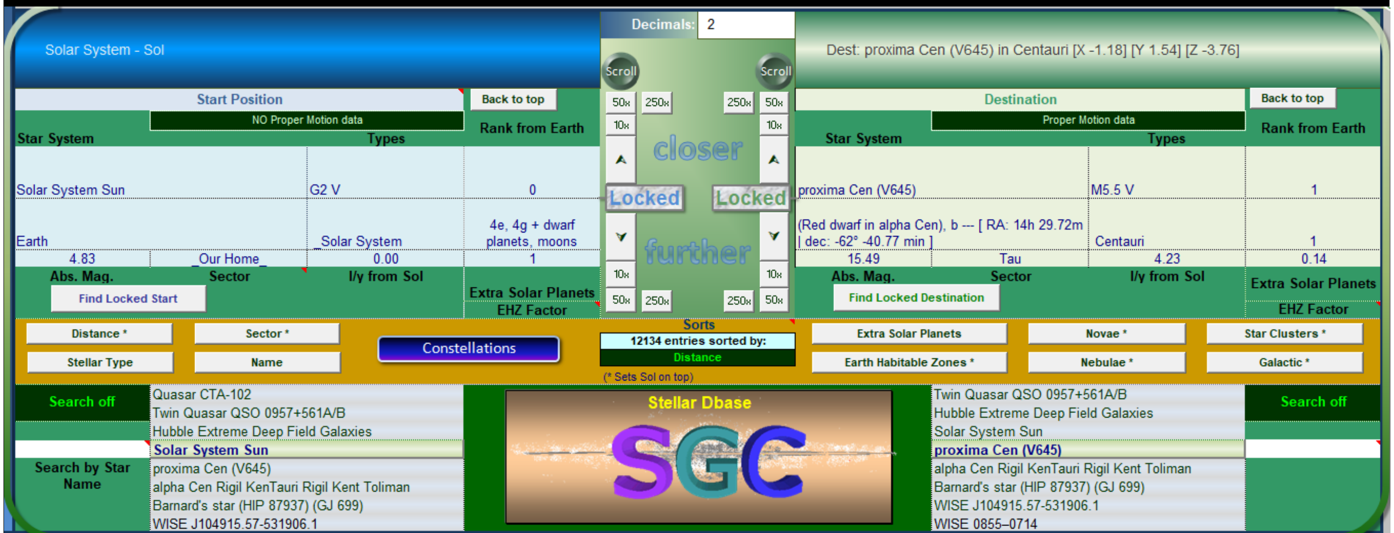

SGC Mission Profile Navigator Guide v. 4.3

Safely embraced by a ship that carries us through space and time, to distant jewels in the night. There, on stranger shores, we can share a breath, under indigo skies.

Visionary Productions
[June, 2023]
smashpen@hotmaIl.com
Producerelease.com/sgc/

by James Shuster

Guide to a Mission Profile Navigator, Excel worksheet to show realistic mission profiles for interstellar voyages, using relativistic limits, accurate positions and track stars with their proper motion data to place them in real positions based on arrival dates.

FORWARD:

This project started in Maui in 1995 when I noticed that there was no easy star map to find in 3D to show our local neighborhood stars. So, I created a fly-through VRML star map at Kihei, Maui High Performance Computing Lab, using a floating 3D axis with the solar system in the middle. If you have a VRML reader that still works, I would be happy to send anyone interested, a copy of this old VRML project.

It then became a series of brain teasing, fine tuning challenges, over the years. The deeper I went, the more issues came up, until I was attempting to resolve issues, that literally no one else, in their right mind, ever even bothers to think about.

Since I started, there have been many excellent star data programs, allowing fly-through space in 3D, when a wealth of details. To my knowledge, I have the only version that takes into consideration stellar proper motion, acceleration, deceleration and relativistic changes in an automated way.

I hope everyone enjoys playing with the MP Navigator and I always welcome feedback.

- James Shuster – Palos Verdes Peninsula, California – July 20, 2014

THANKS:

Paul Hugel – For encouragement to start the project in Maui: nko.org

William Chung – For support and link listing on his site: www.projectrho.com

Brendan Jennings – Long conversations about astronomy and Starships.

Adam Crowl – Excellent insight to alternate propulsion and other technical:

Paul Glister – His active interest and support.

Adam and Paul both contribute to: www.centauri-dreams.org

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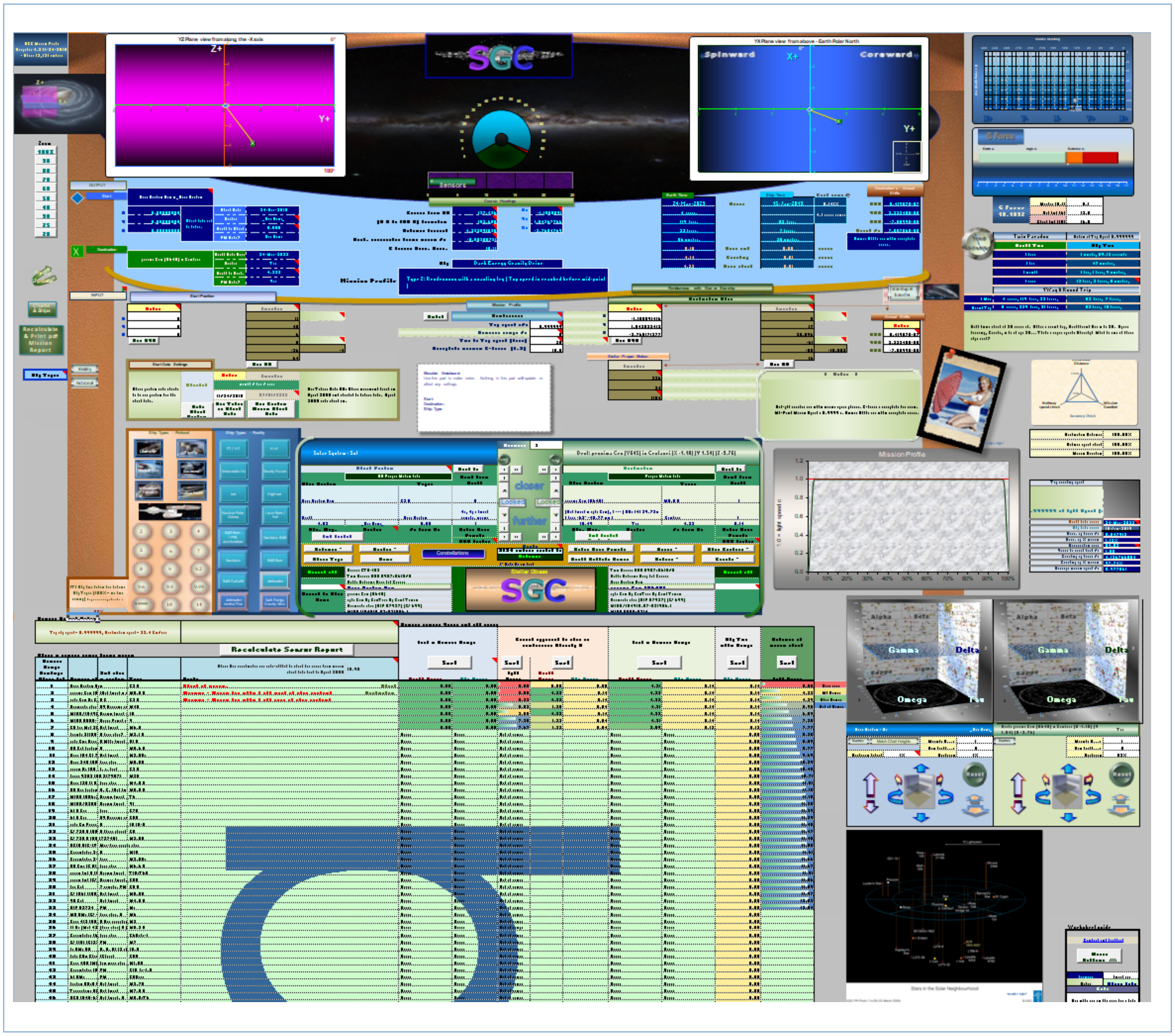
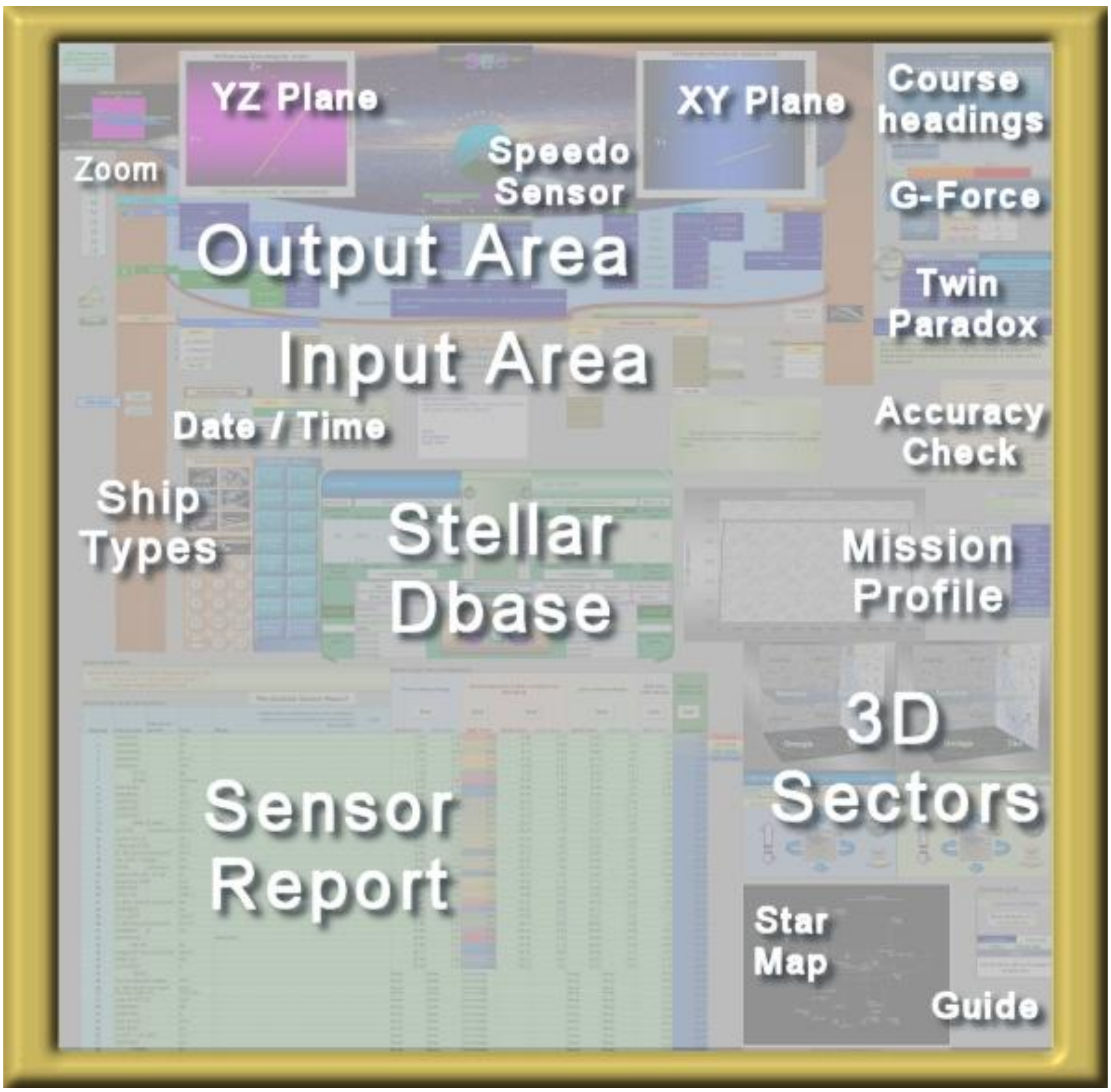


The main, Mission Profile Navigator controls worksheet.

1. Quick Guide

MP Navigator

The Main Page of the Mission Profile Navigator (MP Navigator) has all the controls your need to be able to search for Start Positions and Destinations, changing Ship Types, review mission parameters, check mission times, see alerts, warnings and notes, check course headings and more. Each mission can be saved to a pdf Mission Report. All the controls are available from the Main MP Navigator Excel Worksheet Page.

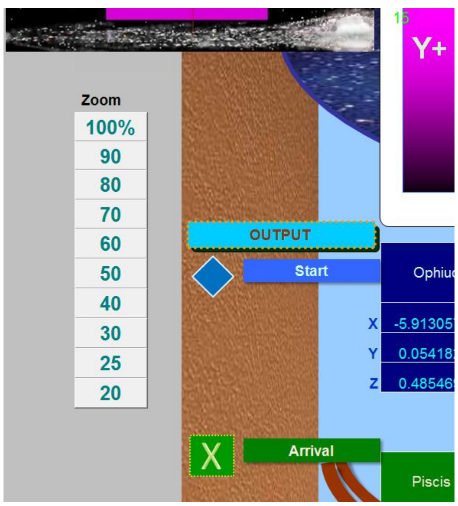


Use only the SGC_MP_Navigator worksheet to enter data. All other tabs have automatic formulae or data and should not be altered.

(Warning: digging down into Excel formulae this extremely complex.
See [Other Navigator worksheets – Under the Hood](#) *)*

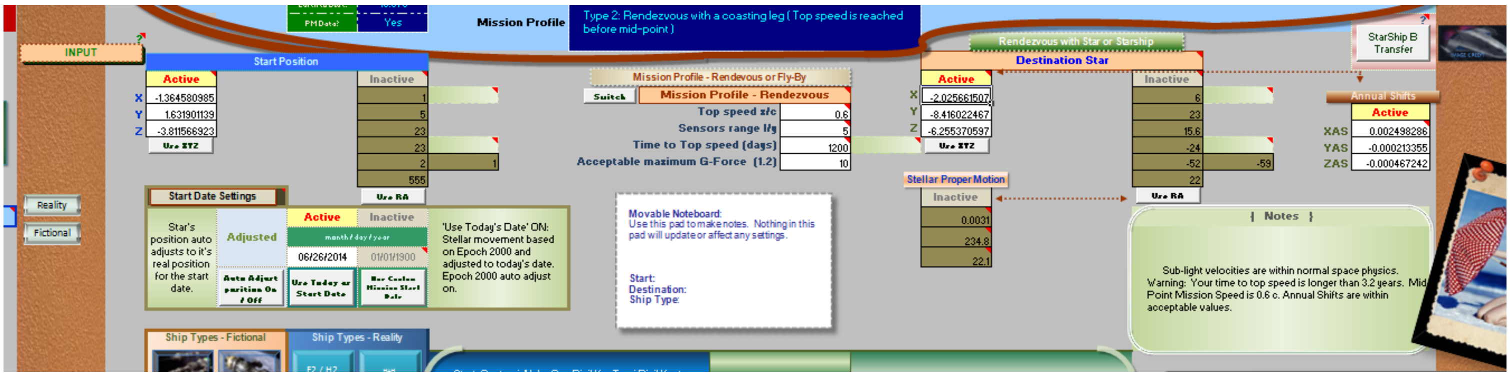
Zoom buttons

Macros for the MP Navigator must be turned on. A handy button selection that will auto zoom the MP Navigator are in the upper left gray area. This duplicates the Zoom slider of Excel in the lower right of the Excel window. If these buttons work, than all the macros should be working.

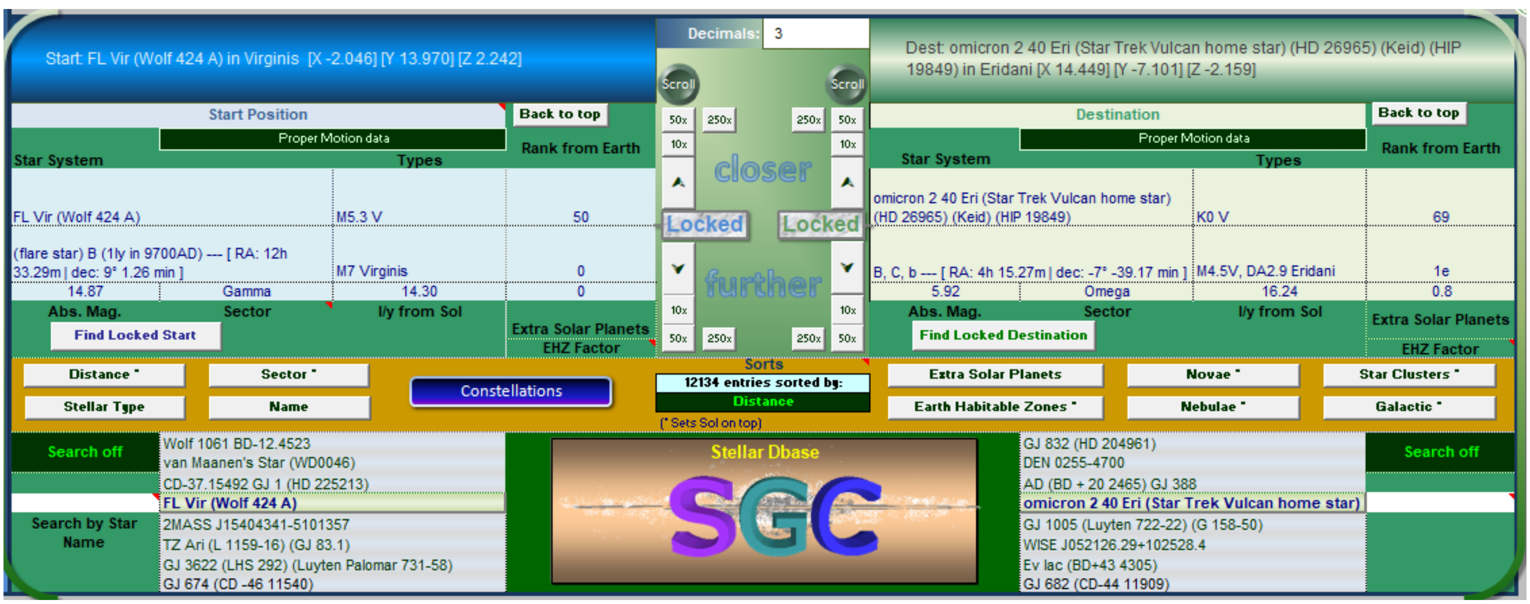


Input Area

Enter data in the center Input area, white cells only or use the automated macro buttons and search cells in the SGC Stellar Dbase, lower center. Be sure to NOT change any colored cells. Dark hazel green shaded cells are inactive, changing is allowed but will not affect the Mission.



