the star 51 Pegasi. It possessed a remarkable trait. This planet orbits 51 Peg at 0.05 AU, much closer than Mercury orbits the Sun. At least six other systems (including Upsilon Andromedae) have similar planets, called epistellar planets, or "Hot Jupiters". These giant planets pose much more of a problem for the world generation system in the GMG, since it is simply incapable of producing planets like this.

All of the above problems have prompted me to create the following revision to the System Generator.

Revised Orbit Track

A slight revision to the orbit track system is necessary because of the Hot Jupiter problem. When you run out of orbital rings but still have a planet left, test for planets at distances of 0.05 and 0.1 AU (check at 0.3 and 0.4 for A-type stars, and check at 0.02 and 0.05 for red dwarfs). If you achieve a positive result, a planet will occupy this "epistellar" orbit. Note, only ONE planet can exist in ONE of these orbits per system.

Binary and Multiple Systems

While binaries (and other multiples) may appear a little daunting at first, they're not actually difficult to generate. First, roll a d8 and consult table 1 below to determine the distance between them. Stable planetary orbits can exist up to thirty percent of the distance between the stars (the closest approach distance in stars with eccentric orbits), and at a distance of greater than twice the distance between them. Each star may have its own worlds in close orbit (any leftovers from each star may orbit the pair from the safe outer distance, if there are any corresponding orbit rings available), and multiples with large separations will act almost like separate solar systems.

Brown Dwarfs

A system may contain a brown dwarf companion. Problematic as these objects are, I have chosen to treat them like planets, since they bear a much stronger resemblance to large Jovian planets than to red dwarf stars. Massing anywhere from 10 to 50 Jupiter masses, a brown dwarf will appear in a system on a roll of 16 on 2d8. Use table 1 to determine separation. If this conflicts with stars in a multiple system, discount the presence of the brown dwarf. The brown dwarf may have "moons" in the same way as a large Jovian planet.

Planet Type

System density decreases after a drop-off zone where beyond this point, planetesimals are scattered too far apart to coalesce easily into large planets. These figures are given in table 3. The Hot Jupiter problem raises its ugly head here, too. Instead of using Table G62, Roll d20 and consult the two-part table below (table 2) to generate planet types:

Since we no longer have an automatically generated Hot/Temperate/Cold rating, use table 3 to determine the relevant zones. Note that each spectral type has been split into two (G0, G5, K0, K5 etc.). This illustrates the range of luminosity within a spectral type. Note also that the figures given for type M0 on the main sequence chart only apply to the very brightest M-types, which are very rare (1 in 20 or so). All other red dwarfs' cold zones extend from stellar orbit outwards. Planets orbiting giant stars are unlikely to have life–bearing planets of their own, but life-compatible planets would be suitable for terraforming and colonisation.

Orbital Eccentricity

As mentioned above, not all planets orbit their stars in neat, circular orbits. Even in our own system, both Mercury and Pluto have eccentricities in excess of 0.2. As far as is known, approximately 1 in 3 planets so far discovered have eccentricities that equal or exceed this figure. The most extreme case so far is the planet orbiting the star 16 Cygni B. Massing at least 2.4 times the mass of Jupiter, this planet has an eccentricity of 0.57, ranging in distance from its sun from 0.7 to 2.7 AU. To determine eccentricity, roll on table 4 below.

Now we have a number, but what does it mean in real terms? All planetary orbits are ellipses, not true circles. Therefore, a planet has a nearest and furthest point in its orbit, referred to as *perihelion* and *aphelion* respectively. These nearest and furthest distances can be worked out as follows:

Perihelion = d x (1 – e)
Aphelion = d x (1 + e)

Where d is the average distance in (AU) and e is the eccentricity figure.

The orbit of the planet dominates the entire distance from perihelion to aphelion. It is entirely possible to create two orbits which actually cross. In such a situation, the more massive planet will likely hurl the less massive planet into the sun or out of the system entirely. The Hubble Space Telescope has taken an image of what is believed to be a planet that has been ejected from a binary system, together with a streamer of dust and gas. Alternatively, you could rule that the less massive planet has a strong *inclination* to the ecliptic plane of your system.

