A Multiple Star System based on Gliese 667 (HR 6426)
With potentially habitable planets for CONTACT 2012
by Gerald D Nordley (23 March 2012)

OOo The Gliese 667 system is a triple star system, somewhat like a smaller version of the Alpha Centauri system. It has two spectral class K stars (between the Sun and red dwarfs in temperature and luminosity) orbiting each other which are in turn orbited by a red dwarf. It is only 22 light years away and is so reachable by human crews traveling near the speed of light within the current human lifetime, and easily so within extended lifetimes.

The red dwarf has recently been found to have from two to possibly four planets. We shall imagine that the other stars have planets as well.

The system's stars have have about four times as much hydrogen and helium compared to other elements as the sun, and they have nearby companions, so the planetary systems are imagined to be smaller in total mass than the Sun's.

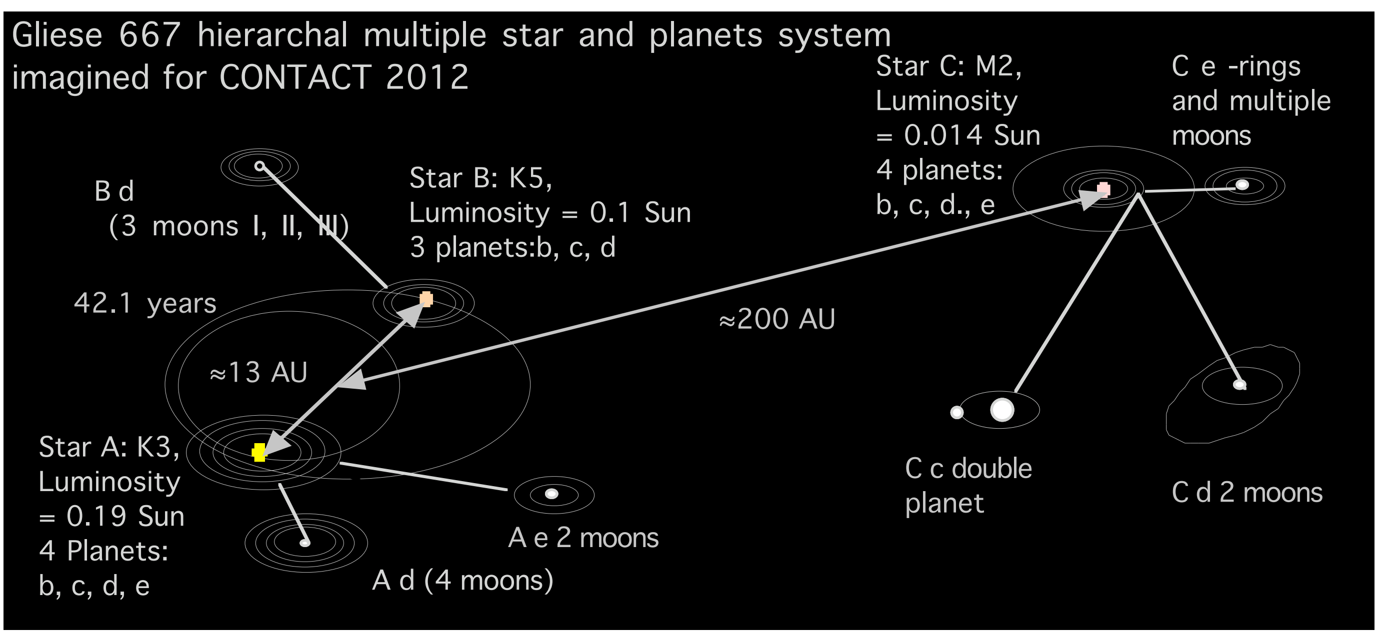
As near as can be told from available data, the stars are between 2 and 10 billion years old, so we are within the realm of the possible to assume them to be similar to the Sun in age.

These stars orbit "barycenters" balanced like children on a teeter-totter with the slightly heavier child sittng closer to the hinge. The A-B orbit is eccentric with a mutual periastron of about 5 AU occurring every 42 years. The A-B-----C current separation is about 200 AU, but the orbit is very poorly defined. We shal assume a 200 AU semimajor axis and a nominal eccentricity. The orbital period is in the hundreds of years.