Stellar Dbase



You may sort the SGC Stellar Dbase by Distance, Sectors, Stellar Type, Name, etc. Sorts with an asterisk will put the Solar System at the top of the list. Choose a star by clicking the center area arrows to scroll up (closer) or down (further). Below the sort area are white "Search by Star Name" cells, far left and right. Typing a name into either area allows you to search for a star's name for the Start Position or Destination side. This locks you into the search mode. To get out of the search mode, press the Scroll button in the top center area left for Start and center right for Destination.

Press the Lock button in the scroll buttons to lock the choice in place for Start Position or Destination. If you browse to another star to review it, the Locked changes to ~ which designates that the new stars you are browsing are not the locked Start or Destination. Locked stars are cancelled when you press any new sort button.

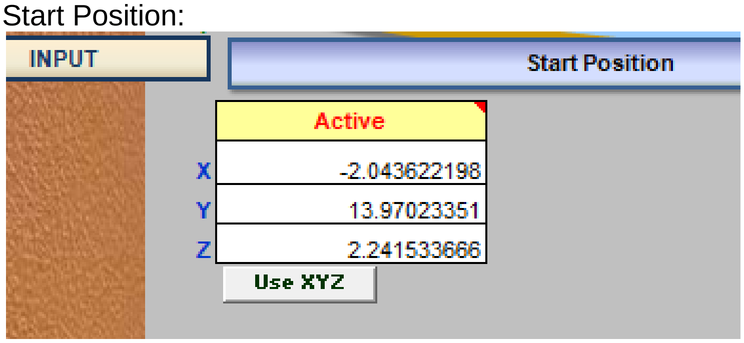
Use XYZ buttons

X,Y,Z values have been found for each star in the Stellar Dbase and are based on X+ = RA 6, and the XY plane lies at Earth declination 0.

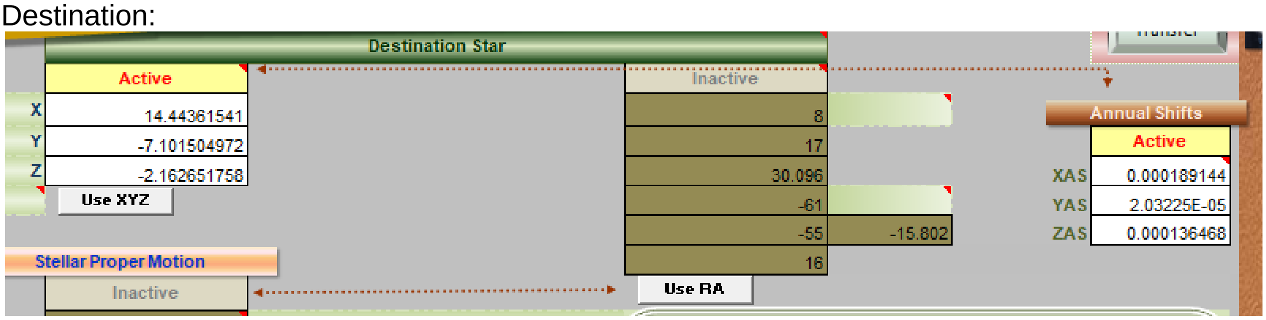
Locking in a star, either Start Position, or Destination, from the SGC Stellar Dbase automatically copies X, Y, Z coordinate values from the Dbase and pastes them into the Input area and turns “Use XYZ” on.

You may also enter any custom X, Y, Z coordinate for the Start Position or the Destination. This is an arbitrary 3 coordinate system specific to the MP Navigator only. See: SGC X, Y, Z coordinates:

Start Position:



Destination:



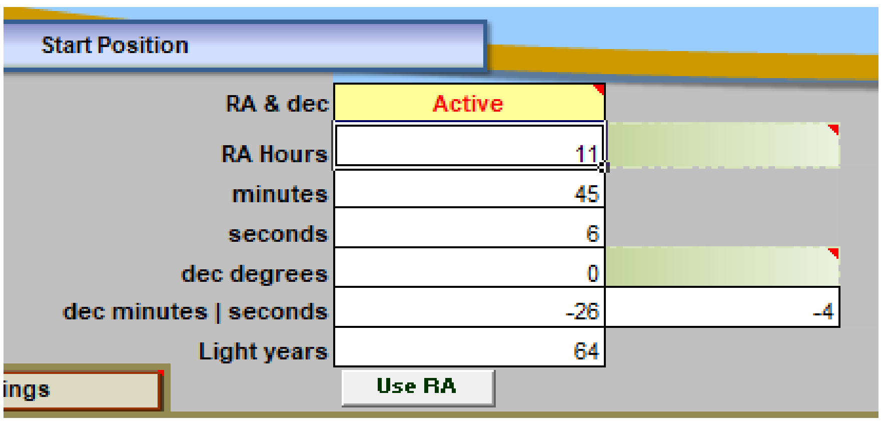
This Proper Motion data has already been converted in the Stellar Dbase for many stars to Annual Shifts (XAS, YAS, ZAS) values. Annual Shifts values are annual movement for each coordinate. 1 = c (light speed). You could update these values directly, but there is no online data for this information. These values have been calculated only for this project. All Proper motion stellar motion is normally listed and handled by the Stellar Proper Motion area, which works with the RA (Right ascension). These RA, dec, PM values are the norm for online stellar data.

Use RA buttons

You can also Use RA (Right Ascension). These are the values easily found in published star lists. In this way, you may enter any location that is not in the Stellar Dbase.

When you choose Use RA, you need to input the values RA from 0 to less than 24 hours and declination from 90+ to 90-.

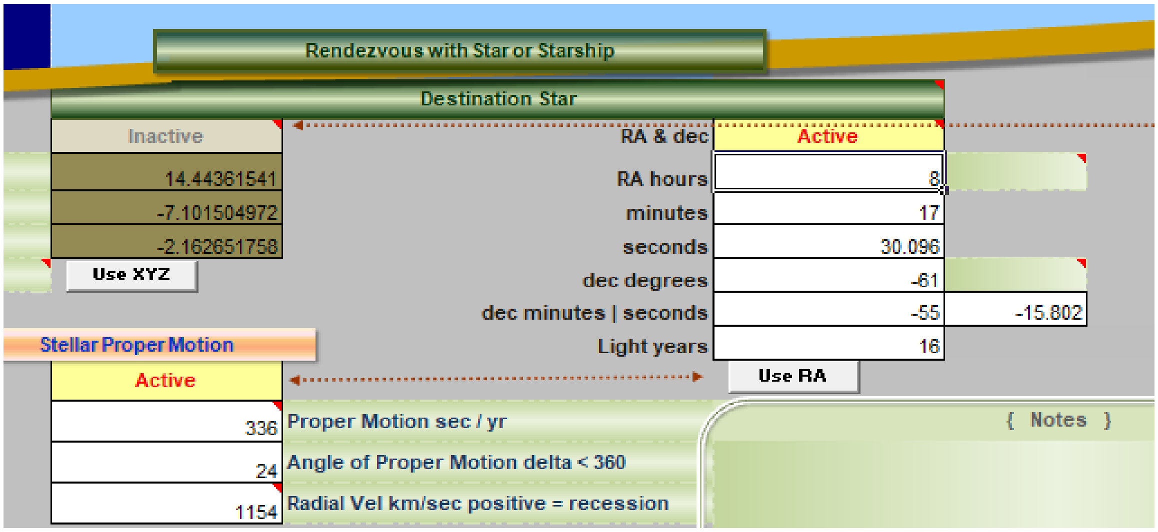
Start Position



Destination

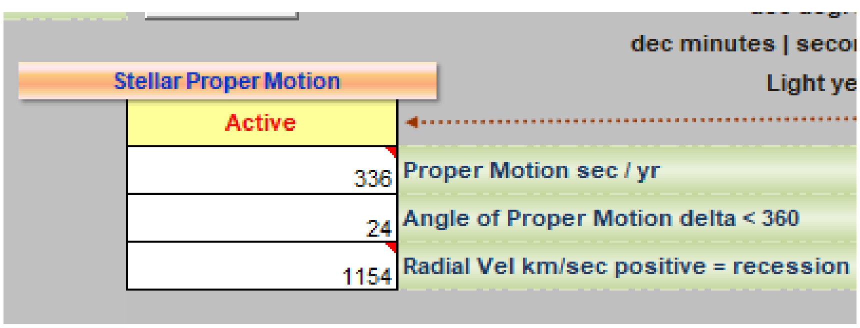
Here, Use RA, is Active and Use XYZ is Inactive. Any numbers in XYZ have no effect. For minus declination values, you need to include a minus sign for each entry: declination degrees, minutes and seconds. An alert appears if you miss doing this.

`Dec degrees -24 -40 -52`	is correct
`-24 40 52`	is not correct. You will get an alert, but the worksheet will still function correctly basing the declination on the first value.



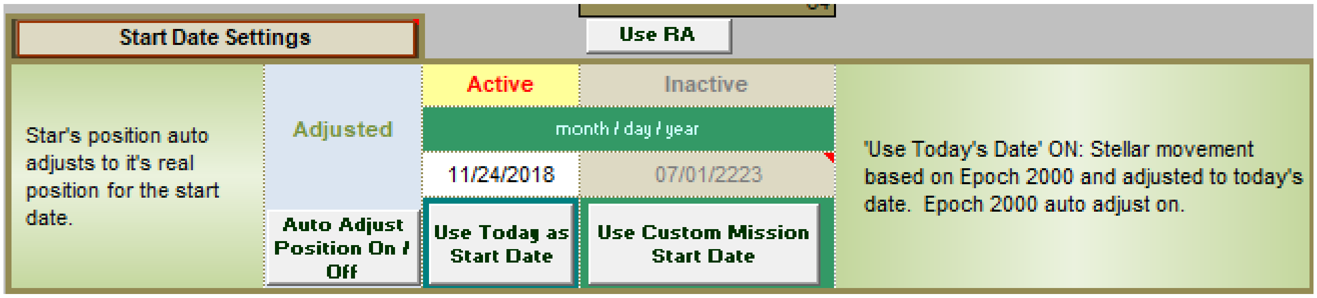
Proper Motion (Use RA)

Stellar Proper Motion values are also possible to enter when using RA. You can enter shifts in arc seconds and radial velocity in kilometers per second, (the speed the star approaches or recedes from Earth). These values are listed in many astronomical databases. The MP Navigator requires you enter Epoch 2000 values, not older Epoch 1950 from older books.



Start Date

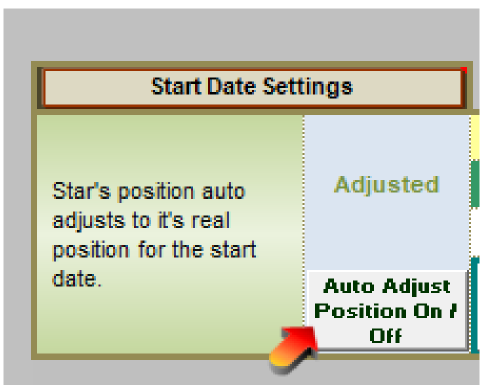
You can choose the current computer date or a different Start Date. If you chose the Use Today as Start Date button, you actually are setting the Start time to the exact instant in time that the computer updates the mission profile. This means the Mission Profile result numbers can change slightly from minute to minute every time you update the Sensor report.



Epoch 2000

Auto adjust from Epoch 2000 changes the Start Position star, from its position, of record, for Epoch 2000 to the current computer time and date or to a custom start date in the past or future. Using Auto adjust button for Epoch 2000 moves a star with known Proper Motion data, along it's galactic orbit to its corrected Real Position.

(Galactic orbit adjustments are an approximation, based on a straight line movement rather than a curved galactic orbit. The possible margin of error is far below our current level of accuracy for any mission less than 100,000 years.) See: Issues with long missions



Trips within a multiple star system

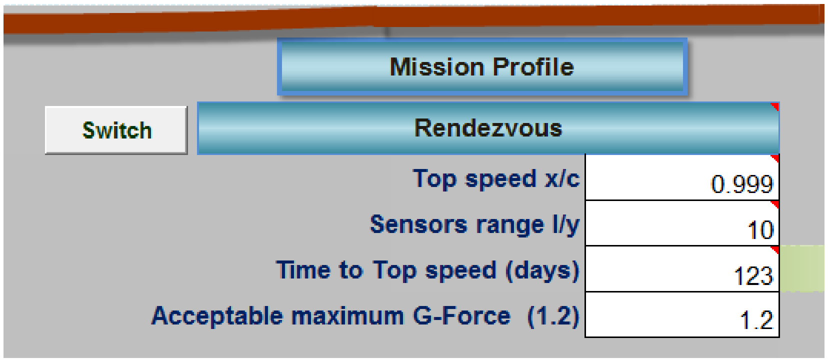
This Epoch 2000 Auto Adjust should be turned off for a mission profile between two stars of the same system because Auto Adjust will automatically move the Start Position on its galactic orbit and also try to move the Destination. If both Start Position and Destination are in the same star system, you do not need Epoch 2000 Auto adjust. For details of how to plot a mission profile between two stars of the same system, see: Use RA in detail.

Ship types

Choose a Ship Type from either the Reality list or Fictional list. Click on the silver buttons on the left pillar to see Ship Type's guides. You may also create your own Ship Type by editing the cell values for Top Speed, "Time to top speed" and acceptable G-Force.

Rendezvous or Fly-by

You may toggle between Rendezvous and Fly-by mission types. With the same Ship Type, Fly-by will pass the star sooner than a rendezvous mission. Use the switch button, top left center of the Input area.



Output area

The Output area, above the Input area, shows a lot of mission parameter information from Sector names, Distance traveled, Distance from Earth. This can be from any star or waypoint to any other. Neither Start, nor Destination needs to be Earth, our Solar System. Output also shows course Headings, Destination movement during mission, arrival times and the Annual Shifts in Destination X, Y, Z values

Course Headings

The MP Navigator is based on Earth Polar,

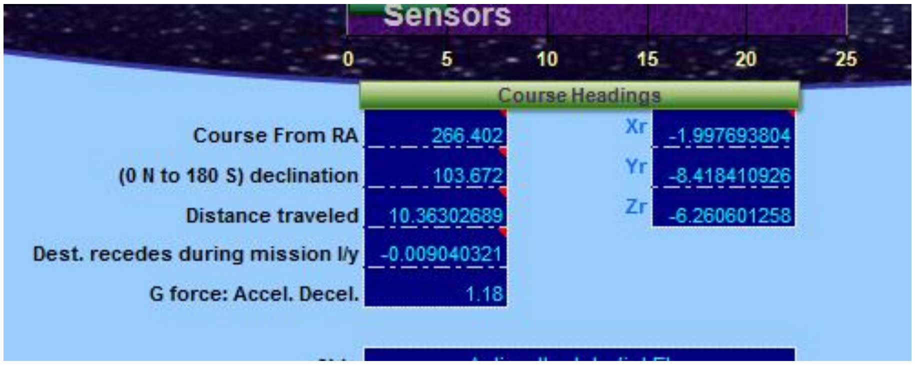
```
0 in Course headings = RA 0.
90 = RA 6
180 = RA 12
270 = RA 18
360 is RA 0 again.
```

To avoid negative Course Headings, the normal declination of 90+ North to 90- South, has been converted to

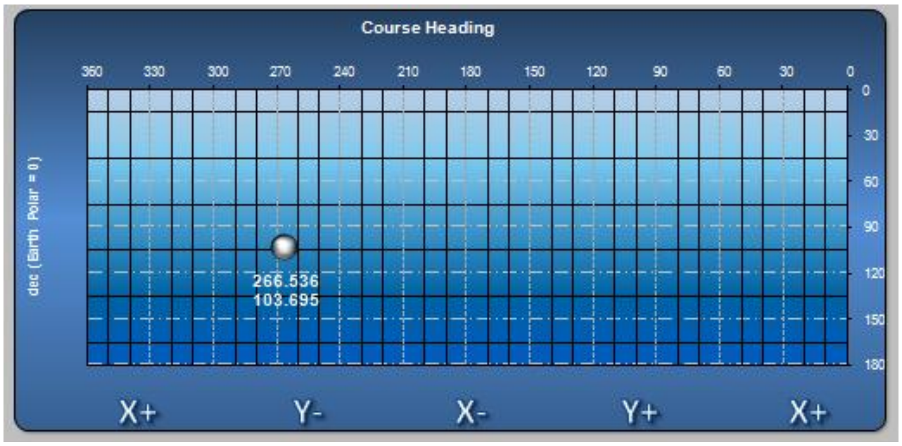
```
  0 = Earth Polar North
180 = Earth Polar South
```

This allows two positive numbers to give Course Headings for any mission. Course headings will auto adjust correctly, even between two remote stars or locations, without having our Solar System in the mission at all.

Output area with Course Headings



Course Heading Chart



Time Dilation

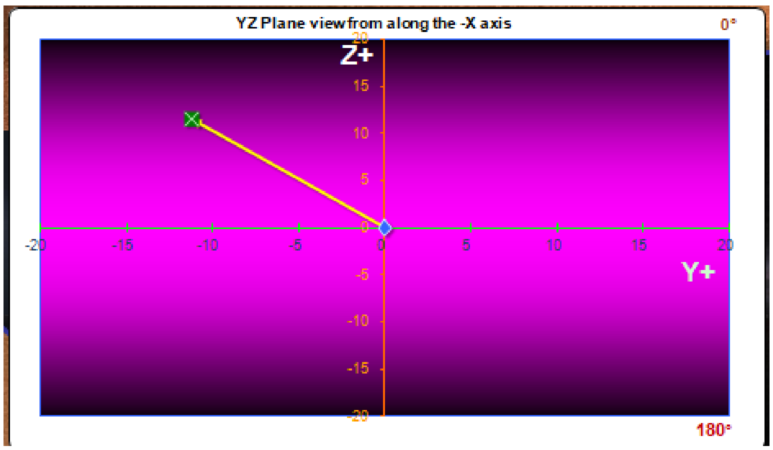
Relativistic time dilation is tracked in Earth mission time verses Ship time.

