Solar System

June 5, 2020

Positions of Solar System bodies and effective distances between them for communiation and travel.

1 Inner System

The inner system map shows positions of notable objects inside Jupiter's orbit. Future orbit positions are displayed for some bodies at one month intervals.

Tycho Station The Belt headquarters of Tycho Manufacturing and Engineering Concern is the largest mobile construction platform in the Sol System. Fifteen thousand workers and their families live within Tycho, building megastructures or massive ships far beyond the reach of a planet.

1.1 Colonized Asteroids

1 Ceres The only dwarf planet in the inner solar system, and the first asteroid discovered by humanity. Tycho corporation spun up the asteroid in a dramatic feat of engineering, granting it a gravity of 0.3 g. Now the most important port of call in the Belt with population of approximately six million permanent residents

2 Pallas The third largest asteroid in the Asteroid Belt, and the second asteroid discovered by humanity. It hosts one of the oldest stations, Pallas Station, in the outer planets, but is also known for a revolt at its colony. The station itself has a long history of a refinement station for the mining operations of the Belt.

4 Vesta The second-most-massive asteroid in the Asteroid Belt after Ceres. It hosts one of the largest settlements in the outer planets. At some time during the UN-MCR Cold War, Vesta was the site of the Vesta Blockade, a confrontation between the UN and MCR that would delay the Martian terraforming efforts for over a century.

10 Hygiea The fourth largest asteroid in the Asteroid Belt and somewhat oblong. It hosts Hygeia Station. Like many places in the Belt, its population suffered from high UN taxes that made survival expensive and kept the population routinely destitute.

1.2 Other Notable asteroids

3 Juno One of the two largest stony asteroids, along with 15 Eunomia. It is estimated to contain 1% of the total mass of the Asteroid Belt. Its orbit has an extreme eccentricity which brings Juno closer to the Sun at perihelion than Vesta and further out at aphelion than Ceres.

5 Astraea The fifth asteroid discovered. Physically unremarkable but notable because after its discovery, thousands of other asteroids would follow. The discovery of Astraea proved to be the starting point for the eventual demotion of the four original asteroids (which were regarded as planets at the time) to their current status.