The Importance of Large Moons

It has recently been theorised that the presence of our moon has helped to stabilise our planet's axial tilt. If this is correct, then planets otherwise suitable for life may have only the most basic microbial life, since more complex forms could not survive the pressure of a randomly changing seasonal pattern. This would not preclude their suitability for colonisation, since their climates would change on timescales of millions of years. However, this does mean that the homeworld of a civilisation (or any world harbouring multicellular life) must have a giant moon like our own, or else be in orbit about a more massive body itself.

A Brief Note Regarding Supergiants

Supergiant stars are not believed to play host to planets, since the immense particle and radiation pressure produced at their ignition would quickly drive out any planet – forming material. Also, the life spans of these stars are so short that planets would barely have time to form before being destroyed in a supernova. Type O and B stars of any class have the same problem.

Tables

Table 1: Binary star separation
d8 Roll:
1: 2d8 million kilometres apart, roll d20. On a 20, system is a contact binary in which the stars are separated by less than a stellar diameter. Intense radiation and particle winds render the system unsuitable for life or colonisation.
2: 1d12/10 AU apart
4: 1d12 AU apart
5: 1d12x10 AU apart
6: 1d12x100 AU apart
7: 1d12x1,000 AU apart
8: 1d6x10,000 AU apart
In multiple systems, the separation of each binary pair and single straggler is at least one order of magnitude greater than the greatest separation of a binary pair. For example, in a trinary system in which the binary pair is separated by 40AU (a roll of 5), the minimum separation between the pair and the single must be 100s of AU (roll 6 or greater).

Table 2: Planetary Type
Inner (Populous) System

Roll (d20)	Planet Type	# of Moons	Moon Modifier
1-4	Large Jovian	2d12*	0
5-7	Small Jovian	2d8*	-1
8-10	Super – Terran	d8-3	-2
11-14	Terran	d6-3	-3
15-18	Sub – Terran	d6-4	-5
19-20	Asteroid Belt	-	-

Outer (Depopulated) System

Roll (d20)	Planet Type	# of Moons	Moon Modifier
1-8	Small Jovian	2d8*	-2
9-12	Terran	d6-4	-3
13-16	Sub – Terran	d6-4	-5
17-20	Comet Belt**	-	-

* 1 in 2 of these moons are Tiny. Check before rolling for moon size on table G63
** A comet belt can only exist in a star's cold zone. Otherwise, it will be an asteroid belt.

Table 3: Stellar temperature zones

Main Sequence Stars

Spectral Type	Density Drop-Off	Hot Zone	Temperate Zone	Cold Zone
A0	19AU	0 – 7AU	7 – 9AU	9+ AU
A5	15AU	0 – 3.7AU	3.7 – 5AU	5+ AU
F0	14AU	0 – 2.8AU	2.8 – 3.9AU	3.9+ AU
F5	13AU	0 – 2AU	2 – 2.7AU	2.7+ AU
G0	11AU	0 – 1.2AU	1.2 – 1.7AU	1.7+ AU
G5	10AU	0 – 0.9AU	0.9 – 1.2AU	1.2+ AU
K0	10AU	0 – 0.6AU	0.6 – 0.9AU	0.9+ AU
K5	9AU	0 – 0.3AU	0.3 – 0.4AU	0.4+ AU
M0	8AU	0 – 0.1AU	0.1 – 0.4AU	0.4+ AU

Giant Stars

Spectral Type	Density Drop-Off	Hot Zone	Temperate Zone	Cold Zone
A0	22AU	0 – 9AU	9 – 13AU	13+ AU
A5	19AU	0 – 7AU	7 – 10AU	10+ AU
F0	15AU	0 – 4.4AU	4.4 – 6AU	6+ AU
F5	15AU	0 – 4.4AU	4.4 – 6AU	6+ AU
G0	13AU	0 – 5AU	5 – 8AU	8+ AU
G5	15AU	0 – 7AU	7 – 10AU	10+ AU
K0	13AU	0 – 7.5AU	7.5 – 11AU	11+ AU
K5	13AU	0 – 10AU	10 – 14AU	14+AU
M0	12AU	0 – 11AU	11 – 15AU	15+AU
M5	12AU	0 - 13AU	13 – 19AU	19+AU

Table 4: Orbital eccentricity

Eccentricity Class: (d6)

- 1-4 Circular — Roll d12 and divide by 100 to determine eccentricity
- 5-6 Eccentric — Roll 2d20+18 and divide by 100 to determine eccentricity