As a rule of thumb, one does not expect stable planetary orbits outside of about a fifth of the stellar periastron distance, and that rule will be observed here.

For A and B, at periastron, the companion star is still about ten times more distant than the host star, and provides only about 1% more insolation. However, that 1% insolation is about as much light as Saturn gets from the Sun, so It will seem like daylight unless the closer star is in the sky. When the companion star is in the night sky, there is no night!

Star C will be just a very bright star in the sky from planets around A or B, but the A B pair in the sky of a planet around C would, like the full moon, be so bright as to cast shadows and prevent one from seeing all but the brightest other objects in the sky.

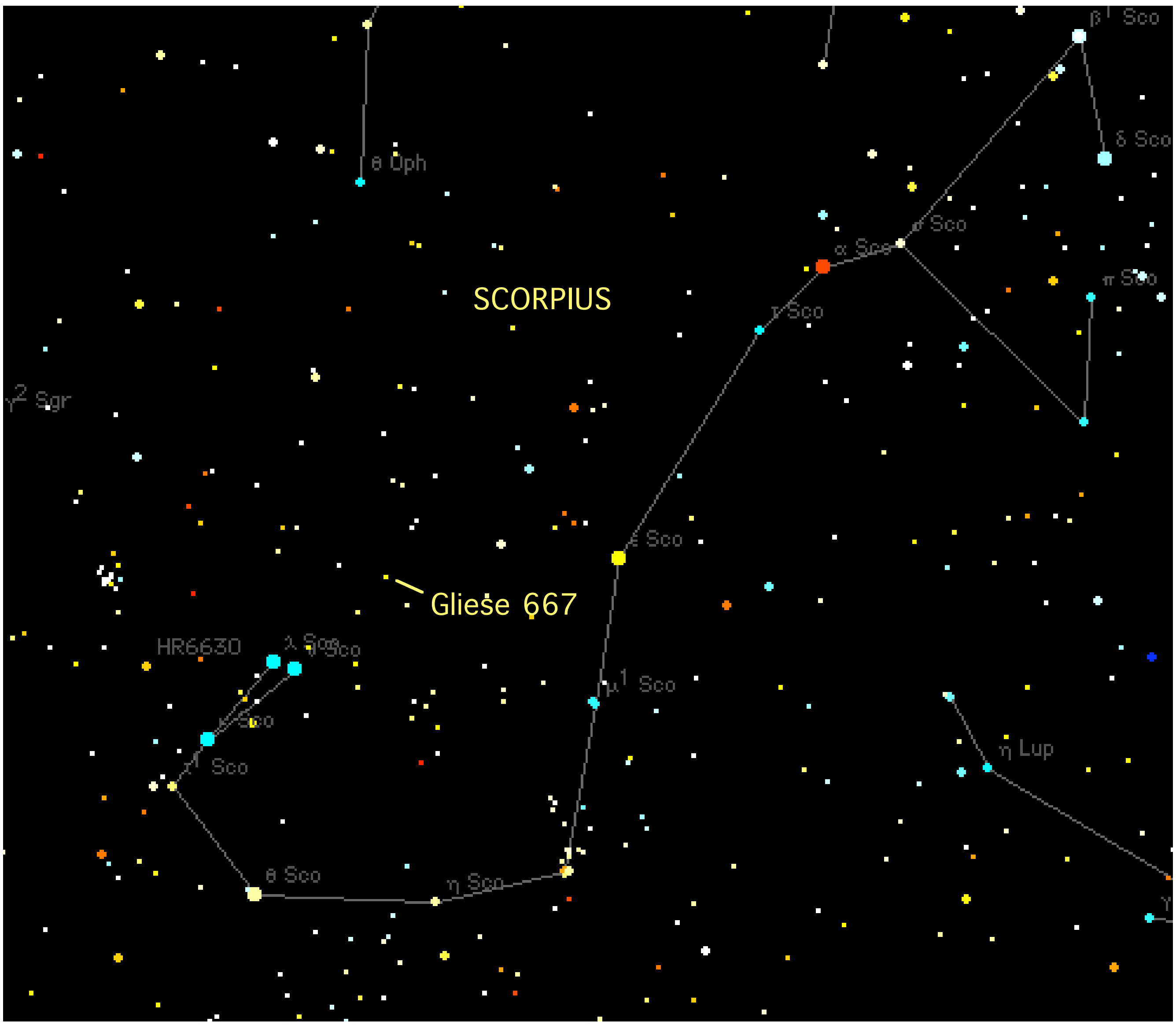


The name we use here, Gliese 667 means that this star system received the number 667 in the first catalog of nearby stars assembled by Wilhelm Gliese (GLEE-zeh), a German Astronomer noted for studies of nearby stars. One will also see this system designated as GJ 667; the "J" is for Hartmut Jahreiss, Gliese's colleague in nearby star studies in Gliese's later years. Their work is continued by the Astronomisches Rechen-Institut in Heidelberg.

The system is also has at least 38 other designations, some of the more common being HR 6426, HD 156384, HIP 84709, SAO 208670, CD-34 11626, LHS 442, and LTT 6888.

A table of properties of possible interest to COTI participants follows the descriptions.

The Gliese 667 triple-star system is located in Sorpius.



Descriptions of Bodies in the Gliese 667 COTI System

O GJ 667A is a K3 star with about one-fifth of solar bolometric luminosity, and seven-tenths of its radius, though from a planet close enough to get the same amount solar energy as the Sun it would appear (to instruments) a bit dimmer, larger, and cooler.

O• Gliese 667A b is about 0.13 AU from the star. It is a Mercury-like world, but it is a bit larger and actually is tide-locked. It gets 11.5 times as much insolation (total energy as Earth and should be about 700 K at it s subsolar point, but might have ice on its rear side. It has only a trace of an atmosphere; some hydrogen from the solar wind and wisps of sulfur and argon.