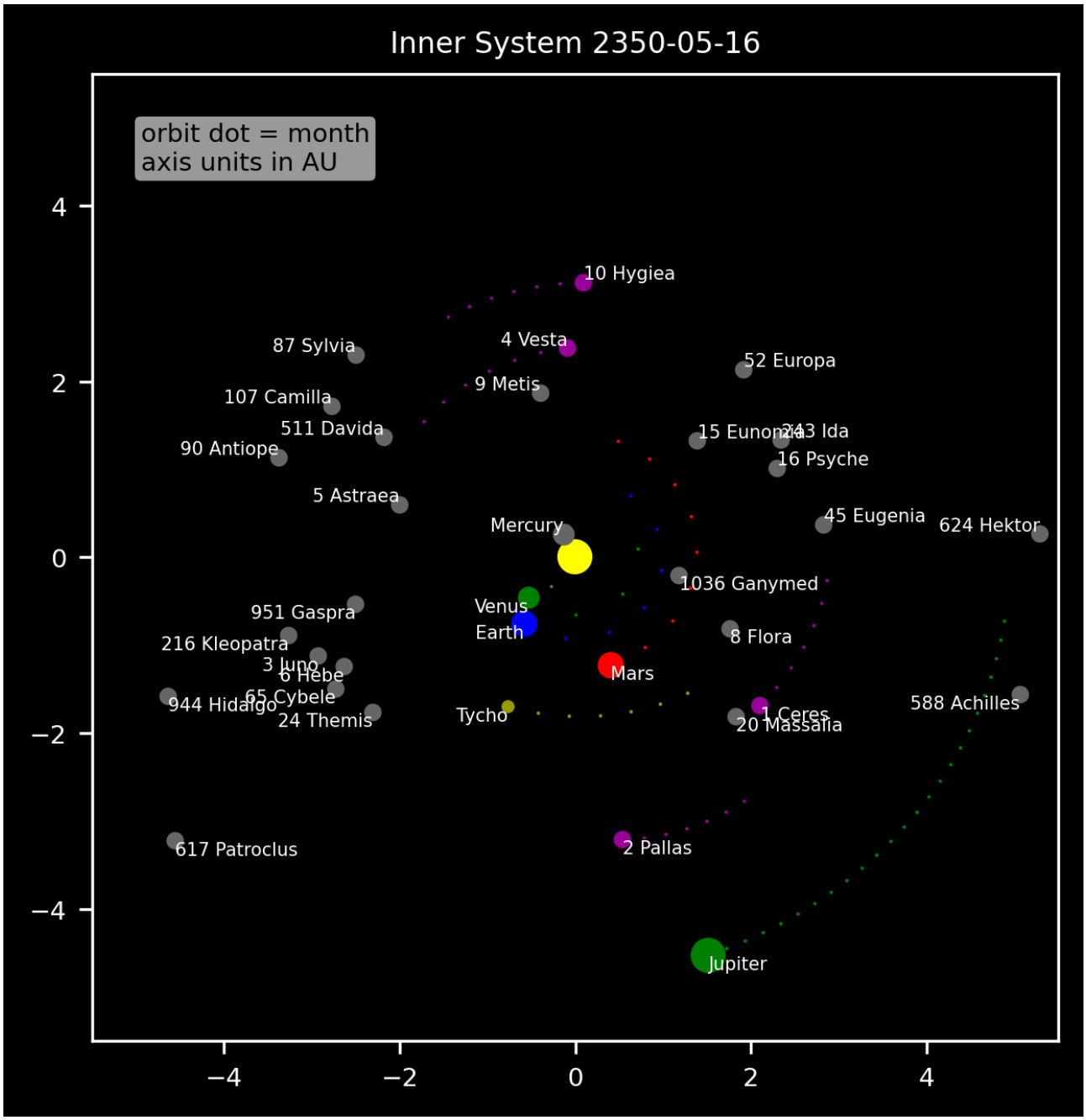
6 Hebe Large main-belt asteroid, containing around 0.5% of the mass of the Belt. This high bulk density means an extremely solid body that has not been impacted by collisions, which is not typical of asteroids of its size. In brightness, Hebe is the fifth-brightest object in the Asteroid Belt.

8 Flora Large, bright main-belt asteroid. It is the innermost large asteroid: no asteroid closer to the Sun has a diameter above 25 kilometres or two-elevenths that of Flora itself, and not until the tiny 149 Medusa was discovered was a single asteroid orbiting at a closer mean distance known.

9 Metis One of the larger main-belt asteroids. It is composed of silicates and metallic nickel-iron, and may be the core remnant of a large asteroid that was destroyed by an ancient collision. Metis is estimated to contain just under half a percent of the total mass of the Asteroid Belt.

15 Eunomia The largest of the stony asteroids. Eunomian family is the most prominent family in the intermediate asteroid belt and the 6th-largest family with nearly six thousand known members, or approximately 1.4% of all asteroids in the Asteroid Belt.

16 Psyche One of the most massive asteroids in the asteroid belt. This object is over 200 km in diameter and contains about 1% of the mass of the entire asteroid belt. It is thought to be the exposed iron core of a protoplanet, and is the most massive metallic M-type asteroid.



20 Massalia Stony asteroid and the parent body of the Massalia family located in the inner region of the asteroid belt, approximately 145 kilometers in diameter. The family is fairly young, estimated to have been created by an impact 150 to 200 million years ago.

24 Themis The largest member of the Themistian family with surface completely covered in ice. There is also organic compounds in the form of tholins, high-molecular weight organics found in the outer solar system, distinguished by a brown or reddish color in optical spectra.

45 Eugenia Famed as one of the first asteroids to be found to have a moon orbiting it, and the first one to been discovered by an Earth-based telescope. Eugenia I Petit-Prince is the larger (diameter of 13 km), outer moon. A second, smaller (diameter of 6 km) satellite orbits closer to Eugenia.