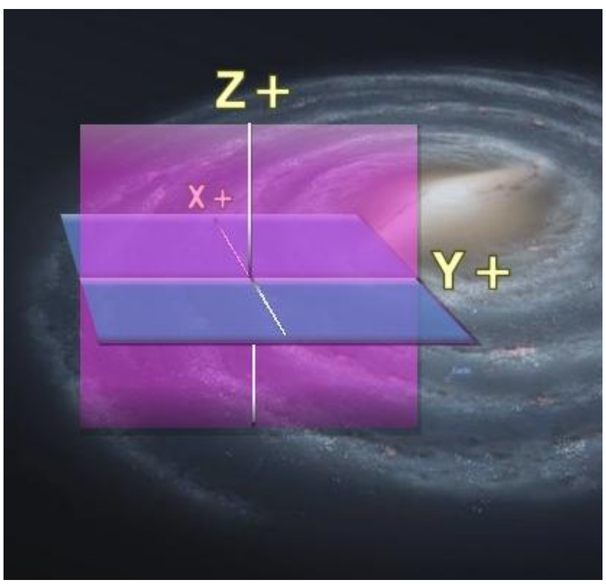
Earth Time		Ship Time	Clock runs @
17-Jan-2035	Arrival	19-Dec-2029	75.30073%
20 years,		15 years,	5 years slower
204 days		175 days	
10 hours,		13 hours,	
35 minutes		53 minutes	
3.29	Accel end	2.4739	years
13.99	Coasting	10.5338	years
17.27	Decel start	13.0077	years

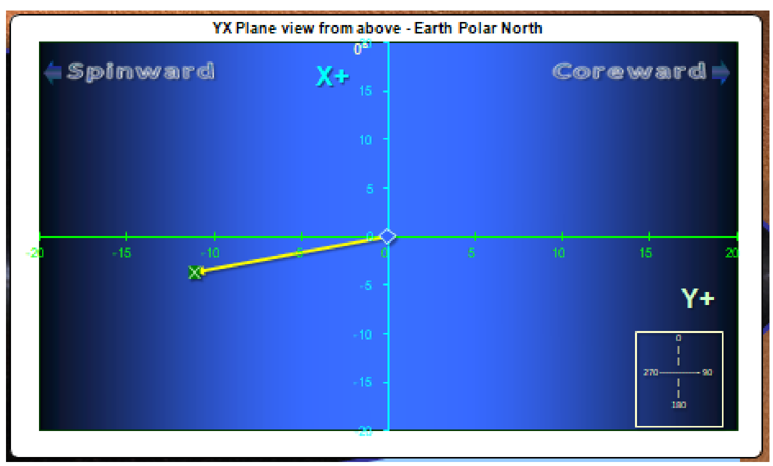
Mission Graphs and Charts

There are several mission charts and graphs to help you visualize all the mission data.

The top two large charts show the Start Position chart and Destination chart in XY and from above the Z axis. Imagine looking down from above water into the blue and look level, across, under the surface of water, into the purple.







Speedometer and Sensor Range

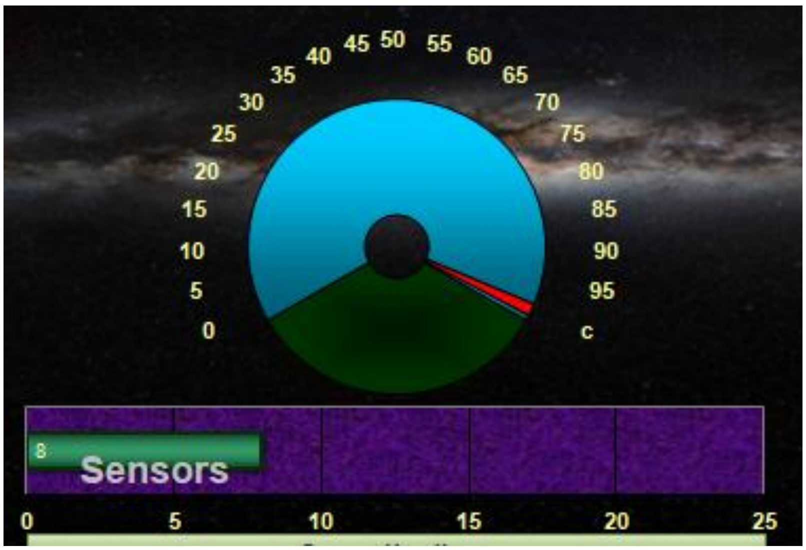
The center speedometer shows the top speed achieved and the sensor range setting. The speedometer changes to show other details in imaginary FTL (Faster than light) journeys.

If you pick a very long “Time to top speed”, the speedometer could show a slower top speed than your preferred top speed, simply because the Starship never reaches the requested top speed before the missions end.

The Speedometer will show a slower speed than your choice when:

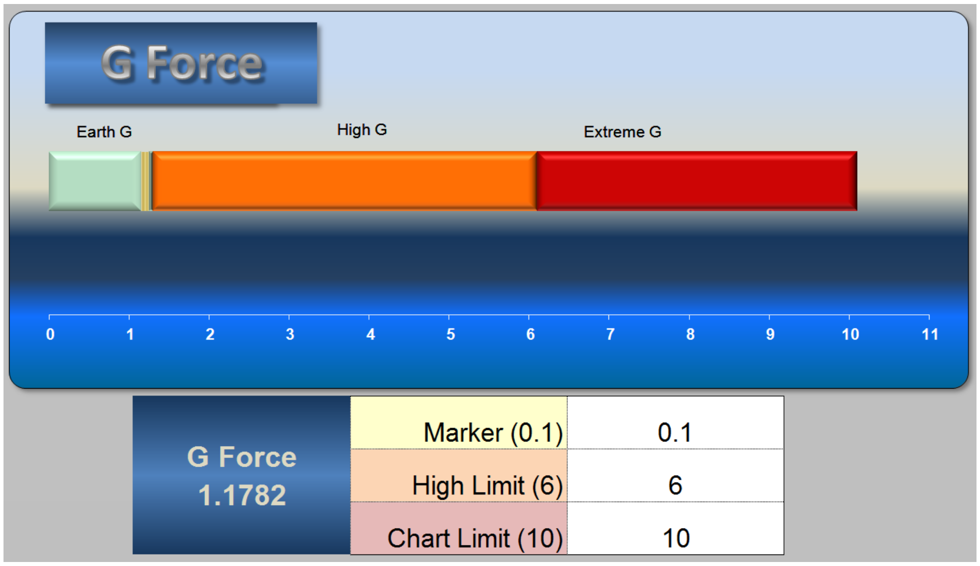
1. A rendezvous mission reaches the mission mid-point before “Time to top speed” is achieved.

2. A fly-by mission reaches the mission end, fly-by point before “Time to top speed” is achieved.



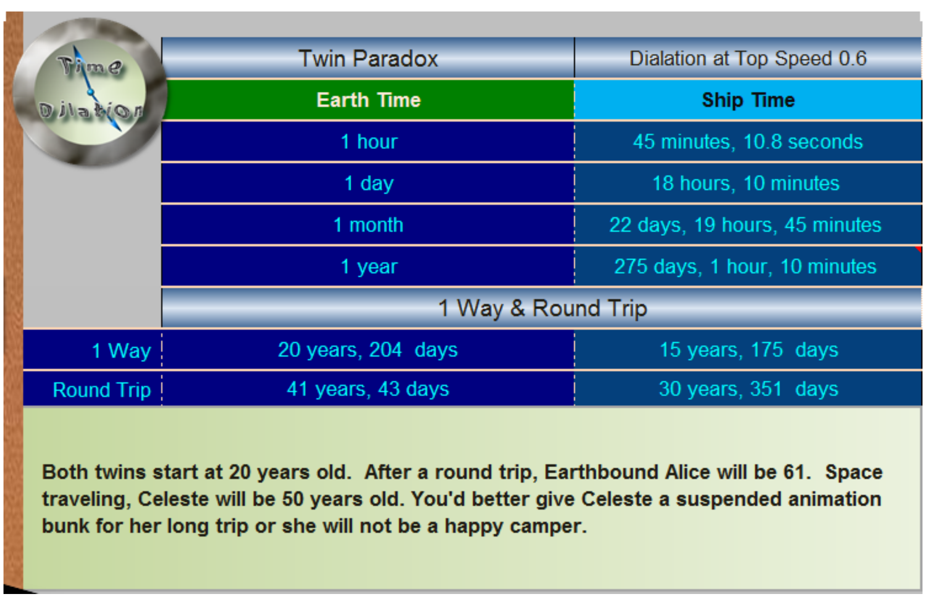
G-Force Graph

The chart in the right gray area, below the Course Headings, is the G-Force bar graph. This shows if the maximum G-Force falls within, whatever settings you set. Ship Type macro buttons will auto set the preferred G-Force value. The white cells under the G-Force graph can also be changed by you to adjust the graph.



Twin Paradox Report

The next area down is the Time Dilation, Twin Paradox report. This only really has noticeable important information happens, when the Starship exceeds .6c light speed. Messages change automatically.



	Twin Paradox	Dialation at Top Speed 0.6
	Earth Time	Ship Time
	1 hour	45 minutes, 10.8 seconds
	1 day	18 hours, 10 minutes
	1 month	22 days, 19 hours, 45 minutes
	1 year	275 days, 1 hour, 10 minutes
	1 Way & Round Trip	
1 Way	20 years, 204 days	15 years, 175 days
Round Trip	41 years, 43 days	30 years, 351 days

Both twins start at 20 years old. After a round trip, Earthbound Alice will be 61. Space traveling, Celeste will be 50 years old. You'd better give Celeste a suspended animation bunk for her long trip or she will not be a happy camper.

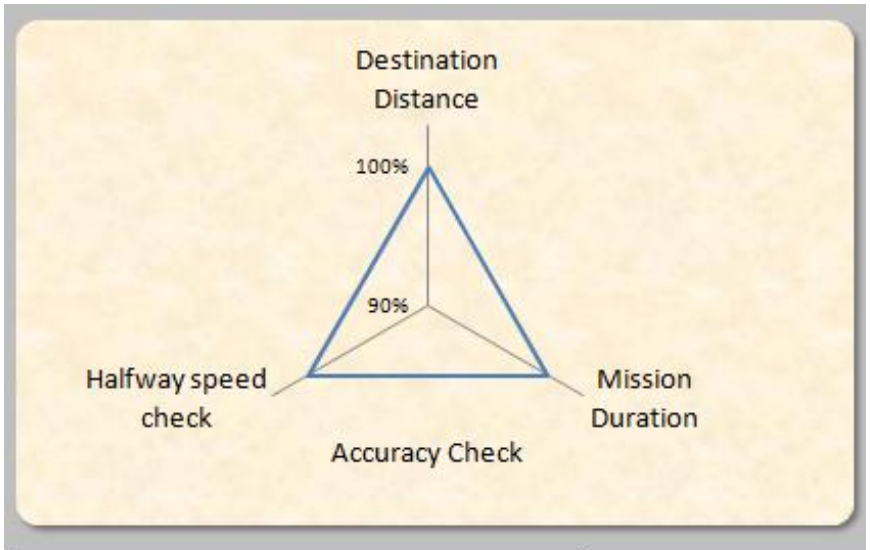
Mission Profile Graph

The next area down is the Mission Profile Graph with acceleration, coasting and deceleration legs and other data. The Graph will automatically change to match the mission types. A Fly-by mission would not have a deceleration leg. Acceleration slope value in the right data area is based on 45 degrees = reaching light speed in 1 year.

Top coasting speed	
0.999 of Light Speed (c)	
Earth date arrival	17-Jul-2035
Ship date arrival	15-Oct-2015
Accel. leg travel l/y	0.168209
Accel. leg % mission	0.81%
Acceleration slope	71.37
Years to reach first l/y	1.17
Coasting leg travel l/y	20.30702206
Coasting leg % mission	98.37%
Average mission speed /c	0.982981

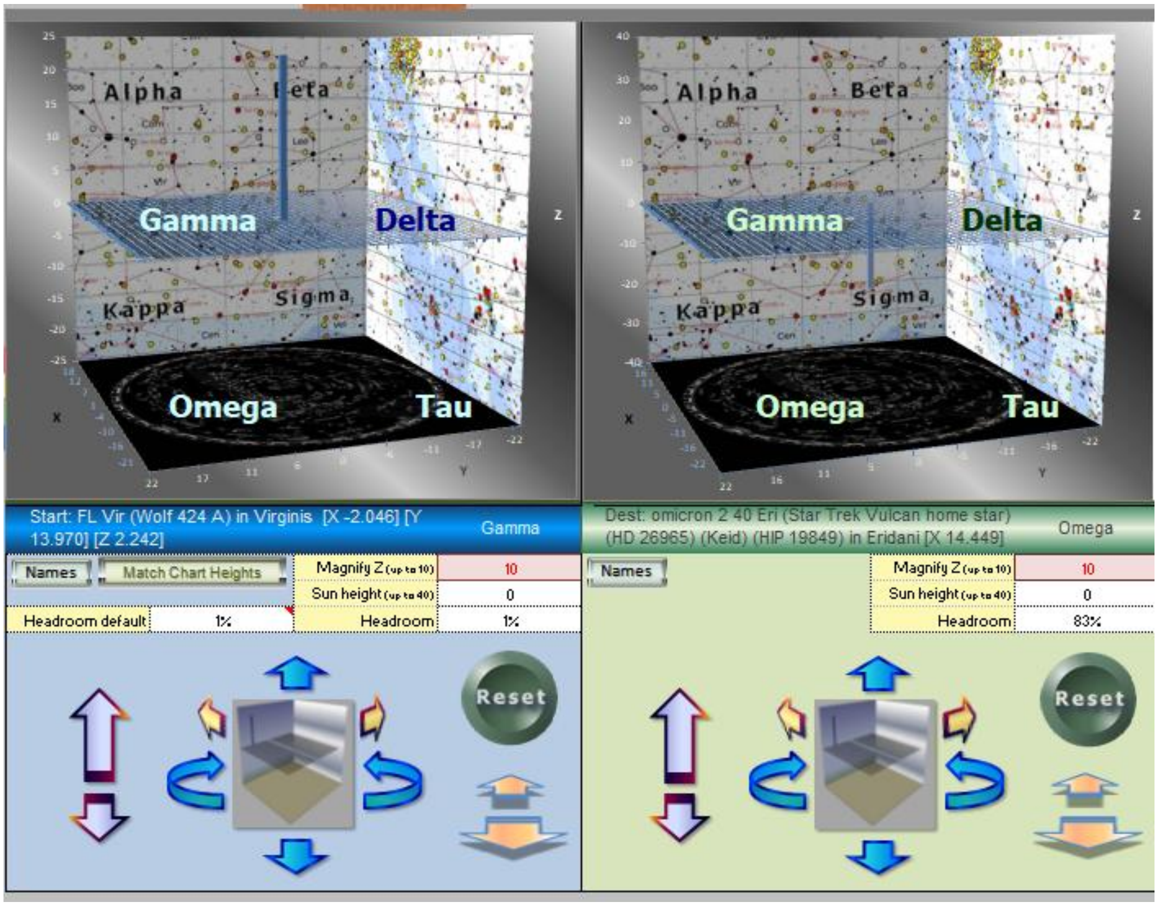
Accuracy Check

The Halfway or Mid-point speed can be different from your input, if the “Time to top speed” is longer than 50% of the mission.



Destination Distance	100.02%
Halfway speed check	100.00%
Mission Duration	100.00%

3D Sector Charts



The next area down is the two 3D Sector charts. Start Position and Destination will each show a pillar, above or below the middle plane. These 3D charts can help you visualize the mission travel in 3D. They do not show other stars.

There are many controls to help you see the pillars better. Any star near to the plane, with a small Z elevation value, may be difficult to see. You can magnify the Z value to help see the pillar for a, hard to see, star.

Other controls allow you to rotate the chart, extend the width, height, depth, change the perspective and reset to the original position. There is also an option magnify the Sun's height in the center of the XY plane. Larger headroom percentage puts extra space above the top of the pillar. If the star is less than 20 light years away, this headroom has no effect.

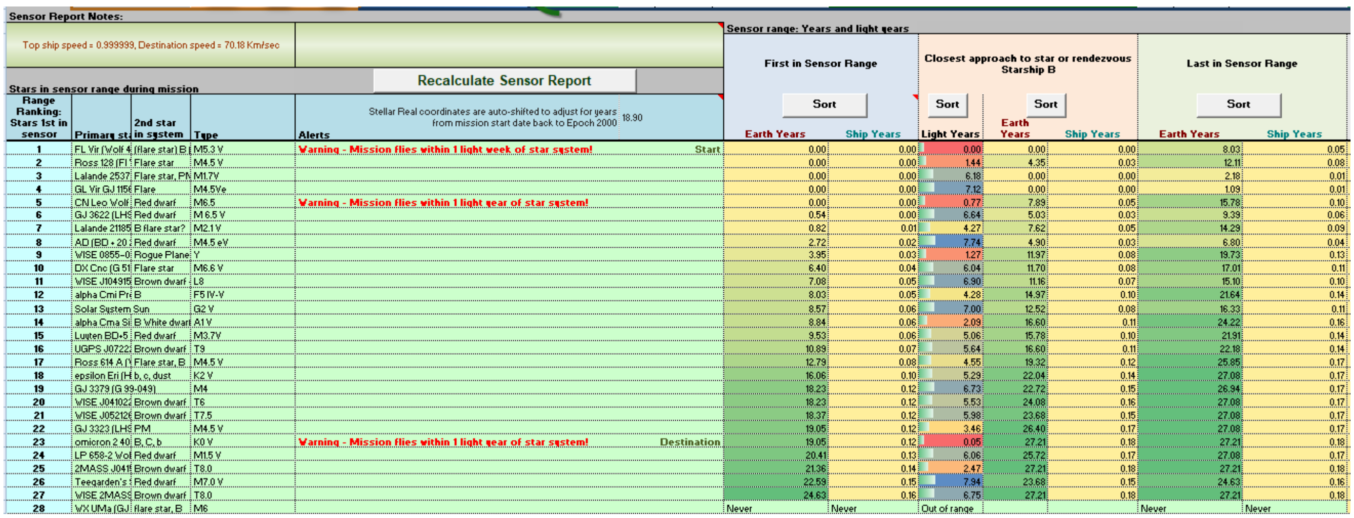
The front sector names may be toggled on or off by the Names button. The left button in the Start Position Chart, "Match Chart Heights" appears, if the chart heights are different. The Headroom default is used with this "Match Chart Heights" button and otherwise will not change anything on its own. Clicking on this to match chart heights is optional. You can override this by manually entering headroom percent for either Start Position or Destination charts. Sector names are arbitrarily created for this project only.

Sensor Report

Click the Recalculate Sensor report button in the lower Sensor report area or in the left margin to update the Sensor report to the current mission.

The lower Sensor report area on the Main MP Navigator page can be updated after each mission parameter change. This is automatically sensed and a warning appears when an update is needed. You only need to update at the very end of your mission adjustments.

The Sensor range can be adjusted to any light year range in the center of the Input Area. The further out you go with a sensor range, the more nearby stars will be included. This report automatically tracks the Starship at 200 mission slice points and compares ship locations with nearby stars positions.