O•• Gliese 667A c is about half an AU from the star. It is a relatively Earth-like world in the L5 (trailing) lagrange point of a subjovian planet. It has sixty percent of Earth's mass and eighty-four percent of its radius, and is so slightly denser. We imagine it to have 86% of Earths gravity, about 0.8 of its atmospheric surface pressure, a relatively high fraction (.005) of CO_2 and hence a low effective bond albedo of 0.2. Its polar troposphere altitude is similar to Earths and this produces a mean surface temperature of something like 281 K, a few degrees Celsius less than Earth's.

It has significant solar tides and ample dissipative mechanisms which have long since brought its equatorial bulge into alignment with its equatorial plane. It rotates in 27 hours these days, down from perhaps ten hours when it was formed, and it is still slowing down.

Its core is relatively large and its mantle a bit thinner than Earth's; it is tectonically active and its ocean trenches are deeper. Mountains would be about 20% higher and the air on the highest of them significantly thinner than Everest.

It approaches and recedes from the subjovian planet in cycles of a few decades as it wanders around its Lagrange point. Its eccentricity also varies, so in some eons it has hot periastron summers, in others less variation. We have not given it a moon for concerns about orbital stability, but no harm would probably be done by giving it a couple of small ones, like Phobos and Deimos of Mars.

Imagine a world with larger polar caps and a more narrow band of tropical temperatures. Open sea and lake area are about 30% of its surface, so perhaps it is drier than Earth, though with great rivers flowing from the icecaps.

O•: Gliese 667A d is a subjovian planet about half the mass and 3/4 the radius of Neptune. It might be a rather featureless dark blue if its upper atmosphere is too warm for clouds.

It forms the second mass of the the equilateral triangle of Langrange's restricted solution to the three body problem. Gliese 667 c may have been trapped into this resonance in the early days of the planetary system as Gliese 667 d migrated inward through the protoplanetary disk. A more usual result would have been Gliese 667A c's ejection or transplanting into an exterior orbit, but in those early chaotic days of planetary system, odd things may come to be.

In any event, there would be much opportunity for life-bearing chunks of meteor impact debris to travel between objects in this orbit, and to be ejected from it toward the other stars, thus ameliorating somewhat the "synchronicity" problem of evolved civilizations finding each other at similar stages of cultural development.