52 Europa The 6th-largest asteroid in the asteroid belt, having an average diameter of around 315 km. It is not round but is shaped like an ellipsoid of approximately 380×330×250 km. Europa is a very dark carbonaceous C-type, and is the second largest of this group.

65 Cybele One of the largest asteroids in the Solar System and is located in the outer asteroid belt. It gives its name to the Cybele group of asteroids that orbit outward from the Sun from the 2:1 orbital resonance with Jupiter. The last outpost of an extended asteroid belt.

87 Sylvia The 8th-largest asteroid in the asteroid belt. It is the parent body of the Sylvia family and member of Cybele group located beyond the core of the belt. Sylvia was the first asteroid known to possess more than one moon. They have been named (87) Sylvia I Romulus and (87) Sylvia II Remus.

90 Antiope A double asteroid in the outer asteroid belt. It was found to consist of two almost-equally-sized bodies orbiting each other. At average diameters of about 88 km and 84 km, both components are among the 500 largest asteroids.

107 Camilla One of the largest asteroids from the outermost edge of the asteroid belt, approximately 220 kilometers. It is a member of the Sylvia family and located within the Cybele group. The X-type asteroid is a rare trinary asteroid with two minor-planet moons.

216 Kleopatra A metallic, ham-bone-shaped asteroid and trinary system orbiting in the central region of the asteroid belt, approximately 138 kilometers in diameter. It is believed that Kleopatra's shape, rotation, and moons are due to an oblique impact perhaps 100 million years ago.

243 Ida An asteroid in the Koronis family of the asteroid belt. It was the second asteroid visited by a spacecraft and the first found to have a natural satellite. Ida's moon Dactyl is only 1.4 kilometres in diameter, about 1/20 the size of Ida.

511 Davida One of the ten most-massive asteroids, and the 7th-largest asteroid. It is approximately 270–310 km in diameter and comprises an estimated 1.5% of the total mass of the Asteroid Belt. It is a C-type asteroid, which means that it is dark in colouring with a carbonaceous chondrite composition.

588 Achilles Large Jupiter trojan from the Greek camp. Archillies was the first Jupiter trojan to be discovered. The dark D-type asteroid measures approximately 133 kilometers in diameter which makes it one of the 10 largest Jupiter trojans.

617 Patroclus A binary Jupiter trojan approximately 140 kilometers in diameter. It was the second trojan to be discovered and the only member of the Trojan camp named after a Greek character. The dark D-type asteroid is also slow rotator and one of the largest Jupiter trojans.

624 Hektor The largest Jupiter trojan and the namesake of the Hektor family, with a highly elongated shape equivalent in volume to a sphere of approximately 225 to 250 kilometers diameter. It has one small 12-kilometer sized satellite, Skamandrios.