Sensor Report Notes:

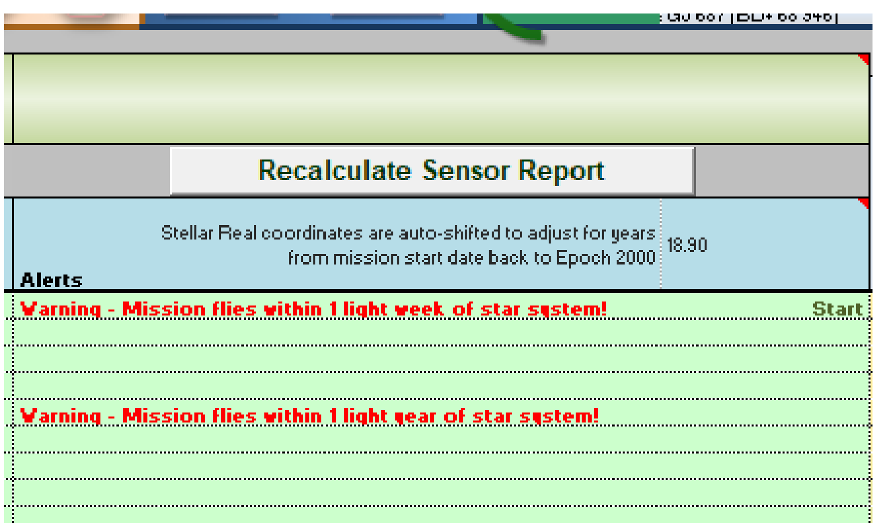
Top ship speed = 0.999999, Destination speed = 70.18 Km/sec

Stars in sensor range during mission

Recalculate Sensor Report

Sensor range: Years and light years

Range Ranking: Stars 1st in sensor	Primary sta	2nd star in system	Type	Alerts (Stellar Real coordinates are auto-shifted to adjust for years from mission start date back to Epoch 2000: 18.90)	First in Sensor Range: Earth Years	First in Sensor Range: Ship Years	Closest approach to star or rendezvous Starship B: Light Years	Closest approach: Earth Years	Closest approach: Ship Years	Last in Sensor Range: Earth Years	Last in Sensor Range: Ship Years
1	FL Vir (Wolf 4	(flare star) B (	M5.3 V	Varning - Mission flies within 1 light week of star system! Start	0.00	0.00	0.00	0.00	0.00	8.03	0.05
2	Ross 128 (FI	Flare star	M4.5 V		0.00	0.00	1.44	4.35	0.03	12.11	0.08
3	Lalande 2537	Flare star, PN	M1.7V		0.00	0.00	6.18	0.00	0.00	2.18	0.01
4	GL Vir GJ 115	Flare	M4.5Ve		0.00	0.00	7.12	0.00	0.00	1.09	0.01
5	CN Leo Wolf	Red dwarf	M6.5	Varning - Mission flies within 1 light year of star system!	0.00	0.00	0.77	7.89	0.05	15.78	0.10
6	GJ 3622 (LHS	Red dwarf	M 6.5 V		0.54	0.00	6.64	5.03	0.03	9.39	0.06
7	Lalande 21185	B flare star?	M2.1 V		0.82	0.01	4.27	7.62	0.05	14.29	0.09
8	AD (BD + 20	Red dwarf	M4.5 eV		2.72	0.02	7.74	4.90	0.03	6.80	0.04
9	WISE 0855-0	Rogue Plane	Y		3.95	0.03	1.27	11.97	0.08	19.73	0.13
10	DX Cnc (G 51	Flare star	M6.6 V		6.40	0.04	6.04	11.70	0.08	17.01	0.11
11	WISE J104915	Brown dwarf	L8		7.08	0.05	6.90	11.16	0.07	15.10	0.10
12	alpha Cmi Pr	B	F5 IV-V		8.03	0.05	4.28	14.97	0.10	21.64	0.14
13	Solar System	Sun	G2 V		8.57	0.06	7.00	12.52	0.08	16.33	0.11
14	alpha Cma Si	B White dwarf	A1 V		8.84	0.06	2.09	16.60	0.11	24.22	0.16
15	Luyten BD+5	Red dwarf	M3.7V		9.53	0.06	5.06	15.78	0.10	21.91	0.14
16	UGPS J0722	Brown dwarf	T9		10.89	0.07	5.64	16.60	0.11	22.18	0.14
17	Ross 614 A (	Flare star, B	M4.5 V		12.79	0.08	4.55	19.32	0.12	25.85	0.17
18	epsilon Eri (H	b, c, dust	K2 V		16.06	0.10	5.29	22.04	0.14	27.08	0.17
19	GJ 3379 (G 99-049)		M4		18.23	0.12	6.73	22.72	0.15	26.94	0.17
20	WISE J041022	Brown dwarf	T6		18.23	0.12	5.53	24.08	0.16	27.08	0.17
21	WISE J052126	Brown dwarf	T7.5		18.37	0.12	5.98	23.68	0.15	27.08	0.17
22	GJ 3323 (LHS	PM	M4.5 V		19.05	0.12	3.46	26.40	0.17	27.08	0.17
23	omicron 2 40	B, C, b	K0 V	Varning - Mission flies within 1 light year of star system! Destination	19.05	0.12	0.05	27.21	0.18	27.21	0.18
24	LP 658-2 Wo	Red dwarf	M1.5 V		20.41	0.13	6.06	25.72	0.17	27.08	0.17
25	2MASS J041	Brown dwarf	T8.0		21.36	0.14	2.47	27.21	0.18	27.21	0.18
26	Teegarden's	Red dwarf	M7.0 V		22.59	0.15	7.94	23.68	0.15	24.63	0.16
27	WISE 2MASS	Brown dwarf	T8.0		24.63	0.16	6.75	27.21	0.18	27.21	0.18
28	WX UMa (GJ	flare star, B	M6		Never	Never	Out of range			Never	Never

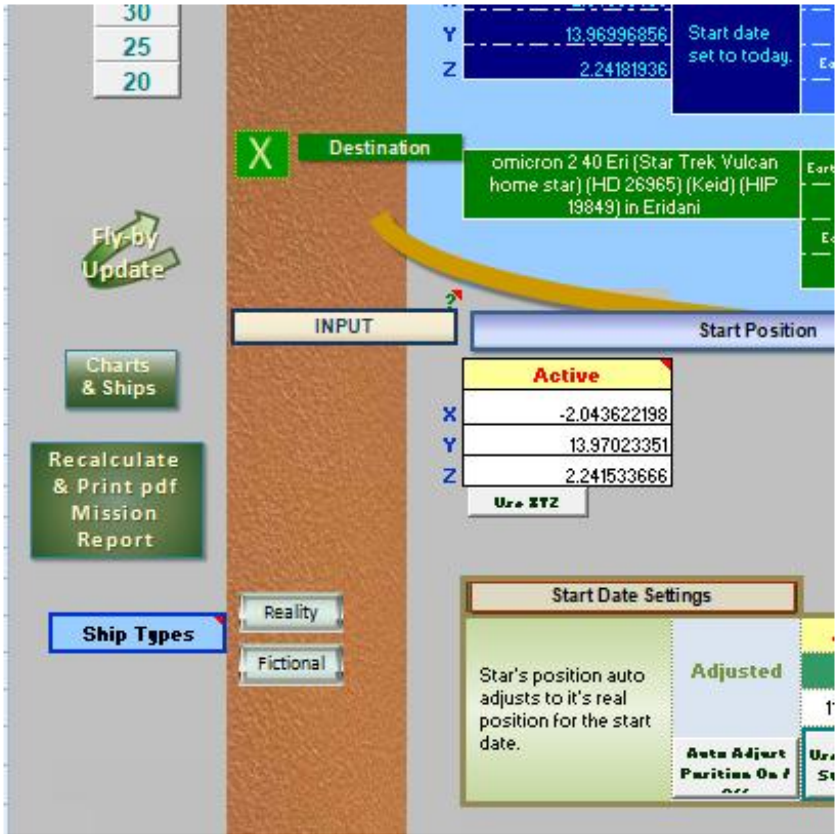


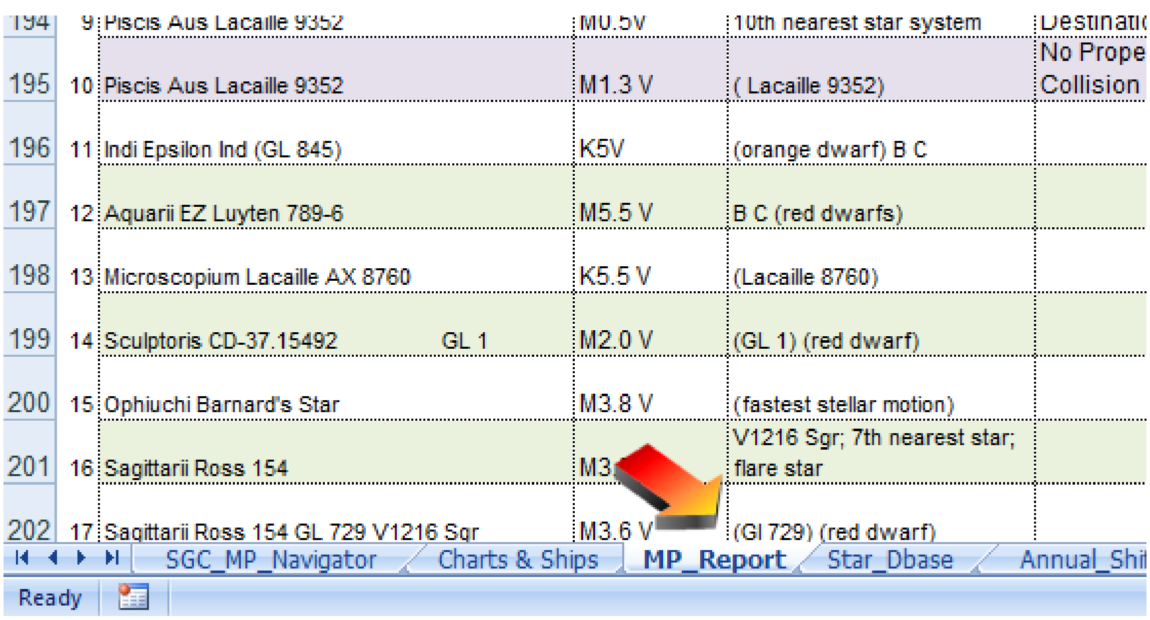
Since both Starship and stars are tracked for their annual movements, starting the same mission at another Start Date will change the sensor report. Using a slower ship, that takes longer to travel, will also change the Sensor report. The results can be sorted by columns with the sort buttons.

Sensor range: Years and light years						
First in Sensor Range		Closest approach to star or rendezvous Starship B			Last in Sensor Range	
Sort		Sort	Sort		Sort	
Earth Years	Ship Years	Light Years	Earth Years	Ship Years	Earth Years	Ship Years
0.00	0.00	0.00	0.00	0.00	8.03	0.05
0.00	0.00	1.44	4.35	0.03	12.11	0.08
0.00	0.00	6.18	0.00	0.00	2.18	0.01
0.00	0.00	7.12	0.00	0.00	1.09	0.01
0.00	0.00	0.77	7.89	0.05	15.78	0.10
0.54	0.00	6.64	5.03	0.03	9.39	0.06
0.82	0.01	4.27	7.62	0.05	14.29	0.09
2.72	0.02	7.74	4.90	0.03	6.80	0.04
3.95	0.03	1.27	11.97	0.08	19.73	0.13

Mission Report Tab

All the mission information is duplicated for a nice print out in the MP_Report Tab. There is an update button in the MP Navigator, left area that will update the sensor report and auto print the result to a pdf. (Excel 2007 or newer)





194	9	Piscis Aus Lacaille 9352	M0.5V	10th nearest star system	Destinati
195	10	Piscis Aus Lacaille 9352	M1.3 V	(Lacaille 9352)	No Prope Collision
196	11	Indi Epsilon Ind (GL 845)	K5V	(orange dwarf) B C	
197	12	Aquarii EZ Luyten 789-6	M5.5 V	B C (red dwarfs)	
198	13	Microscopium Lacaille AX 8760	K5.5 V	(Lacaille 8760)	
199	14	Sculptoris CD-37.15492 GL 1	M2.0 V	(GL 1) (red dwarf)	
200	15	Ophiuchi Barnard's Star	M3.8 V	(fastest stellar motion)	
201	16	Sagittarii Ross 154	M3	V1216 Sgr; 7th nearest star; flare star	
202	17	Sagittarii Ross 154 GL 729 V1216 Sgr	M3.6 V	(Gl 729) (red dwarf)	

SGC_MP_Navigator | Charts & Ships | MP_Report | Star_Dbase | Annual_Shi

Ready

A prompt comes up for a file name. You should rename the report to the Start star, Destination Star, Starship Type and Start Date.

Examples MP_Report:

Interstellar Mission Profile for SGC Navigator - Report - Printable ver 1.1

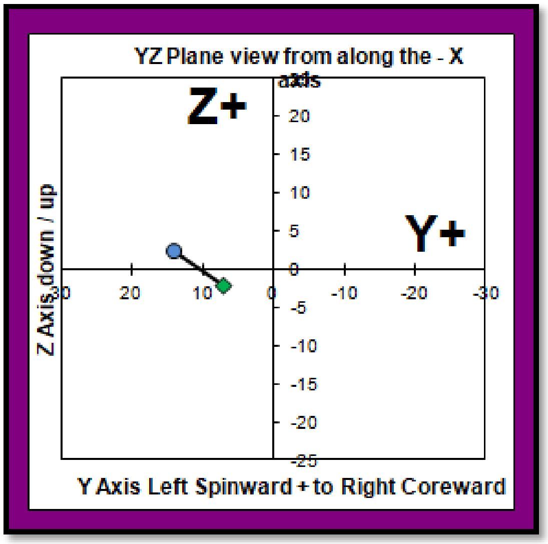
Start: FL Vir (Wolf 424 A) in Virginis [X -2.046] [Y 13.970]	Dest: omicron 2 40 Eri (Star Trek Vulcan home star) (HD 26965) (Keid) (HIP 19849) in Eridani [X 14.449] [Y -7.101] [Z -2.159]
Rendezvous	**Earth date arrival:** Saturday, February 10, 2046
Ship Type: Dark Energy Gravity Drive	**Ship date arrival:** Sunday, January 27, 2019

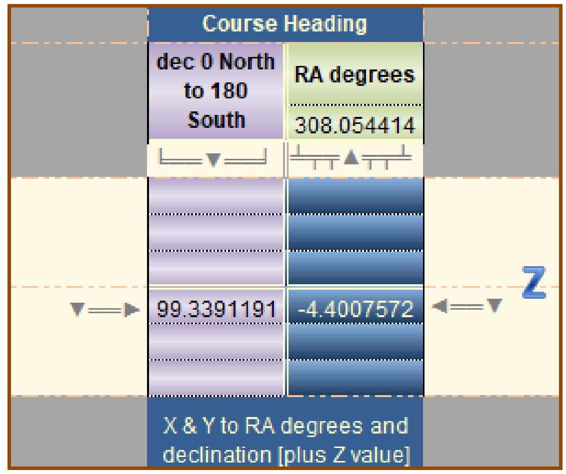
Type 2: Rendezvous with a coasting leg (Top speed is reached before mid-point)

Start Position:					**Start Date:**	24-November-2018
Star System					**Earth Polar**	
Primary Star:	(not listed)				**RA hours:**	inactive
Type:	(not listed)	**Planets:**	(not listed)		**RA min:**	inactive
Binary:					**RA sec:**	inactive
Type:					**dec. degrees**	inactive
Rank from Earth:	(Star is not locked)	Abs Mag.:	(not listed)		**dec. minutes**	inactive
					dec. seconds	inactive

			Galactic SGC		
Stats	**Distance l/y**	**Sector**	**X**	**Y**	**Z**
Earth to Start Position:	14.2958546	**Gamma**	-2.0458945	13.9699686	2.24181936

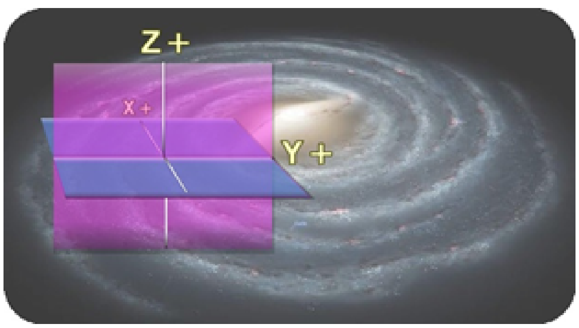
The Mission Report tab has one extra Course Heading chart that resembles an aviation VOR avionics dial.

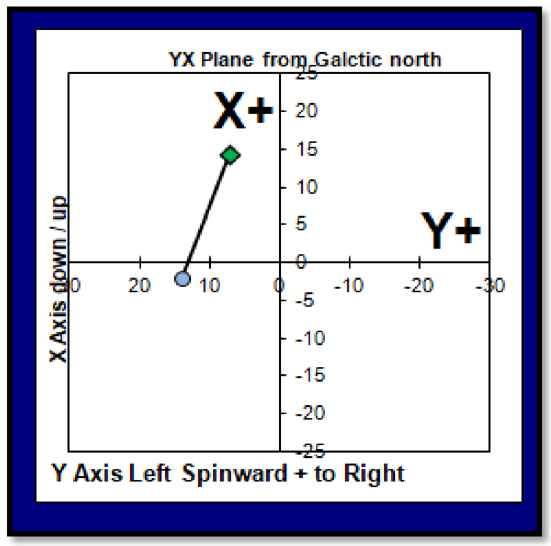




Circle = Start Position = Gamma Sector

Diamond = Destination = Omega Sector



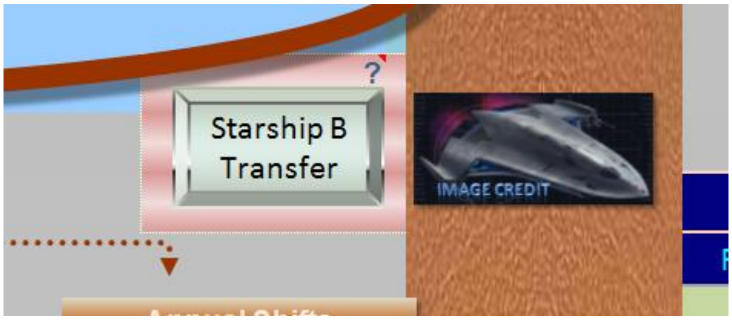


	Twin Paradox	Dilation at Top Speed 0.999999
	Earth Time	**Ship Time**
	1 hour	23.22 seconds
	1 day	9 minutes,
	1 month	1 minute,
	1 year	2 days, 8 hours, 21 minutes,
	1 Way & Round Trip	
1 Way	27 years, 78 days, 2 hours,	64 days, 3 hours,
Round Trip	54 years, 156 days, 5 hours,	102 days, 6 hours,

Both twins start at 20 years old. After a round trip, Earthbound Alice will be 74. Space traveling, Celeste, will be still age 20... That's a super speedy Starship! What do one of these ships cost?