With a nod to COTI possibilities, we give Gliese 667A a robust magnetic field aligned with its spin axis, like Saturn's, any satellites are protected from stellar wind erosion and its magnetosphere temperature is mild enough not to be a problem in itself. It should have great auroras visible to denizens of the satellites when they pass through its shadow.

Its core rotates in 1.02 days, though superrotating winds make the planets appear to rotate faster. These winds carry the tidal bulge of the atmosphere ahead of its large synchronous satellite, pulling it forward slightly in its orbit and thus the host star's radiation makes up for some of the dynamic energy dissipated in the satellite's vulcanism.

Gliese 667A d is imagined to have have a system of four satellites between its Roche limit and the fraction of its Hill sphere that marks the fuzzy limit for stable satellite orbits, in this case about 1.7 million kilometers from the planet's center. It is imagined the planet has three major moons within these limits and a fourth "irregular" satellite near its boundary, d1, dII, dIII and dIV

O•:. dI is a Mars sized satellite of "d" almost a tenth the mass of Earth with a surface gravity of a third of Earth's. It is only about twice as far from the planet as the Roche limit for objects of 3 tons/cubic meter density and is severely distorted. Its atmosphere has a surface pressure of 1.32 bar and with 8 Watts per square meter of tidal heating, the mean surface temperature is up around 276 kelvins, just over freezing. We imagine it to be about 88% covered with water with large shield volcanos dotting its seas. Tsunami waves there, by the way, would be about 3 times as high as on Earth for the same energy.

O•:. . dII is a "warm Titan," somewhat smaller and denser, with a Titan-like 1.5 bar nitrogen atmosphere. It orbits "d" 77,000 km further out than "dI" with twice the inner satellite's period and much less than half as much stress. Its a water world, 92 percent covered with seas. Most of what land area it has is the rim of a huge impact crater almost exactly in the center of its leading hemisphere and the jumbled highlands opposite that. With the deep atmosphere and oceans, it lots of thermal transport; and there shouldn't be too much difference between polar and equatorial temperatures. Its mean temperature is about 291 K, somewhat higher than Earth's.

O•:... dIII is a "dwarf planet" -sized moon in a 209-thousand-km orbit similar to most of those of Saturn and Uranus. It has a subterranean ocean under a deep ice crust, only wisps of an atmosphere, a surface gravity of 6% of Earth's, and a mean surface temperature of about -40. Its orbital period is 4 days plus change, twice that of dII, completing a 1:2:4 resonance set like that of Jupiter's first three Galilean moons.

O•:.... dIV is a 73 km irregular satellite in a loose retrograde orbit at just under half a Hill radius. It is a captured representative of a conjectured population of asteroid and kuiperoids in sparse disk beyond GJ 667Ae that merges into figure-8 belt and disk of debris circling both stars and merging with Kuiper belt of GJ 667C. These are the industrial resources for spacefarers around these stars.

O•:• GJ 667Ae is the (much) bigger part of a "double planet," a "cold Earth" in an orbit with twice the period of GJ 667d (a 2:1 resonance again). at .7 AU, its insolation is 40% of the Earth's. Giving it an atmosphere with three bars of pressure and enough CO_2 to bring the effective bond Albedo down to 0.15, we get a cool but habitable 277 K mean surface temperature. Let's say the visible surface is 30% water, 30% land, and 40% ice. The planet's mean solar day is 28.25 hours.

The large moon is synchronous and so doesn't produce a moving tidal bulge, but the stellar tides would approximate Earth's lunar tides.

With a significant eccentricity of 0.2 and a 27-deg obliquity (the angle between the normal to the orbital plane and the spin axis; Earth's is 23.4 deg), areas of the planet experience significant variations in insolation over the course of its 0.725-year orbit around the star. The precession of this double-planet's angular momentum axis would likely be driven by conjunctions with GJ 667d and be slow, as a guess, with a period in the neighborhood of a hundred-thousand years.

It's been given a breathable atmosphere for COTI: 92% nitrogen and 7% oxygen (at three bars, of course). The climate, with not to much variation given the heavy atmosphere, might be something like Alaska's, as it varies from Juneau to Barrow.