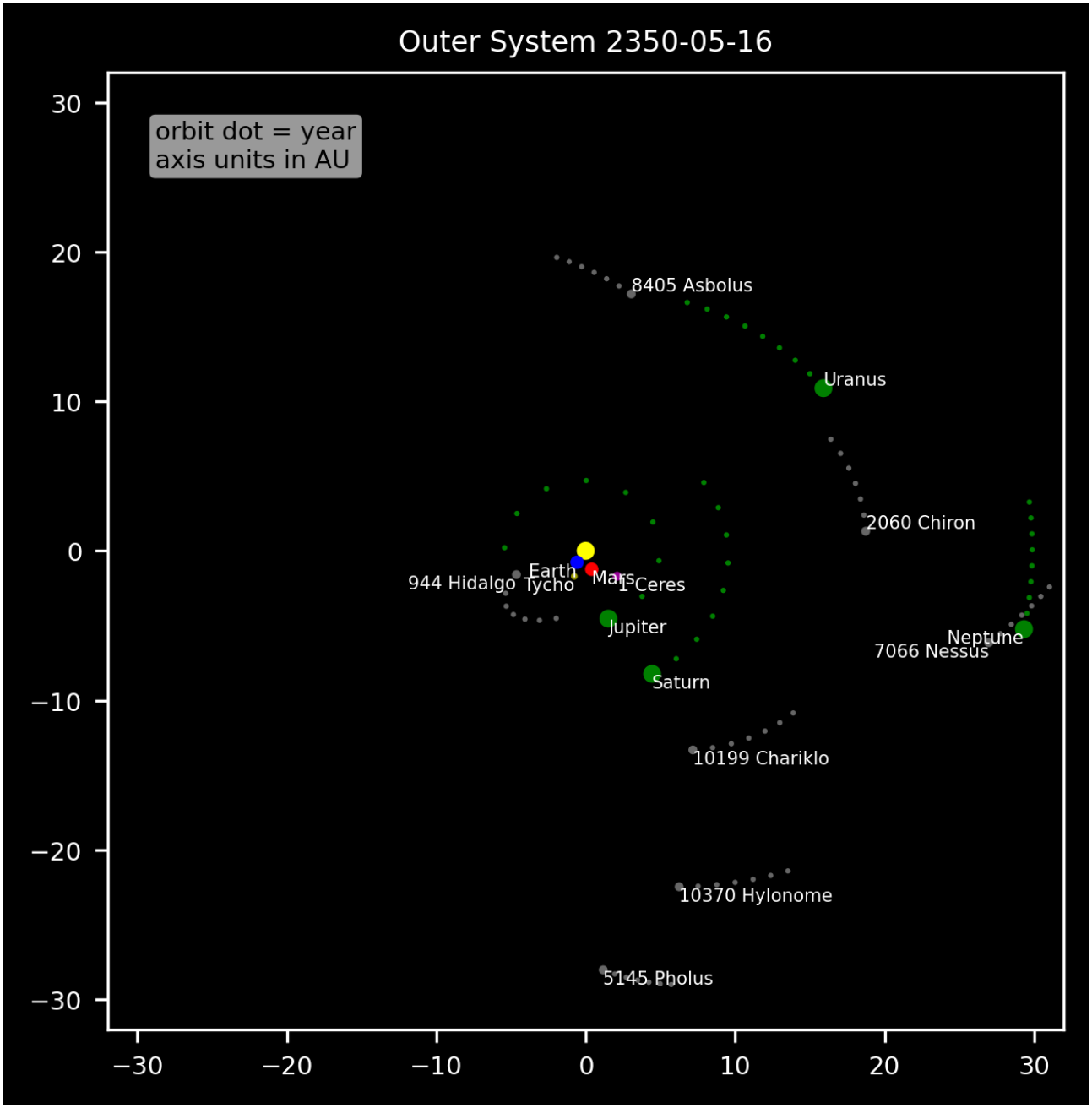
944 Hidalgo A centaur and unusual object on an eccentric, cometary-like orbit between the asteroid belt and the outer Solar System, approximately 52 kilometers in diameter. It is the first member of the dynamical class of centaurs ever to be discovered.

951 Gaspra An S-type asteroid that orbits very close to the inner edge of the asteroid belt. Gaspra was the first asteroid ever to be closely approached when it was visited by the Galileo spacecraft, which flew by on its way to Jupiter on 29 October 1990.

1036 Ganymed A stony asteroid on a highly eccentric orbit, classified as a near-Earth object of the Amor group. With a diameter of 35 kilometers, Ganymed is the largest of all near-Earth objects. Amor asteroids is a subgroup of the near-Earth asteroids that approach the orbit of Earth from beyond, but do not cross.

2 Outer System

The outer system map shows positions of giant planets within orbit of Neptune. Earth, Mars and some asteroid colonies are included for reference. Future orbit positions are displayed for some objects at one year intervals.



2.1 Centaurs

Centaurs are small Solar System bodies with either a perihelion or a semi-major axis between those of the outer planets. They generally have unstable orbits because they cross or have crossed the orbits of one or more of the giant planets; almost all their orbits have dynamic lifetimes of only a few million years. Centaurs typically behave with characteristics of both asteroids and comets.