Second Starship B Rendezvous

It's possible to setup a rendezvous with a second Starship. The steps of how to do this is explained in 11.



2. MP Navigator's Purpose

Why make such a complex Mission Profile Navigator? If you want to know how long a mission takes to cross interstellar space, the math is fairly straight forward to get a quick answer.

```
Distance / Average Speed = Mission Time
```

The short answer is pretty much always that it takes a long, long, long… time. Realistic missions are too long for anyone to consider going, even with an advanced technology Starship. Perhaps, when we develop antimatter propulsion, some shielding method to avoid being destroyed by a passing space rock and find an economic reason to be that far out in interstellar space, one of these missions might become possible. Don't hold your breath.

So, since we are far from reaching the stars, why bother with actual realistic details, such as Course Headings? Well, because it's possible to get very accurate answers in Excel, far beyond our current weakest link in stellar measurements, which, is our estimates of stellar distances.

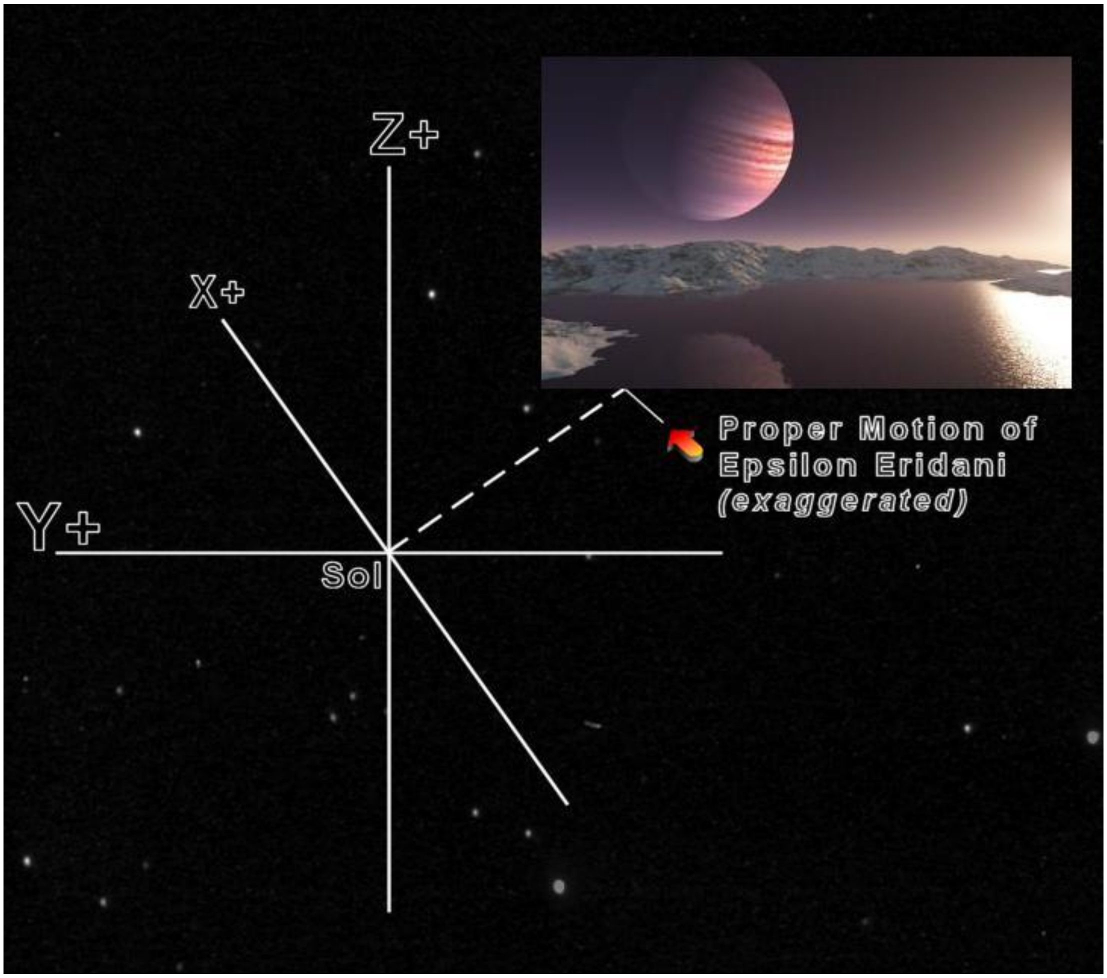
Once you start down this road to find precision data about a mission, a lot of interesting questions come up.

Some basic questions:

- How do you plot a mission to a moving star?
- What is the course heading?
- What happens to the mission duration and course heading, if you change from a rendezvous to a Fly-by mission?
- What if you start from another star system, not from Earth?

Try to answer any of these questions yourself and you will find the deeper you go, the more questions come up. It's obviously complex.

Exaggerated Proper Motion track of Epsilon Eridani, 10.5 light years distant

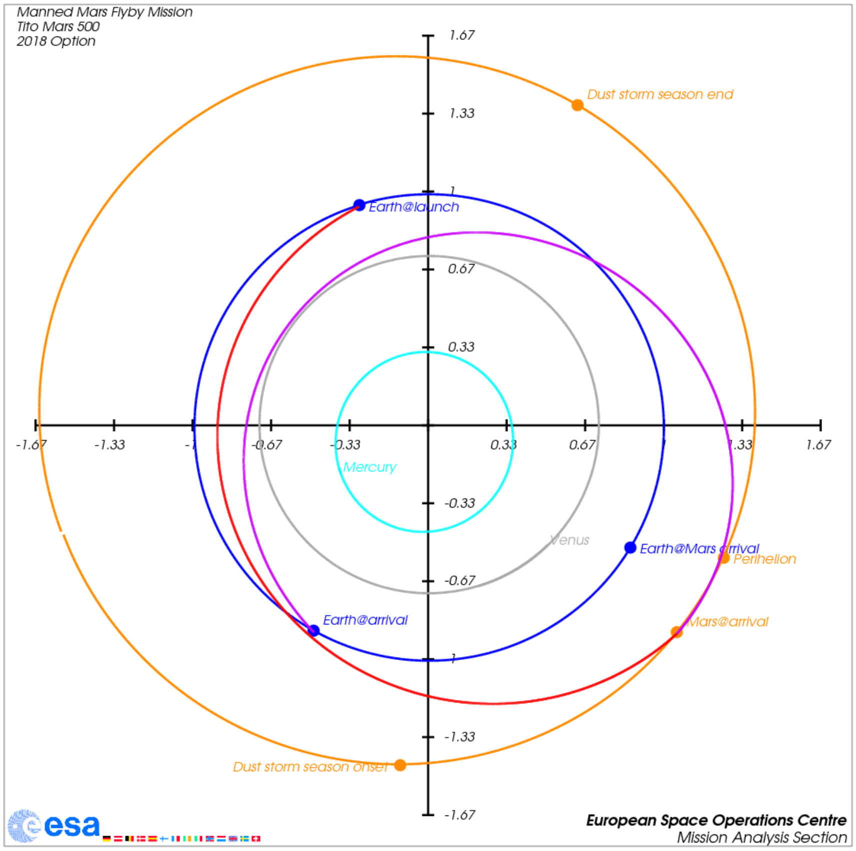


Painting Credit

Getting out of the Solar system

Escaping the Solar system require orbital mechanics. For this version of the Mission Profile Navigator, we discount any orbital trajectories. We also ignore galactic angular momentum by calling Earth coordinates 0,0,0. The current Earth time is used to define where Earth and other stars are in the galaxy. Earth remains at 0,0,0 for today and 1000 or 10,000 years from today. Of course, we are not the center of the galaxy, if we were to consider a wider galactic empire of many stars, then Earth would not deserve this center rating. For our purpose, it works and we can still find precise answers to navigation questions. So Earth remains 0,0,0, plus whatever date and apologies to Copernicus.

Getting out of the solar system takes extra effort and time, but this is a local issue and will be different for every star system. It depends how deep within the star's gravity well you start, and how powerful of a specific impulse your rocket engine has and how much fuel you wish to use. If you wish to allow, say 1 year to escape the gravity of a system, prior to starting your interstellar part of the mission, then you can simply adjust the mission start to one year after the date you wish to leave Earth.



Orbital trajectories like this are not handled by the MP Navigator.

Chart Credit

Travel between stars

The MP Navigator tracks mission profile data on interstellar trips:

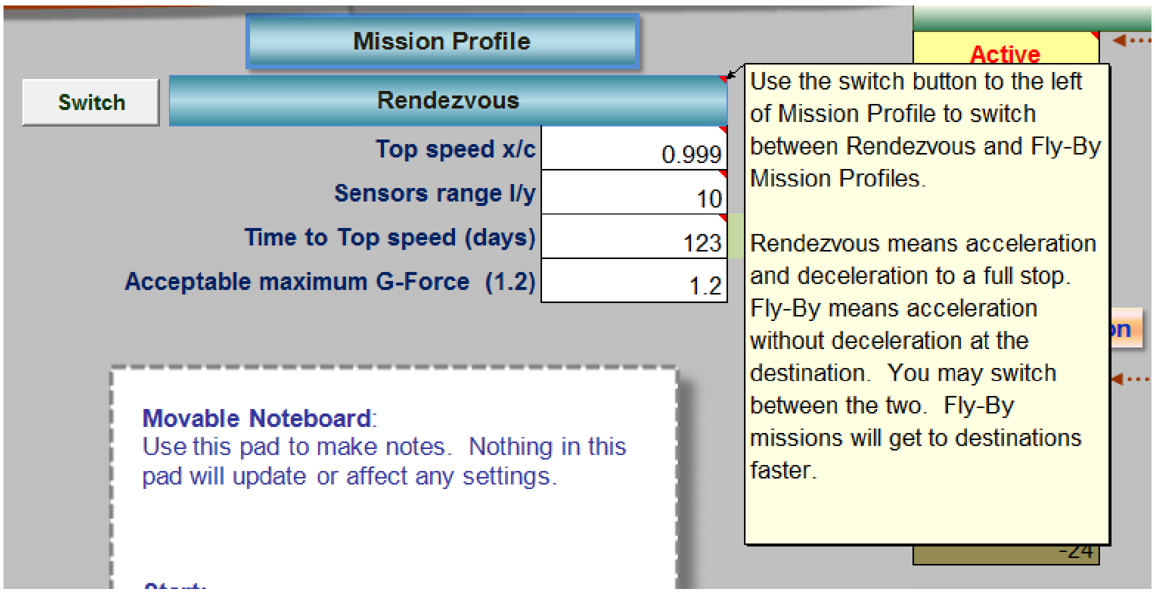
1. Dbase auto inserts Start Position and Destination for over 12,000 stellar and galactic locations.
2. Complete mission parameters report in pdf.
3. Destination Proper Motion movement tracked, if known.
4. Optional rendezvous with 2nd Starship B
5. Auto corrects coordinates to Rendezvous with a moving star
6. 38 preset starship types
7. Start Date: past, present and future – auto adjusts stellar shifts in positions based on distance and stellar positions shifts since Epoch 2000.
8. Travel to and from locations, other than our Solar System.
9. Sensor report tracks which real location of stars are within Sensor Range.
10. Relativistic time differences in Earth time versus Ship time
11. Mission type auto adjusts top speed, if time to top speed exceeds 50% of a rendezvous mission or 100% of a Fly-by mission.

3. Main controls

Let's look closer at the all MP Navigator controls and readouts.

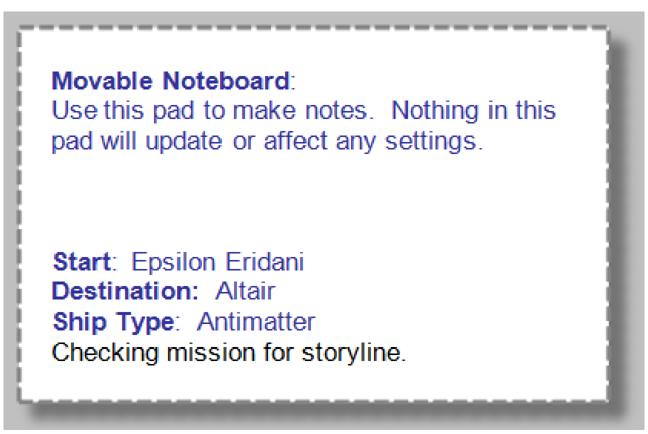
Red corner comments

Any cell with a top right corner red triangle has a pop-up comment. Scroll over the cell to read this help info.



Moveable Note board

Any notes can be added to this note board and moved around the MP Navigator. Macro buttons have top priority on layers over text boxes, so this will slide under buttons. It can be enlarged and edited as you wish.



Stellar Dbase Controls

The Stellar Dbase includes most all visible stars, star clusters, nebulae, local galactic border zone areas, and some galaxies in our local group as well as the most distance quasar and the edge of the visible universe, for those who really want to test their starship design on a really long trek.

For each entry, there is data on the star type, binary systems, known and suspected planets and rating of probability of Earthlike planets. The Stellar Dbase already has each entry converted to X, Y, Z coordinate values and Annual Shifts if Proper Motion for that star is known.

The Stellar Dbase can be sorted, scrolled and searched using the sort buttons, with up and down arrows and a text search entry areas for both Start and Destination. While scrolling, the mission is not yet locked in either Start or Destination until the Lock buttons are used.

In this example, the two stars Start Position on the left and Destination on the right, are already locked. You may still browse to other stars by using the scroll buttons. These locked star names show in areas 1 and 2. You can browse up or down the list using the scroll buttons. You can return immediately to the locked stars by clicking the #16 button, “Find Locked Start” or the similar button in the Destination area, “Find Locked Destination”.

1. Start Position - Shows the last locked Start Position. This area window will also show various alerts if Auto Adjust in the Start Date area is turned off or if you choose “Use RA” option. For mid-space locations, this window just shows X, Y, Z data. (You can manually enter any coordinate in the white cells in the Use XYZ areas. This causes a mid-space location.)
2. The last locked Destination – Scrolling through destinations does not cause this area to update, until you Lock in a new Destination.

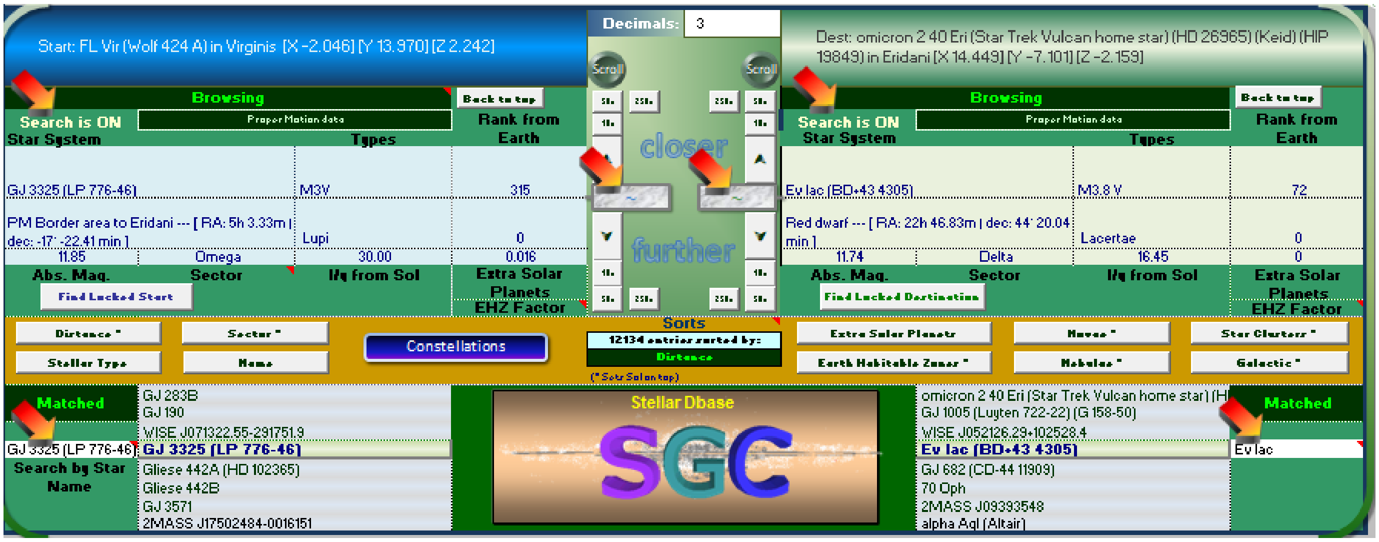
3. Info window to show if you are browsing to other locations or on the locked star, listed in area #1.
4. Back to Top of the Stellar Dbase sort. This often brings the dbase back to the Solar System for sorts with *.
5. Check for Proper Motion data in Stellar Dbase for the star. Most of the database has Proper Motion data describing stellar movement. White Dwarfs and dim or distance stars sometimes have no PM data. This cell info will show here if no PM data is available.
6. Name of primary star.
7. Type of primary star.
8. Distance Rank from Earth. (This dbase has equal distance stars ranked sequentially.)
9. Secondary star is often just B, or other notes about primary star
10. Second star type if available
11. Exo-planets in system (g = gas giants, e = rocky, less than 2 times earth size)
12. Absolute Magnitude of star
13. What Sector the star is in. (Sector Name with a plus sign is greater than 50 light years) Alpha is less than 50 lights years. Alpha + is over 50 light years.
14. Distance in light years from our Solar System
15. EHZ Earth Habitable Zone factor. 1 is closest to Earth.
16. Find the current Locked Start Position. You may have scrolled through the stellar database and no longer be 'Locked' in the start location.
17. Editable white area: Number of decimal accuracy for X, Y, Z values in Start and Destination areas, 1 and 2.
18. Button to turn scrolling back on.. This is only needed after a Search by Star Name.
19. Scroll buttons UP (Closer to our Solar System) 1x, 10x, 50x, 250x
20. Button to lock Start Position with status of the star currently in the browser. As you scroll through other stars, this field will change to ~. You may click it and Lock the current star look up as the new Start Location.
21. Scroll buttons DOWN (Further from our Solar System) 1x, 20x, 50x, 250x.
22. Sort Dbase options: By Name, Sector, Stellar Type, Distance (default) Extra Solar Planets listed first, Earth Habitable Zones listed first, Novae, Nebulae, Star Clusters and Galactic (which includes border zones of galactic arms coreward and rimward, center of galaxy, etc.)
23. Sort Dbase Status area, showing the number of locations and the sort type.
24. Search area status. If search is on, this area shows an alert. Search will freeze the scrolling arrows from working.
25. Search white cell entry. This is available for both Start Position and Destination. Search for any name, secondary name or even fictitious name of the system. For example Vulcan or Romulas will find the supposed star systems, associated with Star Trek. You can also search white dwarf or giant.