O•:•. GJ 667AeI is a 210-km airless rock circling GJ 667e in an eccentric 2:3 resonance hour orbit around "Ae." Its apsidal rotation is synchronized with eI's so that its always at periapsis when it goes between the large bodies.

O•:•.. GJ 667AeII is a warm Callisto in synchronous orbit, its atmosphere protected from solar winds by its primary's magnetic field. Its surface is an ocean under 3.7 bars of nitrogen with ammonia and methane fractions of around one percent by mass. It has extensive polar caps, but the temperate and equatorial regions are largely ice-free, hence an albedo low enough for a mean temperature just under 0 C. Its surface gravity is a Titan-like 1/7 g so waves will be high.

The world ocean goes down a thousand km or so, morphing into various forms of ice as the pressure increases. Heat trapped in the core will escape as plumes of mineral-laden hot water and there may be a thin layer of meteorite pebbles and dust on the caps, so traces of other elements are present, just not common. The ocean may be briny, like Europa's.

O•:•• GJ 667A f is a Triton or Pluto like "dwarf" planet with a thin traces of Nitrogen, helium and Neon for an atmosphere. Its eccentric orbit crosses that of GJ 667A e, but due to its high inclination and 1.5 resonance, it is over an AU away from the double planet when makes its brief forays toward the central star.

At periastron, 667A f gets almost 60% of terrestrial insolation, enough to produce some melting in the equatorial regions, a temporary water vapor atmosphere, and some water loss and drying out. It has been drying out for billions of years, but started with a lot of ice and so will continue drying out for billions of years more.

O Gliese 667B is a somewhat less bright (0.1 solar luminosity) and massive version of Gliese 667A. With a spectral class of K4 or so (the literature goes from K3 to K5) it is a bit cooler than the A star, but one would be hard pressed to tell the difference without sensitive instruments.

O• Gliese 667 Bb is Mercury-like in mass, radius and density, and at 0.236 AU, orbits somewhat closer than Mercury in our system, but its host star has only a tenth of solar luminosity, the result being that "Bb" receives less than twice the terrestrial insolation, as opposed to about 8 for Mercury. This puts "Bb" at the inner edge of some people's habitable zone. Here, we imagine it to be tidelocked with a deep enough atmosphere (scale height of some 30 km), so that water freezes out before it gets to the ozone layer. A surface pressure of .42 bars gives a sun-side mean surface temperature of 335K (about 60 C), but that's an average; the twilight zone will be cooler. We imagine enough wind heat transport plus half an orbit's worth of illumination from A to keep the rear side well over 100 K and probably temperate in some areas just darkside of the twilight zone. Water ice builds up on the back side, flows toward the front, melts, flows into the twilight zone ocean, is evaporated, and returns to the dark side.

For COTI, we give life to the ocean and an Nitrogen/Oxygen atmosphere with about equal proportions, plus some Argon.

O•• Gliese 667B c is somewhat larger (7165 km radius) and more massive (1.2 times) than Earth and at 0.38 AU from its dimmer host star gets about 72% of Earth's insolation. It has eccentricity seasons due to the influence of the subjovian next planet out, so insolation varies from 0.965 down to 0.568, fifty-five and a half days later. The year is ≈112 mean solar days.

It also gets about four times the maximum tidal force that Earth receives from the Sun and the Moon. It is assumed here that that is not enough to bring the planet into a tide-lock over the age of this star system, but that the rotation rate has slowed some, to 39.36 hours, which combined with orbital motion gives it a solar day of about 40 hours. We do wave our hands at this tidal authority to suppose that the axial tilt is near zero.

The mean atmospheric surface pressure is imagined to be 1.3 bars, the atmospheric composition is Earthlike (presupposing oxygen-generating biota). The mean surface temperature is a comfortable 284 K.

No moons are listed, for tidal reasons.

O••• Gliese 667B d is a subjovian planet somewhat smaller than Neptune with a radius of 3.2 Earth's and a mass of about 10 Earths. It orbits in a 1.5-year orbit at 1.09 AU in a 5:1 resonance with "c." It has a typical giant planet atmosphere and it is cool enough (216 K effective temp) to be colorful. We give it a resplendent ring system, which could serve as a treasure trove of space resources for the inner planets, and three major moons, all close in, given that it is relatively close to its host star.