944 Hidalgo The first member of the dynamical class of centaurs ever to be discovered. The dark D-type object has a rotation period of 10.1 hours and an elongated shape. Its orbit takes it to the inner edge of the Asteroid Belt and as far out as to the orbit of Saturn.

2060 Chiron Although Chiron was initially called an asteroid and classified only as a minor planet with the designation "2060 Chiron", it was later found to exhibit behavior typical of a comet. Today it is classified as both a minor planet and a comet.

5145 Pholus An eccentric centaur in the outer Solar System, approximately 180 kilometers in diameter, that crosses the orbit of both Saturn and Neptune. The very reddish object has an elongated shape and a rotation period of 9.98 hours. It was the second centaur to be discovered.

7066 Nessus A centaur on an eccentric orbit, located beyond Saturn in the outer Solar System. The dark and reddish minor planet is elongated and measures approximately 60 kilometers in diameter. It has a relatively long orbital half-life of about 4.9 million years.

8405 Asbolus A centaur orbiting in the outer Solar System between the orbits of Jupiter and Neptune. It measures approximately 80 kilometers in diameter and has a fresh impact crater on its surface, less than 10 million years old.

10199 Chariklo The largest centaur with a diameter of 232 km. It orbits the Sun between Saturn and Uranus, grazing the orbit of Uranus. Chariklo has two ice rings (named Oiapoque and Chuí) with radii 396 and 405 km and widths of about 7 km and 3.5 km respectively.

10370 Hylonome A minor planet orbiting in the outer Solar System. The dark and icy body belongs to the class of centaurs and measures approximately 75 kilometers in diameter. It is a Neptune-crosser, and an outer-grazer of the orbit of Uranus, which it hence does not cross.

3 Communication Delay

One of the few true constants in the universe remains the speed of light. Whether communications are sent as radio waves or on the laser of a tightbeam, they travel 300,000 kilometers per second. Often a message can be slowed while the receiver waits for redundant copies of lost packets of data to arrive, or for a message to work its way to the top of the queue at a tightbeam relay station and get passed along on the next stage of its journey. Worse, a distance of 15 light minutes between Earth and Ceres doesn't mean it takes 15 minutes to establish a connection: it means it takes 15 minutes for the first part of the message to travel the distance ("How are you?"), then another 15 minutes for the reply to return ("I'm fine, thanks."). Conversations of alternating messages can take hours or days to complete. Because of this, most transmitted conversations are sent as recorded messages rather than attempting a live conversation, unless the light-speed delay is only a few seconds.

Communication Delay in Minutes 2350-05-16

	Mercury	Venus	Earth	Mars	Tycho	Ceres	Pallas	Vesta	Hygiea	Jupiter	Saturn
Mercury	0	7.3	10	14	21	27	30	19	26	46	86
Venus	7.3	0	2.8	11	15	26	25	26	33	41	82
Earth	10	2.8	0	9.3	12	25	24	28	36	38	80
Mars	14	11	9.3	0	12	16	19	33	40	31	72
Tycho	21	15	12	12	0	24	23	40	47	31	72
Ceres	27	26	25	16	24	0	24	43	49	25	61
Pallas	30	25	24	19	23	24	0	47	53	25	63
Vesta	19	26	28	33	40	43	47	0	7.4	64	103
Hygiea	26	33	36	40	47	49	53	7.4	0	71	109
Jupiter	46	41	38	31	31	25	25	64	71	0	41
Saturn	86	82	80	72	72	61	63	103	109	41	0

Communication delay between planet's moons is usually less than 10 seconds. Delay between Earth and Moon is about 1.3 seconds.

4 Travel Times

Because the Epstein Drive removed Δv limitations to space travel, ships no longer needed to execute Hohmann transfers to maneuver between bodies. To transfer, ships can simply burn prograde at a constant rate, then flip around and decelerate by burning retrograde. This maneuver is called a Brachistochrone trajectory, from the Greek meaning "shortest time." A course using this maneuver tends to be curved as it uses the sun's gravity to increase the ship's acceleration.