Stellar Dbase - Search Mode

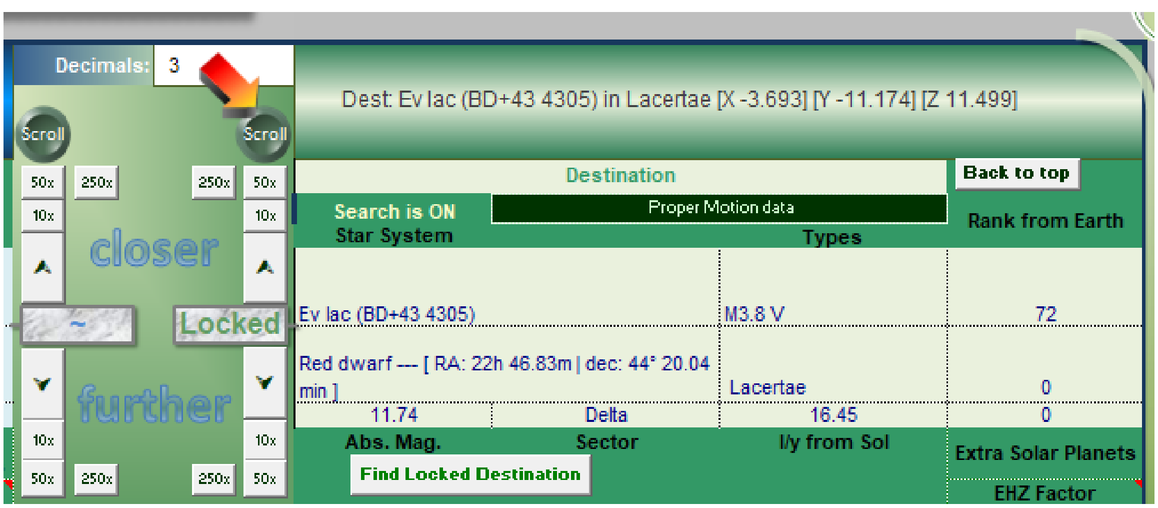
A user may enter search mode by typing the name of the star in the search cells in the lower left and right of the Stellar Dbase. Alternate names and some fictional names will also work. For example: how long would it take for a journey from Vulcan to Romulas?

Once the Stellar Dbase is in search mode for either the Start Position or Destination, the scroll buttons will on each side will no longer work. You need to click the green scroll buttons above the scroll arrows to switch back to scrolling.

You can mix search on one side and scroll on the other.

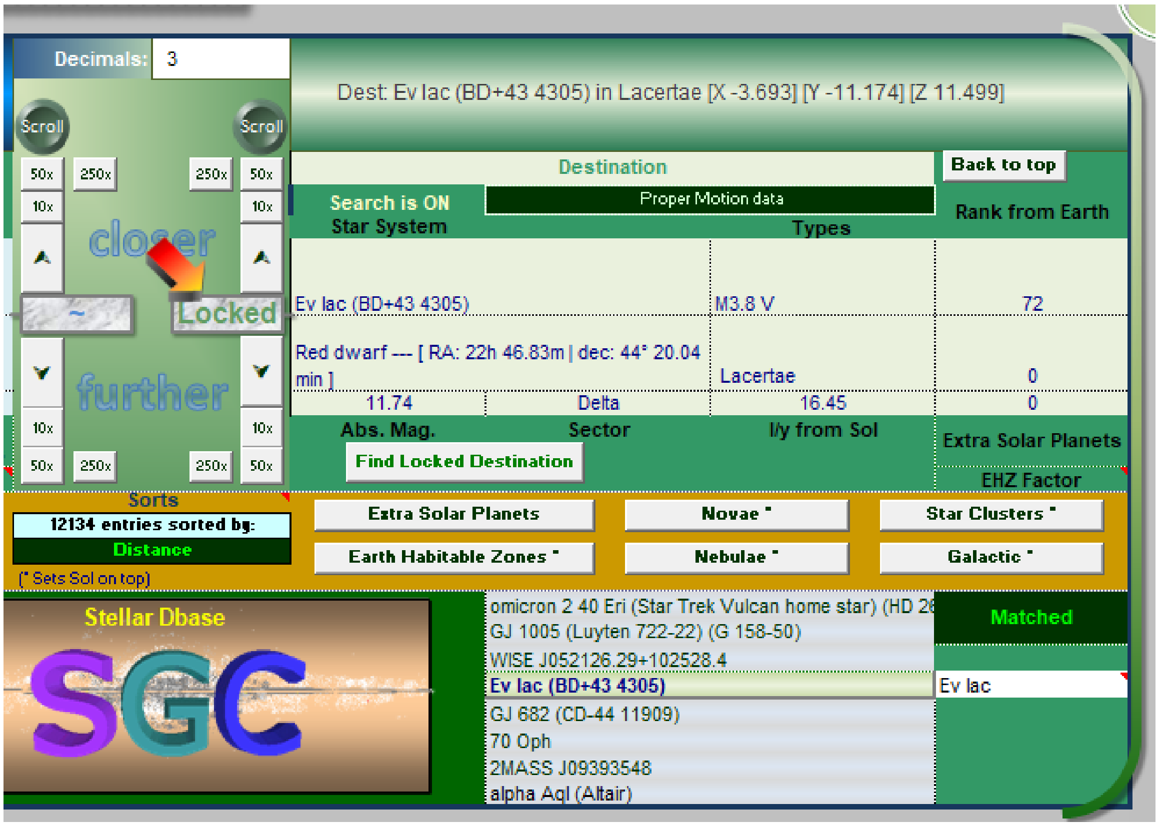


Getting out of Search mode and back to use the Scroll Arrows, simply click on the Scroll Button.



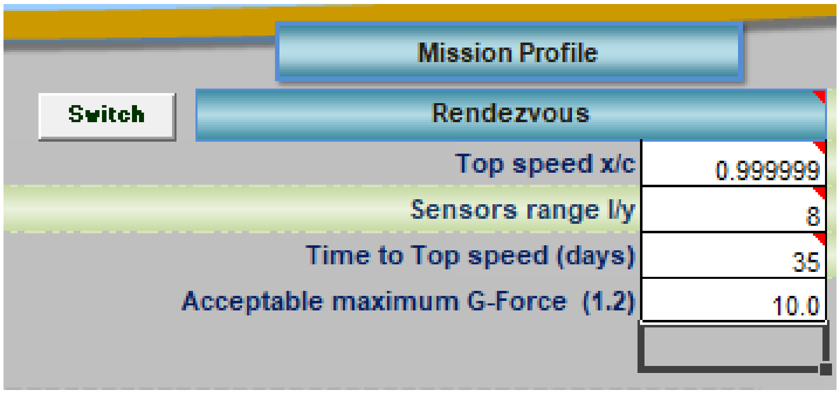
Once you decide that Start or Destination is correct for your mission, click the silver marble button with the tilde ~. This will lock in the location.

In this example: Ev Lac was searched and Locked in as the Destination.



Speed controls

These cells define your ship speed. They are in the middle center of the Input area. White cells can be edited by you. You can always choose the Sensor range. The other values do get updated by Ship type presets.

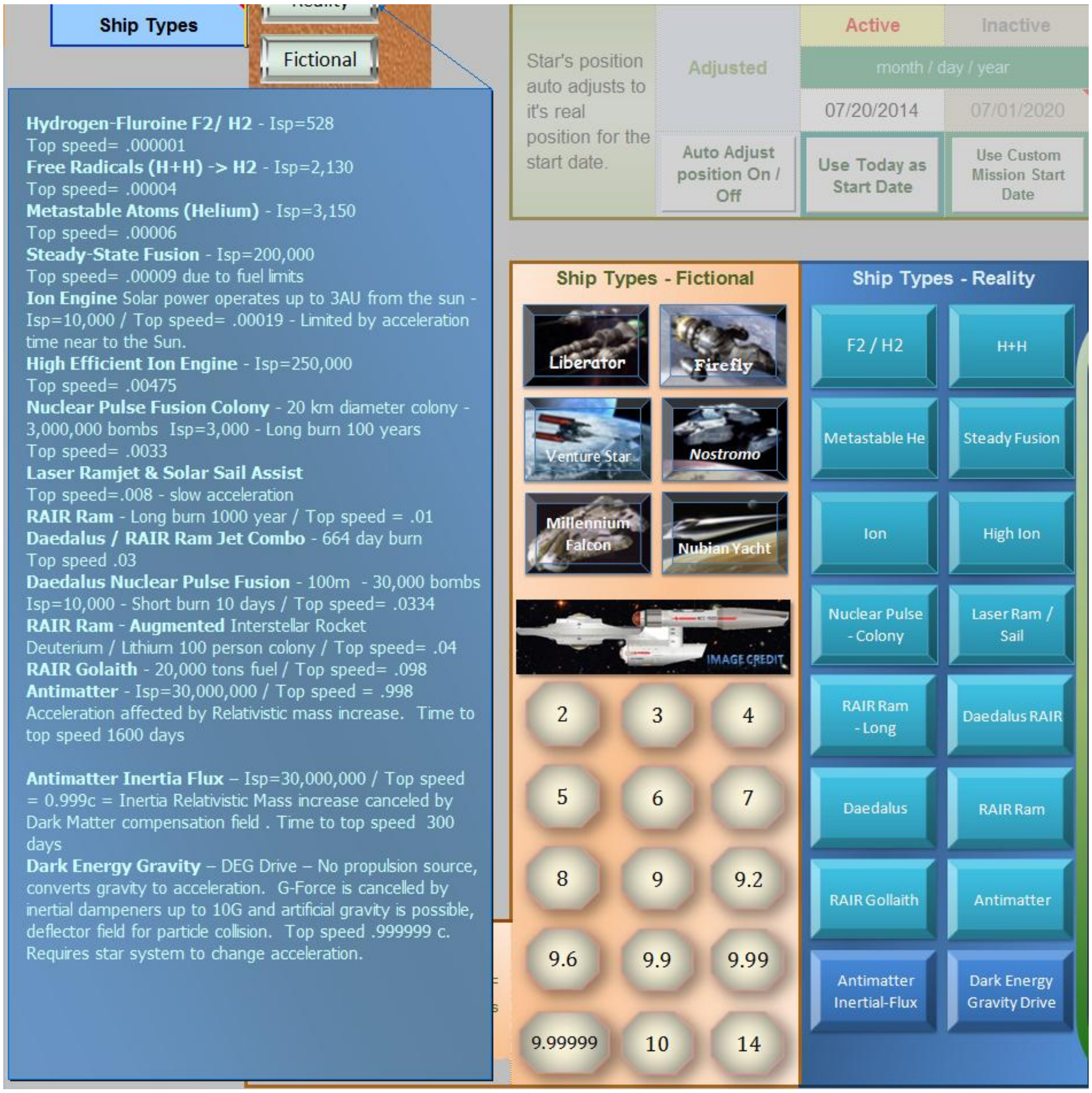


- Top speed where 1 = c, the speed of light
- Sensor range defines the sensor diameter sphere that checks for nearby stars. (user always controls this value)
- Time to Top speed defines the acceleration leg of the mission.
- Acceptable maximum G-Force (No higher than 1.2 recommended)

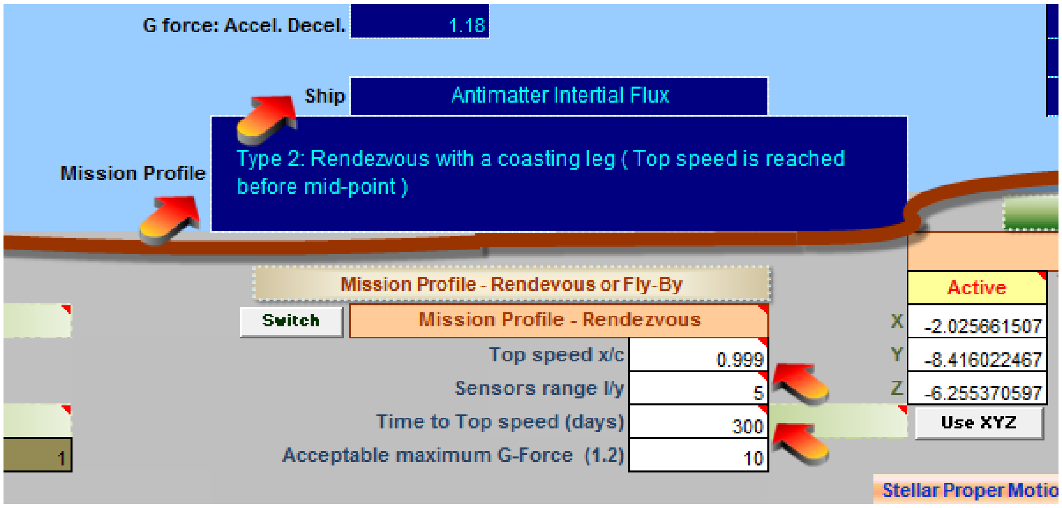
These values are up to you to define, based on what ship design, whatever top speed and time to top speed. The MP Navigator has preset ship buttons that updates automatically to preset values. Otherwise, the MP Navigator makes no calculations for top speed design limits, fuel capacity, specific impulse issues, etc. This is up to you to decide when making their own ship design.

Ship types

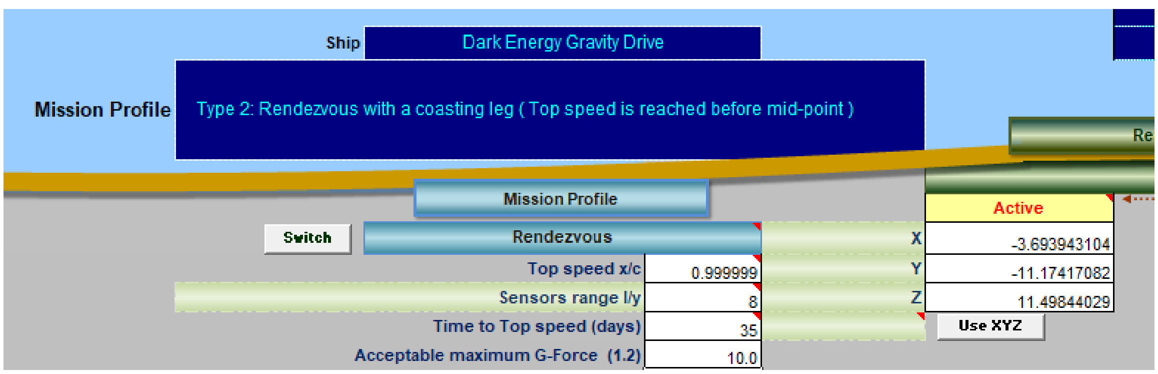
The lower left of the main controls Input area have two ranks of buttons, one for Ship Types – Fictional and the other Ship Types Reality. More info may be viewed by clicking either of the buttons on the left pillar.



These Ship Type macro buttons update the Top Speed, Time to top speed and the Output area Ship Type and Mission Profile.



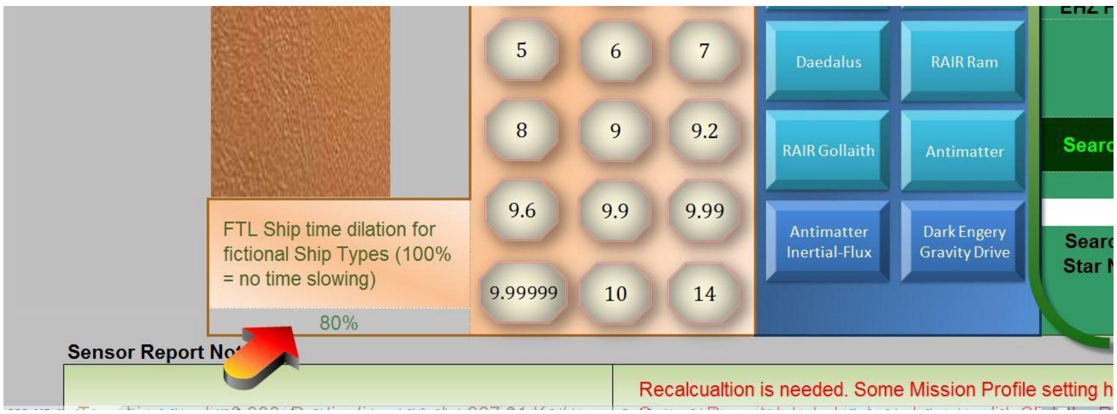
If you pick a Time to Top Speed that is longer than half of the mission, a warning will appear and the Mission Profile readout will show an alert that top speed cannot be reached.



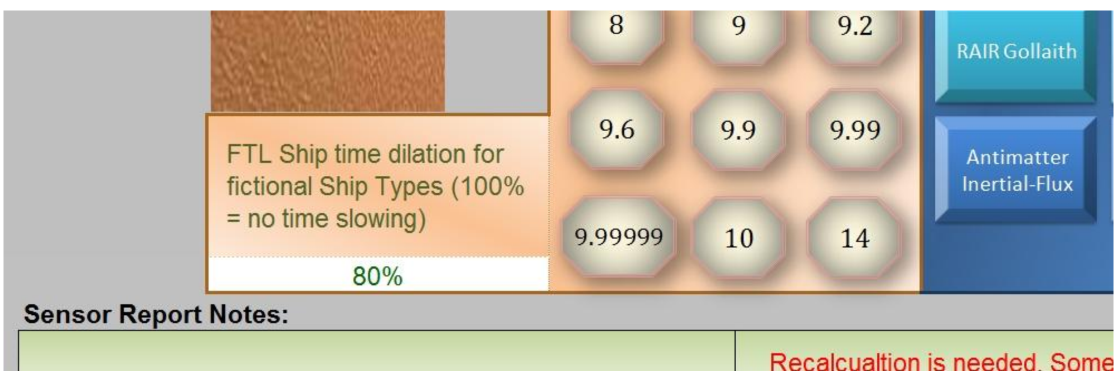
FTL Time Dilation control

Since FTL (Faster than light) travel is in the realm of fiction, the associated time dilation that goes with such a journey is up to you to set to match their story needs. As a default, it is set to 80% of Earth Time. The setting only works in FTL Ship Types and is in the lower left pillar above the Sensor Report Notes. Changes here, make an immediate change in the Output Area Ship Time numbers and only work for FTL missions.

For normal Sub-Light voyages, this is turned off.