O•••. Gliese 667B dI is an asteroid-sized potato-shaped moon at 123.5 km radius with a dark surface and low albedo. With a mean radius of 121 km and a mass of about 1E19 kg, it's just big enough to keep the rings in order. Its density is only 1.32 times that of water, so it could have a lot of macroporosity (i.e. caves).

O•••.. Gliese 667B dII orbits the planet at 254 thousand kilometers where its orbital period and day are about 69 hours It is somewhat smaller and less massive than Mars and retains a deep 5.1 bar atmosphere atmosphere giving it an Earthlike 285 K surface temperature. Its surface gravity is 27% of Earth's, intermediate between the Moon and Mars. One suspects it is the result of the merger of two more normally sized satellites whose orbits lost energy unevenly due to tidal interactions, billions of years ago. It is slightly egg shaped, with the inner pole less dense and higher than the outer pole, wherein resides a great sea. On some plateaus and highlands around the inner pole, almost a hundred kilometers above sea level, the air pressure gets down to 2 bars or so, but they are covered with ice.

O•••... Gliese 667B dIII is a bit like what our moon would be like with an atmosphere. It orbits at an almost lunar distance of about 291 thousand km and is only a little larger and more massive. Its surface gravity is like our moon's. We give it some methane and CO_2 to bring the effective bond albedo down to 0.15 and pump the atmosphere up to 5.1 bar for a cool, but liquid, 275 K surface temperature. Its land and ice area is about thirty percent; the rest is water. There's a fair amount of impressive surface structure: there's enough tidal stress due to the big inner satellite to keep the mantle liquid and the crust thin, so vulcanism and tectonics are present. The surface structure is impressive--high because of the low gravity and highly eroded due to the water--especially at the central peak of the huge crater that marks the inner pole.

o Gliese 667C The third star in this system is a red dwarf with a bolometric luminosity given as 0.0137 Suns and a mass given as 0.31 Suns. The temperature is given as 3700 K. At this temperature and luminosity, the radius would be about 0.29 suns. It provides Earth-equivalent insolation at a distance of 0.117 AU, though one should probably adjust this outward to about 0.13 AU because its redder light is more efficient at transferring energy to planets. We shall simply use lower Bond albedos for our planets to allow for this.

The tidal stress on a planet at this distance would be about 193 times the tidal stress on the Earth from the Sun, so we should probably assume that terrestrial planets in this star's habitability zone will be tide locked. This probably applies to jovian and subjovian planet cores as well, though superrotating winds could give the atmospheres the appearance of rotation. The four planets of this star are based on actual radial velocity measurement data, though it is less and less certain as one goes out from the star.

We have the minimum masses of these planets; the masses they would have if we saw the system edge on. We do have an inclination to the line of sight of the K-star pair, however, and it is 50 degrees. The orbit of Gliese 667C is not bound by this, of course--200 AU is a long distance--but a large inclination difference could lead to perturbations that tend to screw up planetary systems, invalidating the ones we've already supposed. Also, the Gliese 667C planetary system appears in good health. Therefore, we adopt the inclination of 50 degrees for the AB-C orbit and the C planets as well and divide the minimum masses by sine(50 deg).

When we look at planets in this mass range that have known densities, some have densities typical of giant planets (Kepler 11d, GJ 1214 d, HD 97658 b, Kepler 11e, some have densities found in terrestrial planets, (Kepler 11b, Kepler 18b, 55 Cnc e) and some are anomalously high. Here, we've assigned the giant planet densities to GJ 667b, and d, and a terrestrial planet density to GJ 667c, more for the interest of having a high surface gravity planet for someone to work with for COTI, than for any other good reason.

o• Gliese 667C b, at is taken to be a hot mini neptune with an effective temperature of 426 K and a radius of 2.88 Earths (≈3/4 Neptune). It's probably too close to the star to have long-lived satellites.

o•• Gliese 667C c is our "super Earth." At a 0.12 AU distance from the star, its insolation is a very terrestrial .912 times Earth's . Its mass we take to be 5.93 times that of Earth. Allowing for some compression, we give it an overall density of 6.00 times that of water, a radius of 1.76 times that of Earth, and a surface gravity of 1.9 gs.