The time it takes to execute a flight path along a Brachistochrone trajectory depends on two factors: the distance between the two points, and the acceleration of the ship. The greater the acceleration, the less time it takes to travel, but the multiple g-forces created by these "hard burns" are extremely stressful on the human body. Crash couches and pharmaceutical cocktails like "the juice" alleviate some, but not all, of the damage inflicted by the hardest burns.

The following tables show the time to travel the average distance between the two locations at an average acceleration of 0.5g and 1.0g, presented as total required travel time under acceleration without any of the necessary breaks taken into consideration. The first one is tolerable for belters and the second one suitable for earthers.

Travel Time in Hours (0.5g) 2350-05-16

	Mercury	Venus	Earth	Mars	Tycho	Ceres	Pallas	Vesta	Hygiea	Jupiter	Saturn
Mercury	0	91.2	107	128	156	175	183	146	172	227	312
Venus	91.2	0	56.5	110	128	171	170	171	193	215	304
Earth	107	56.5	0	103	116	167	164	180	201	209	300
Mars	128	110	103	0	119	133	147	193	213	188	285
Tycho	156	128	116	119	0	164	163	212	231	186	285
Ceres	175	171	167	133	164	0	164	219	235	168	263
Pallas	183	170	164	147	163	164	0	230	246	170	268
Vesta	146	171	180	193	212	219	230	0	91.7	269	342
Hygiea	172	193	201	213	231	235	246	91.7	0	283	352
Jupiter	227	215	209	188	186	168	170	269	283	0	217
Saturn	312	304	300	285	285	263	268	342	352	217	0

Travel Time in Hours (1.0g) 2350-05-16

	Mercury	Venus	Earth	Mars	Tycho	Ceres	Pallas	Vesta	Hygiea	Jupiter	Saturn
Mercury	0	64.5	75.4	90.5	110	124	130	103	122	161	221
Venus	64.5	0	39.9	77.5	90.8	121	120	121	137	152	215
Earth	75.4	39.9	0	72.6	82.1	118	116	127	142	147	212
Mars	90.5	77.5	72.6	0	84	94	104	136	150	133	201
Tycho	110	90.8	82.1	84	0	116	115	150	163	132	202
Ceres	124	121	118	94	116	0	116	155	166	119	186
Pallas	130	120	116	104	115	116	0	163	174	120	189
Vesta	103	121	127	136	150	155	163	0	64.9	190	242
Hygiea	122	137	142	150	163	166	174	64.9	0	200	249
Jupiter	161	152	147	133	132	119	120	190	200	0	153
Saturn	221	215	212	201	202	186	189	242	249	153	0

The last table starts and ends journey with acceleration boost. The central part of the journey uses normal 0.5g acceleration and flip at the middle.

Travel Time in Hours (0.5g + 6.0g x 4.0h) 2350-05-16

	Mercury	Venus	Earth	Mars	Tycho	Ceres	Pallas	Vesta	Hygiea	Jupiter	Saturn
Mercury	0	41.5	52.8	69.6	92.7	110	117	84.7	107	157	237
Venus	41.5	0	19.9	55	69.9	106	105	106	126	146	230
Earth	52.8	19.9	0	49.8	60	103	99.9	114	133	140	226
Mars	69.6	55	49.8	0	62.3	73.6	85.8	126	144	121	211
Tycho	92.7	69.9	60	62.3	0	100	99	143	160	120	212
Ceres	110	106	103	73.6	100	0	99.8	150	164	104	190
Pallas	117	105	99.9	85.8	99	99.8	0	160	174	105	195
Vesta	84.7	106	114	126	143	150	160	0	41.9	196	266
Hygiea	107	126	133	144	160	164	174	41.9	0	209	276
Jupiter	157	146	140	121	120	104	105	196	209	0	147
Saturn	237	230	226	211	212	190	195	266	276	147	0