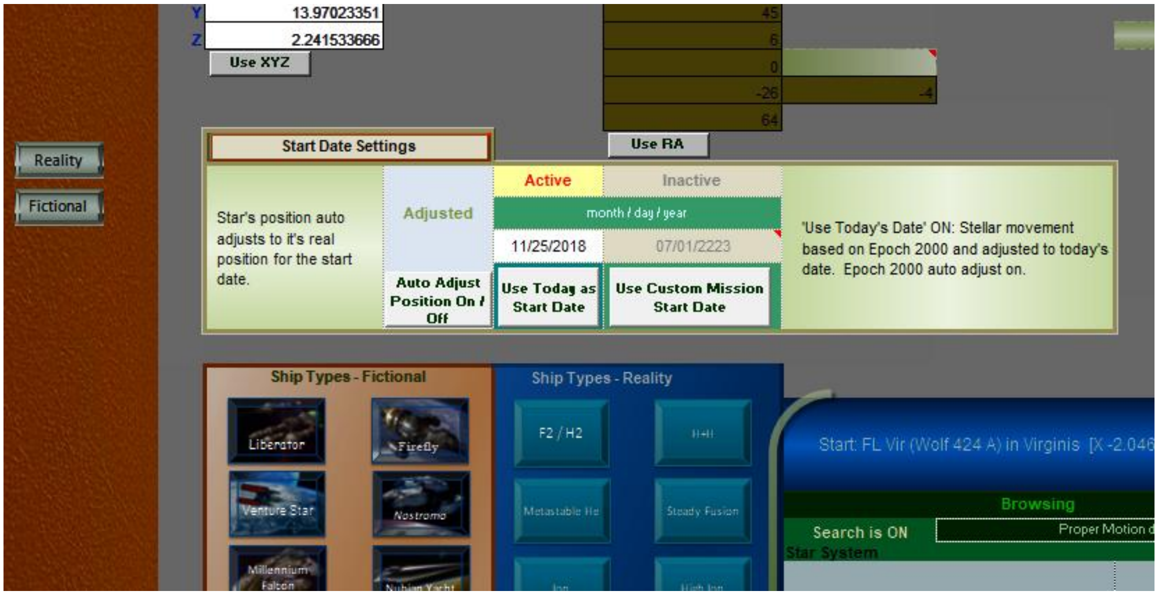
You can adjust this for FTL type voyages. 1% means 1 day Ship time equals 100 days Earth time. The default at 80% shows a 20% slowing of Ship time.



The change shows up in the Output Area Ship Time area.

You can get creative and set FTL time dilation to a negative percentage, which allows time travel to the past. Here is an example for a FTL mission starting in July 2014 and FTL time dilation set to – 100%. The arrival date is in the past. (Values less than -100% are possible). However, the earliest date allowed by Excel is January 1, 1900. (If you try this, notice some fun updates in the Time Dilation report in the right area of the MP Navigator.)

Start Date



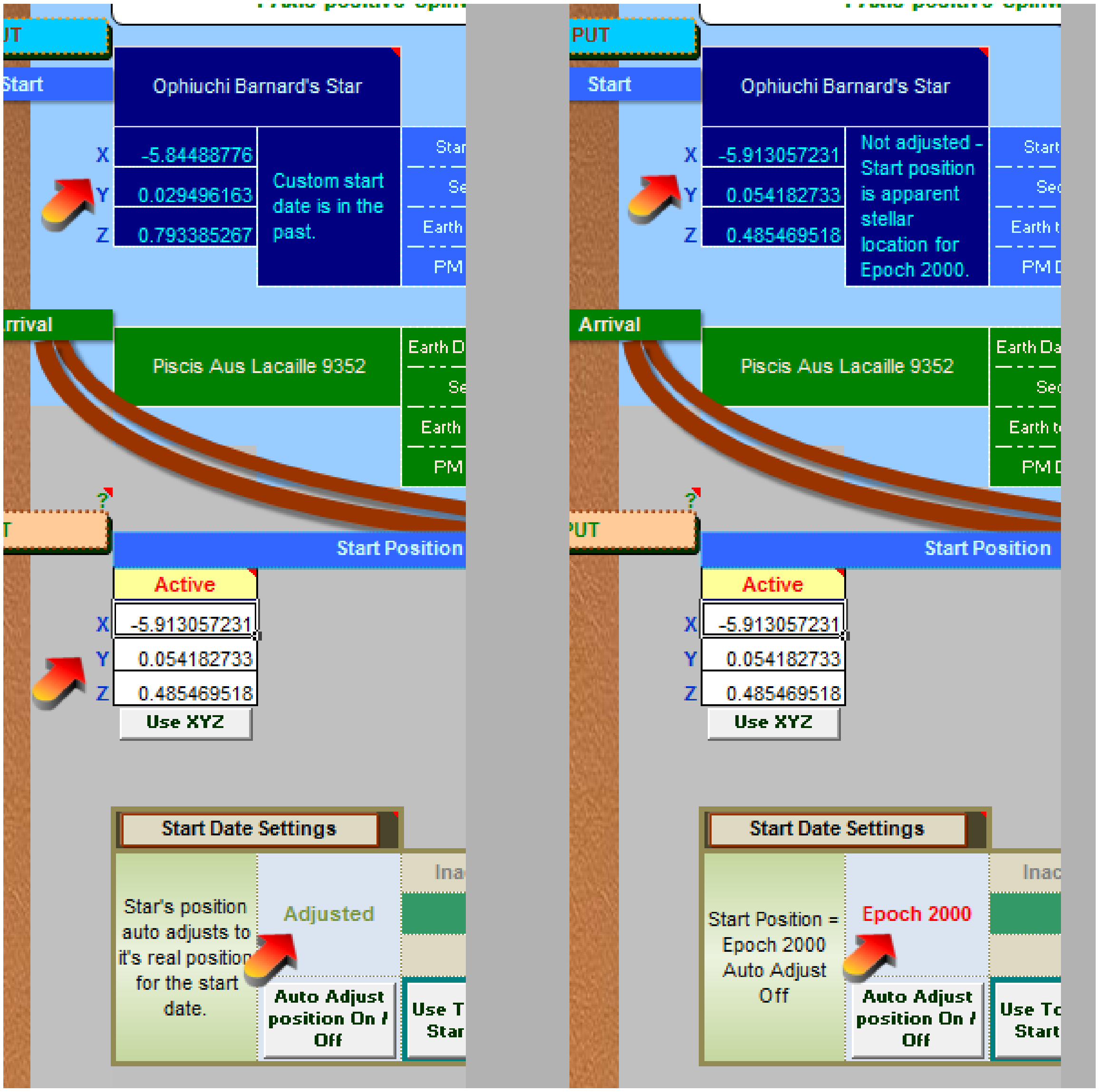
Three areas to this control area:

- Auto adjust Position On or Off (use Epoch 2000)
- Use Today as Start Date
- Use Custom Mission Start Date

Auto Adjust will move any Stellar Dbase star with known Proper Motion data, from its Epoch 2000 coordinates to the coordinates where it is expected to be on the Start Date you choose.

When Auto Adjust is on, it is possible to see the difference between the Epoch 2000 coordinates and the auto adjusted coordinates of the Starting Position star.

Let’s take the fastest moving star, Barnard’s Star. It is a halo star, Z plane type orbit, which is coming from far above and heading below the galactic plane. So it is zipping past us much faster than other nearby stars which are rotating with us, as we go around the galactic center.



When Auto Adjust is on, on the left area above, the Adjusted X, Y, Z coordinates appear in the upper output area. Notice that adjusted to mid 2014 (today's date) is quite different, from the recorded position of Barnard's Star on Epoch 2000, January 1, 2000.

When you turn Auto Adjust Off, the Epoch 2000 X, Y, Z values are used in the Upper Output area. There is also an alert that changes in the Output area to let you know you are not using auto adjustment.

An interesting chart from Wikipedia showing how the nearby stars juggle their positions, over time. At about 38,000 years in the future, Ross 248 will be our closest star to us, at just under 3 light years.

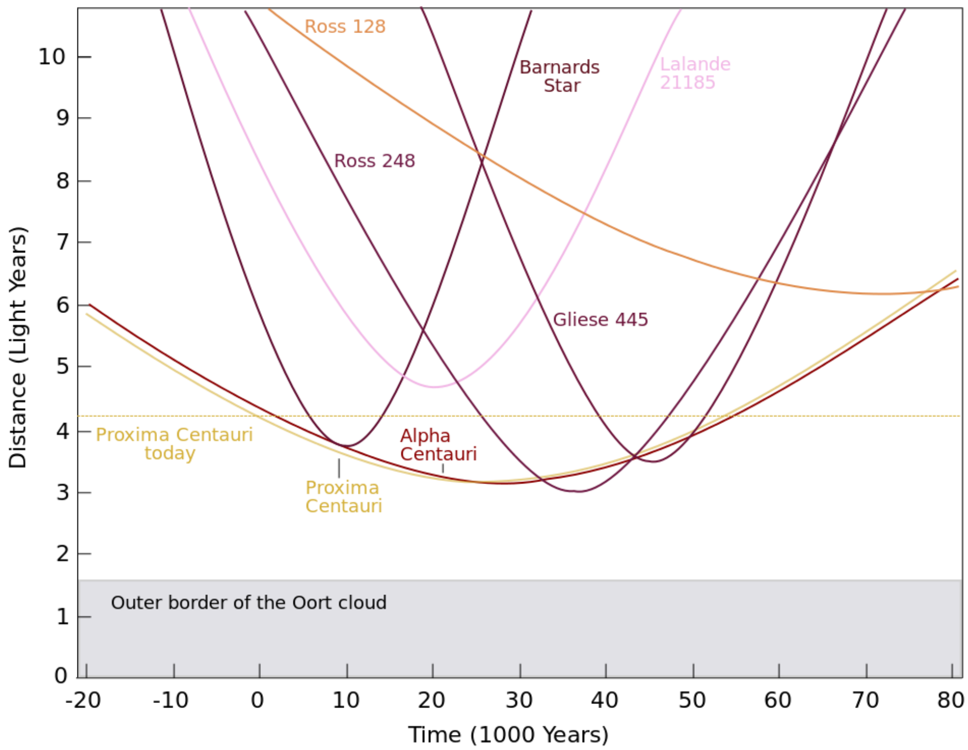
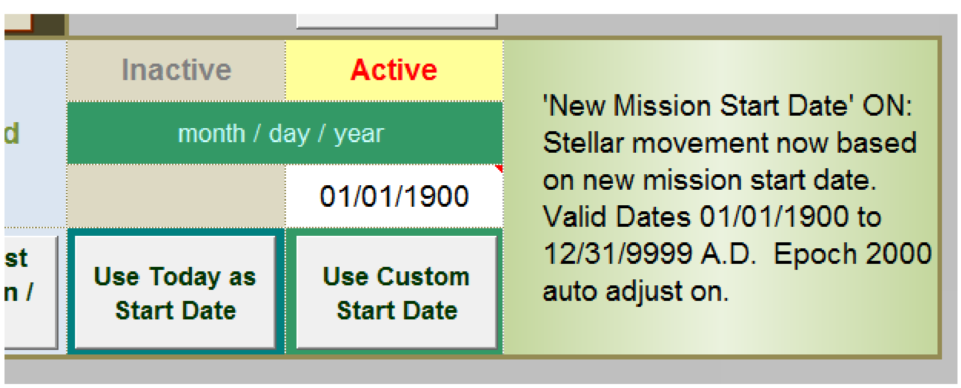


Chart Credit

Custom Start Date

You may pick a custom date in the future or in the past.



This can result in an arrival at your destination, also in the past.

Cross checking the coordinates for our neighborhood speedster, Barnard's Star shows that on January 1, 1900 it was at:

```
X = -5.844887724
Y = 0.02949615
Z = 0.793385428
```

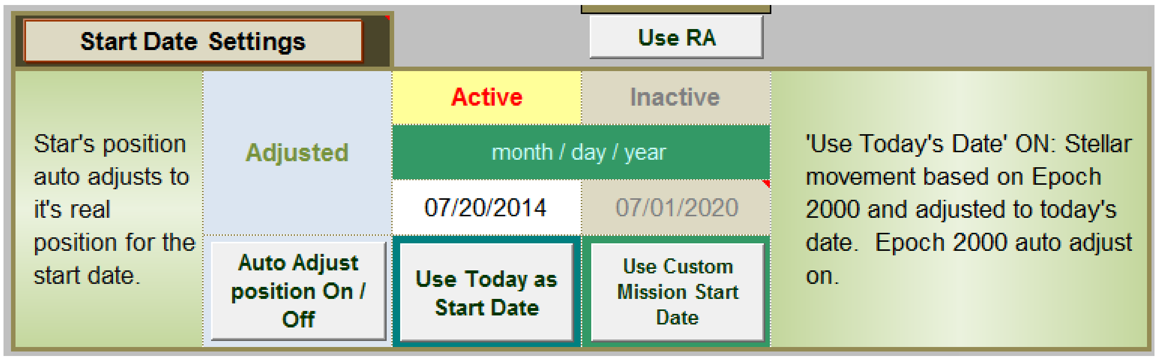
Checking for today's date in mid 2014, 114.5 years later, and doing some quick math, we find that there is a 96.2 trillion mile difference, relative to Earth.

```
X = -5.913057231
Y = 0.054182733
Z = 0.485469518
```

That is a sizeable distance, which is totally ignored by any coordinate system that does not take into account Start Date position shifting.

Start Date – Suggested setting

The suggested setting is Auto adjust on and the Start Date set to your current today's date – in this image, its 7/20/2014. This will give a mission profile report that makes more sense, as there will be no special Start Date shifts. Comparing different Ship Types and mission parameters should be easier.

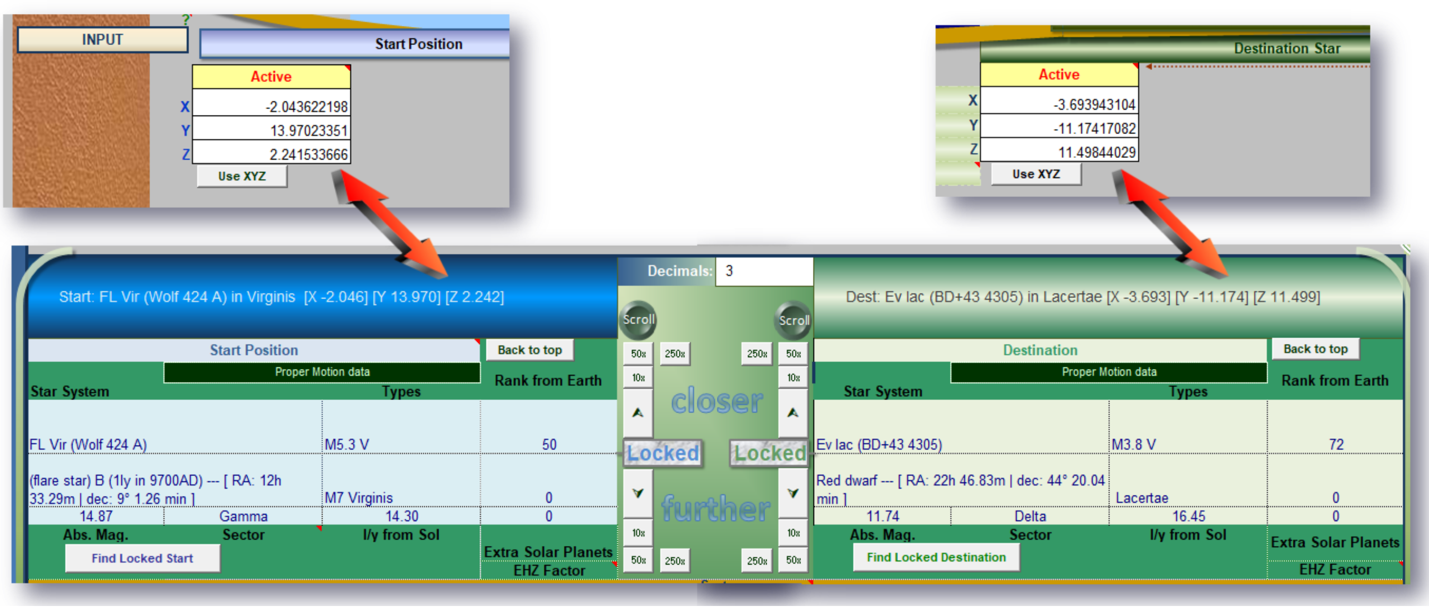


Use XYZ in detail

Both the Start Position and Destination can be set using the XYZ Coordinates. You can edit any white cell in the Input area.

The Start Position does not use Proper Motion values. Once you leave your Start Position, you don't really care where it moves off to. So, it is not tracked.

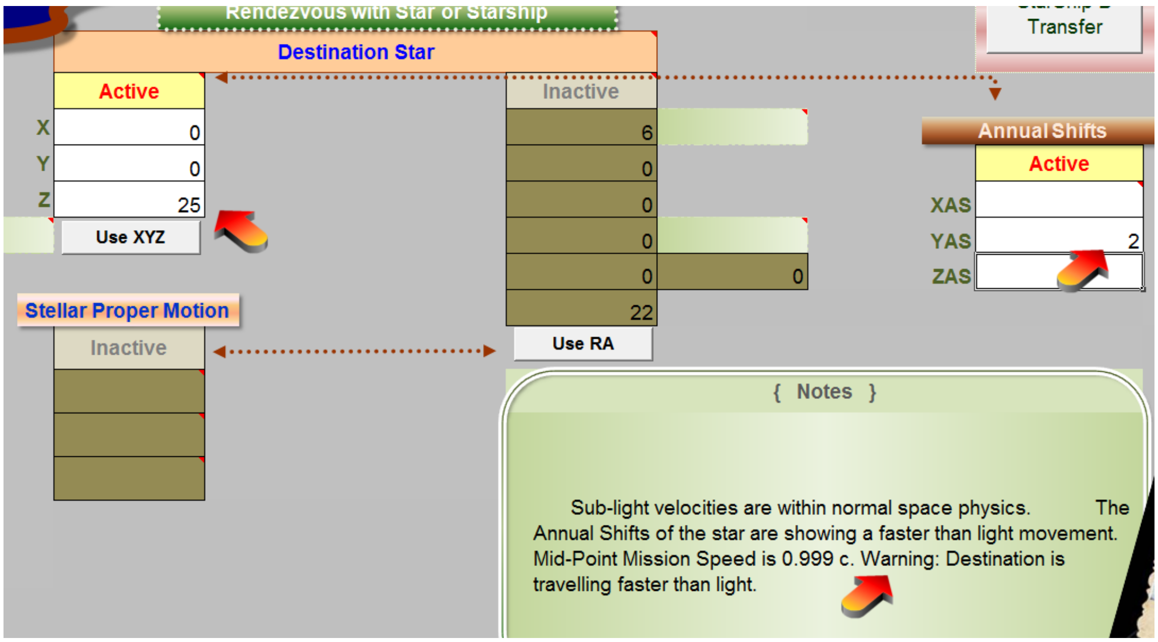
In this example below, the database stars are automatically transferred to the X, Y, Z coordinates when you Lock in the locations.