If we don't want it to be tidelocked, we need to do something special; the tidal strain on this planet will be about 10 times that of Mercury.

Because of its mass, it still has an appreciable quarter Hill radius, however. Thus we give it a large moon orbiting in a period faster than planet's rotation. The moon tries to spin the planet up as the star tries to spin it down. Eccentricity resonances and superrotating winds pump energy into the system to ameliorate losses. Maybe that works. Or maybe that makes the dynamical system so complicated that nobody can prove it doesn't work, at least not without a major grant. (We science fiction writers think like that.) The planet rotates once every 56 hours and change.

With low topographic relief, we allow water to spread over 90% of its surface. The height of the troposphere is only 6.2 km versus ≈11 for Earth at the poles. Setting the surface pressure to 1 bar gives us a surface temperature of about 281 K. Imagine broad shallow oceans with low volcanic islands with very shallow slopes. Ice should cover both poles.

o••. Gliese 667C cI. Since it's in the habitable zone, we'll give it a habitable satellite. Its quarter-Hill stability limit is, like Earth's about a half million kilometers out; but we barely hang onto our moon. "cI" is going to be held tighter at 131 thousand kilometers, where it will be locked in a 1:2 resonance with the planet's spin period. From "c" it will appear roughly five times as large as our moon. The moon will appear to take two local days between moonrise and moonrise. It will be somewhat egg shaped, with things stretched a few kilometers in the direction of the planet.

Unlike our moon, this moon is made of the same stuff as the planet, but less compressed. It was possibly a gentle capture instead of a collision. Perhaps they accreted together with "c" grabbing the lion's share. At any rate, we have a Luna-sized moon but more massive and about 100 kilometers smaller. Its surface is about 68% water, the rest rock and ice. With a higher density (more iron), tidal heating, and a much shorter orbital period, we imagine that it has its own magnetosphere, protecting its atmosphere from erosion by the stellar wind. (The magnetic interactions between this satellite and its primary may be of great interest to specialists.) Also, the red dwarf's integrated ultraviolet flux will be only a percent or so of the Suns, molecules will stay molecules for much longer times.

Atmospheric pressure is 0.813 bars. Its stratosphere starts at about 57 km--there's plenty of room for hydrogen-containing volatiles to freeze out before coming within range of what ultraviolet there is. If COTI folk want the same partial pressure of oxygen we have now, the percentage by mass would be about 27%.

Space travelers note: Deep atmospheres like this favor some kind of air-breathing propulsion for a first stage.

o••.• Gliese 667C d. This is the less confirmed second planet of the C system. Assuming the 50 deg. orbital plane inclination, its mass would be about 7.4 times the mass of Earth, or about half the mass of Uranus. We'll assume a somewhat greater density, 1.7 times that of water, than Uranus has in honor of its close-in position in the C system, and get a radius of about 3/4 that of Uranus, or 2.9 times that of Earth.

It gets about a quarter of the insolation that Earth gets. With an effective temperature of about 213 Kelvins, it should be cool enough to show some bands, spots, etc. It could have a small, dark ring system inside its Roche radius, less than two planetary radii out. Tides are still strong here, and we anticipate that the spin axis and magnetic field are aligned perpendicular to the orbital plane. The planet's core rotates once in 0.85 days.

o••.•. Gliese 667C dI is a highly distorted rock-and-ice moon about 5,000 km outside the Roche limit. It is somewhat similar to Ceres in composition, mass and radius. It's tidally heated and spews water and dust that coats the ring particles and makes them bright. The interior of this object might be an offbeat locations for life forms.

o••.•.. Gliese 667C dII is of lunar size and gravity, orbiting "Cc" in 17 hours. It lies deep within the host planet's magnetic field and has accumulated six bars of nitrogen atmosphere, mostly from comet impacts. We imagine it life-bearing for COTI purposes, with water oceans and ash-darkened ice on its near freezing surface. It has considerable tidal heating, with hot spots where the temperature is well in excess of the normal 273 K. Its deep atmosphere and dark oceans absorb sunlight efficiently, it reflects only 8% of what it gets from Gliese 667. It is a place of high surface relief, with ice-capped volcanic mountains and ridges fifty kilometers tall, often eroded into steep canyons and fjords.

o••.•..• Gliese 667C e is a suspected jovian planet about 2.5 AU out from its host star. If suspicions are correct, it gets maybe the same insolation as Neptune and has a Saturn-like mass and radius. Its orbit, courtesy of the other stars in the system, is relatively eccentric, swinging from 1.8 AU out to 3.35 AU in the course of its 7.5 year orbit. It will be prominent in the sky around periastron, over a magnitude and a half brighter than when at apoastron. We imagine it has a pretty ring system to inspire space travelers and dozens of satellites to explore and exploit. But we are out of time.

This is not, in all probability, anything like what the Gliese 667 system will eventually be found to be. Astronomers have given us some clues, and your COTI system builder has used these and a lot of imagination and shortcuts to create these worlds. Most importantly, it is highly improbably that conditions have conspired to put as many habitable worlds in one star system; in actuality, we would be lucky to find one. Somewhat less improbably, we might very well find the materials to build human colonies there.

Table of the GJ 668 COTI system. Items of particular COTI interest are marked in red.

World Name	size of orbit (AU)	Orbital period (days)	solar Day hours	world radius E=1	Surface gravity (E=1)	Insolation (E=1) max	min	press. (bar) (E=1)	mean temp. K E=288
'GJ667Ab	0.1300	21.364	512.7	0.515	0.475	16.750	8.429	trace	499.06
'GJ667Ac	0.4801	151.640	27.8	0.840	0.857	0.926	0.777	0.8	294.9
'GJ667Ad	0.4801	151.640	24.6	3.156	0.848	0.871	0.823	1	291.9
'GJ667AdI	0.0006	1.022	24.7	0.517	0.338	'_	'_	1.32	276.42
'GJ667AdII	0.0009	2.053	49.9	0.287	1254	'_	'_	1.5	290.65
'GJ667AdIII	0.0014	4.097	101	0.121	0.064	'_	'_	0.01	243.5
'GJ667AdIV	0.0113	94.229	5973.3	0.011	0.005	'_	'_	trace	231.9
'GJ667Ae	0.6960	132.305	28.3	0.757	0.358	0.630	0.280	3	276.65
'GJ667AeI	0.0001	264.640	18.8	0.033	0.019	'_	'_	trace	214.84
'GJ667AeII	0.0002	0.781	28.3	0.378	0.14	'_	'_	3.4	268.8
'GJ667Af	0.9120	1.172	6.8	0.183	0.068	0.609	0.093	trace	144.29
'GJ667Bb	0.2358	396.961	34.4	0.374	0.373	1.913	1.787	0.42	325.28
'GJ667Bc	0.3760	55.583	39.9	1.125	0.961	0.965	0.568	1.3	284.1
'GJ667Bd	0.5953	88.135	13.2	3.277	0.956	0.421	0.398	1	236.72
'GJ667BdI	0.0008	111.920	37.8	0.019	0.005	'_	'_	trace	216.04
'GJ667BdII	0.0012	222.994	68.9	0.474	0.285	'_	'_	5.124	285.44
'GJ667BdIII	0.0017	1.563	113.5	0.285	0.143	'_	'_	4.7	268.07
'GJ667Cb	0.0494	2.836	20.3	2.884	0.893	8.189	4.087	1	512.35
'GJ667Cc	0.1226	4.631	15.7	2.538	0.922	1.425	0.633	1	299.84
'GJ667CcI	0.0006	7.202	27	0.258	0.181	'_	'_	0.8	286.5
'GJ667Cd	0.2351	28.151	19.9	2.878	0.891	0.320	0.198	1	213.42
'GJ667CdI	0.0003	1.082	8.6	0.094	0.041	'_	'_	trace	190.64
'GJ667CdII	0.0005	74.781	17.3	0.254	0.166	'_	'_	6.2	273.21
'GJ667Ce	2.5770	2713.442	11.7	8.814	1.44	0.004	0.001	1	108.49