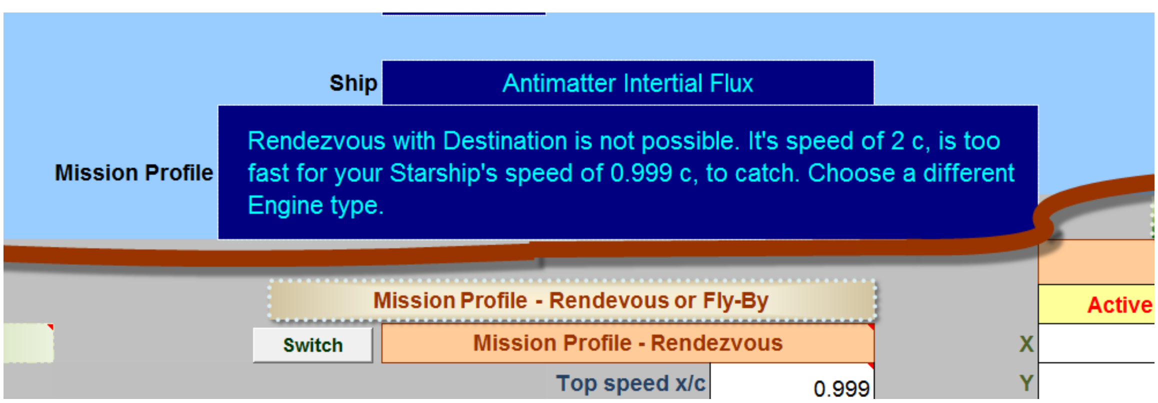
Destination X,Y,Z

The same adjustments for X, Y and Z can either be handled by the Stellar Dbase or directly input by you for Destination area.

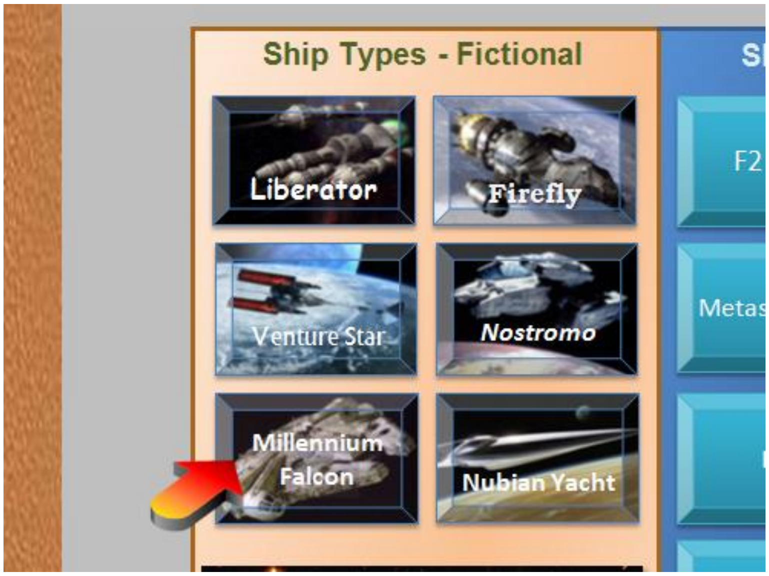
In this example, the destination is set to Z value 25, which is 25 light years towards Earth Polar. The YAS value Annual Shifts, is set to 2, which means this destination, perhaps a Starship, is travelling at twice the speed of light at 25 light years higher in the Orion Spur. Y plus makes it heading away from the center of the Galaxy. You will get a Warning in the notes to alert that Destination is travelling faster than light.



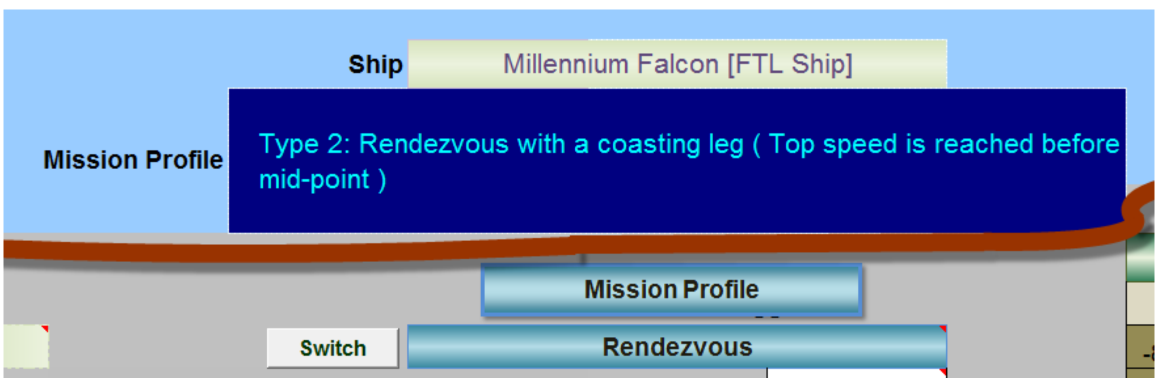
The Mission Profile alert also mentions an issue. Even with a fast Antimatter sub-light Ship Type, it is not going to be possible to catch the destination.



That's destination is a real speed demon, running at twice light speed. We can catch it, if we pick a faster ship from the Ship Types – Fictional, none other than the Star Wars, Millennium Falcon.

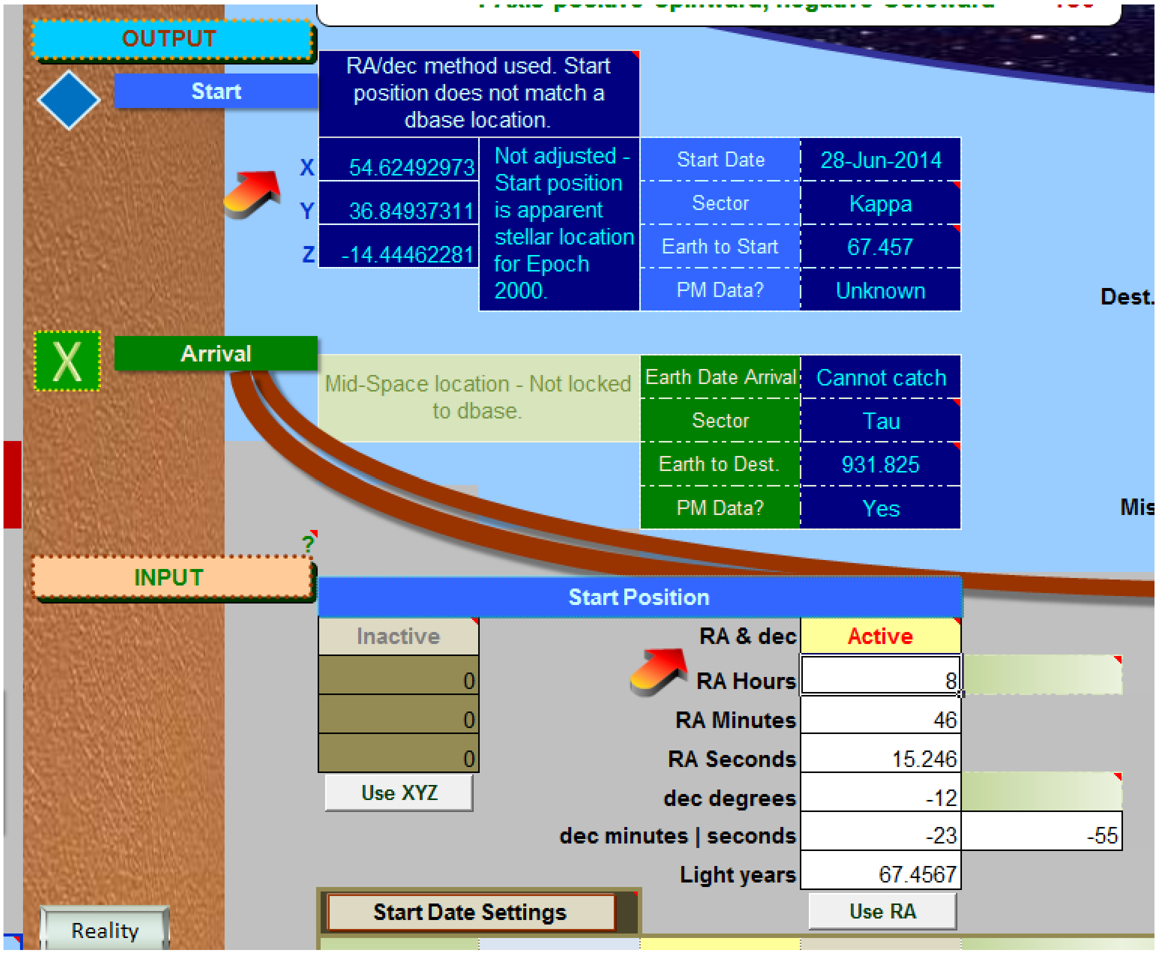


The Mission Profile ship update and the area below and resolves the previous warning.



Use RA in detail

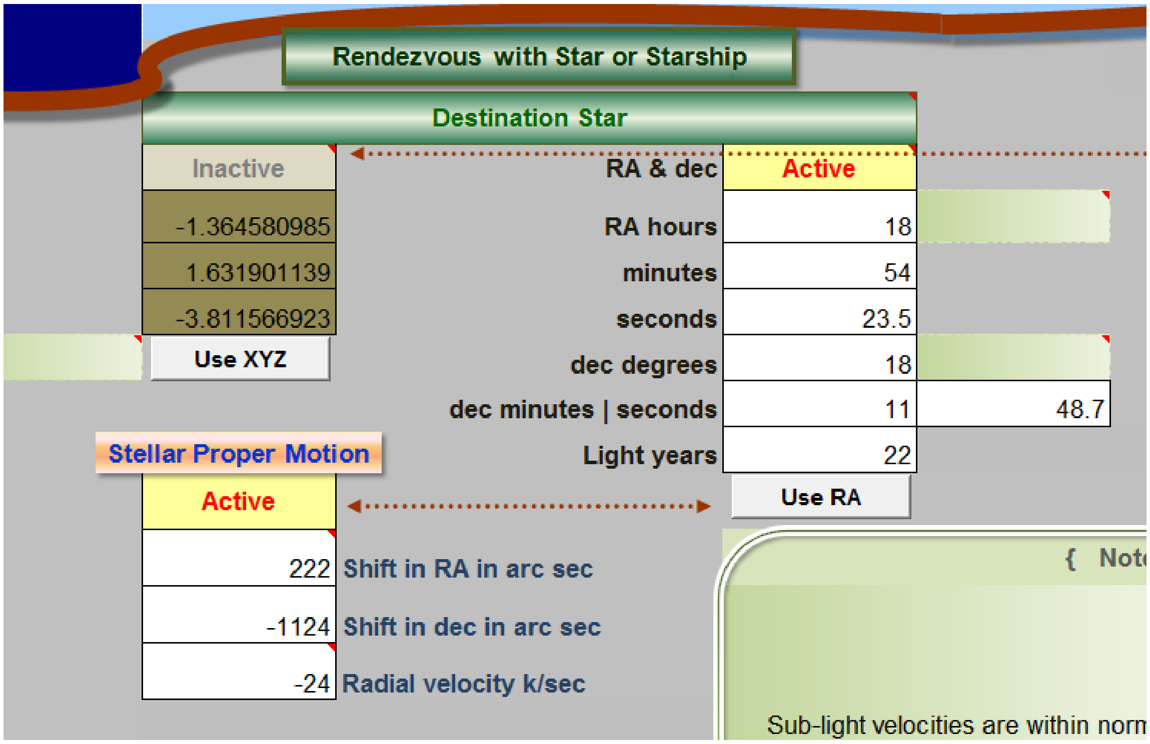
You may update the white cells in the Start Position RA area. The Start Position is automatically converted to X, Y, Z in the Output area.



A good place to find RA and Proper Motion values are with Wikipedia Constellation Stars. Many stars are listed on each constellation page under a link in the right column List of Stars. An example List of stars in Andromeda. Most all stars from these lists are already in the Stellar Dbase.

Other sources of star catalogs are: VizieR Catalogue Service, Study for mission stars within 32.6 light years is at RECONS. Other good sources are: Alcyone, and Extrasolar Planets.

In the destination area, you can also enter into white cells RA (Right Ascension), dec (declination) data as well as Stellar Proper Motion data, if known.



Mission Profile between two stars in the same system

Trying to calculate the mission time between Alpha Centauri and Proxima Centauri is an example of a mission where you should turn Auto Adjust off. This causes any mission profile you make within a multi star system to be based only on Epoch 2000 values, not where the stars are today in their orbits. There are several dual star systems with separate stellar dbase coordinates.

Here are example steps for setting a mission between Alpha Centauri and Proxima Centauri:

1. Turn Auto Adjust position off in the Start Date area
2. Turn on Use XYZ for Start Position
3. Turn on Use RA for the Destination
4. Enter Start RA values for Alpha Centauri. This will update the Output area – Start X, Y, Z.
5. Enter Destination RA values to match Proxima Centauri.

The mission profile will now show a good estimate of a mission from Alpha Centauri to Proxima Centauri, based on your updated RA values. For a short mission you can use Stellar Proper Motion values for Proxima Centauri. For a mission longer than 10 years, you should not use Proper Motion and delete these entries. The MP Navigator converts Stellar Proper Motion to linear Annual shifts in X, Y, Z (XAS, YAS, ZAS). This is, of course, inaccurate for orbital coordinate math. (Proxima Centauri estimated orbit around Alpha and Beta Centauri is extremely long, around 500,000 years.)

Use XYZ and Use RA can be mixed for Start and Destination. The MP Navigator allows any combination to work.

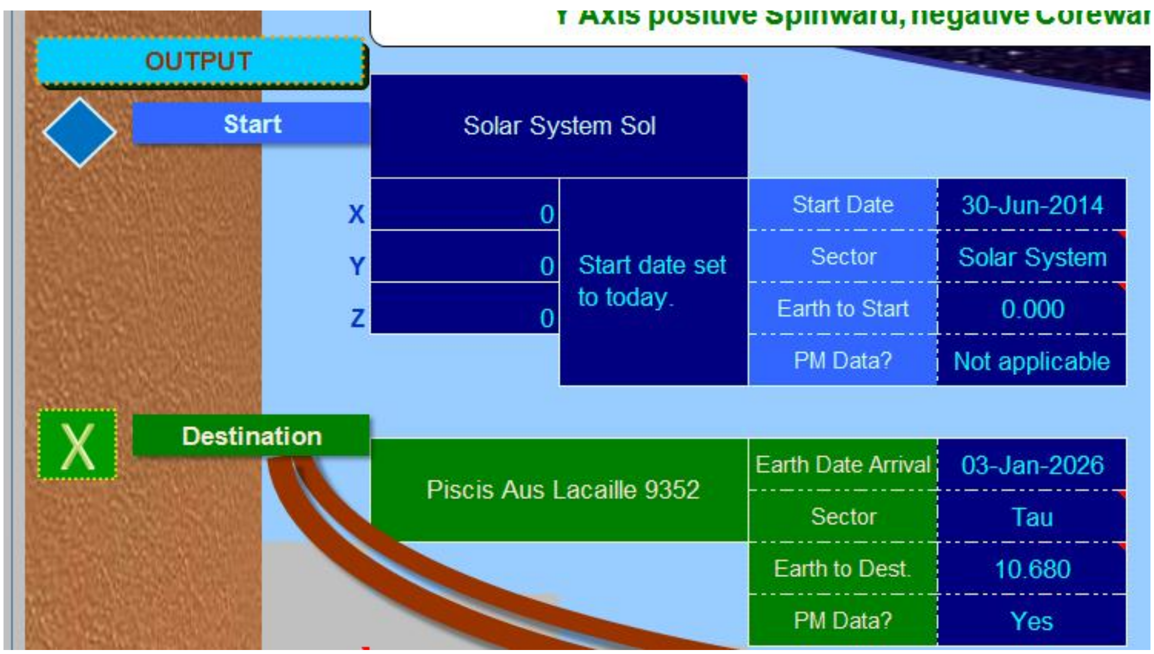
Stellar Proper Motion

Enter the Shift in RA and Dec into the white cells and the MP Navigator will auto find the Annual Shifts of the star. The standard for Radial velocity is negative is approaching and positive is receding from Earth.

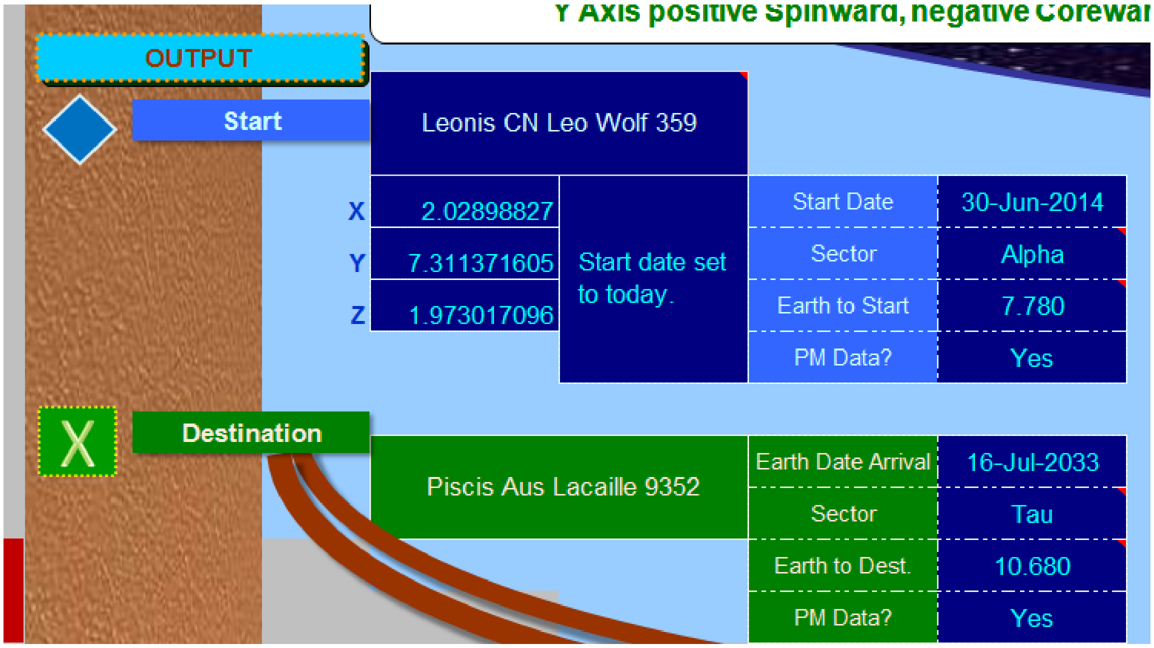
Output Area

The Output area contains only colored formulae cells. You should not try to change any cells in this area. The MP Navigator locked version prohibits changes.

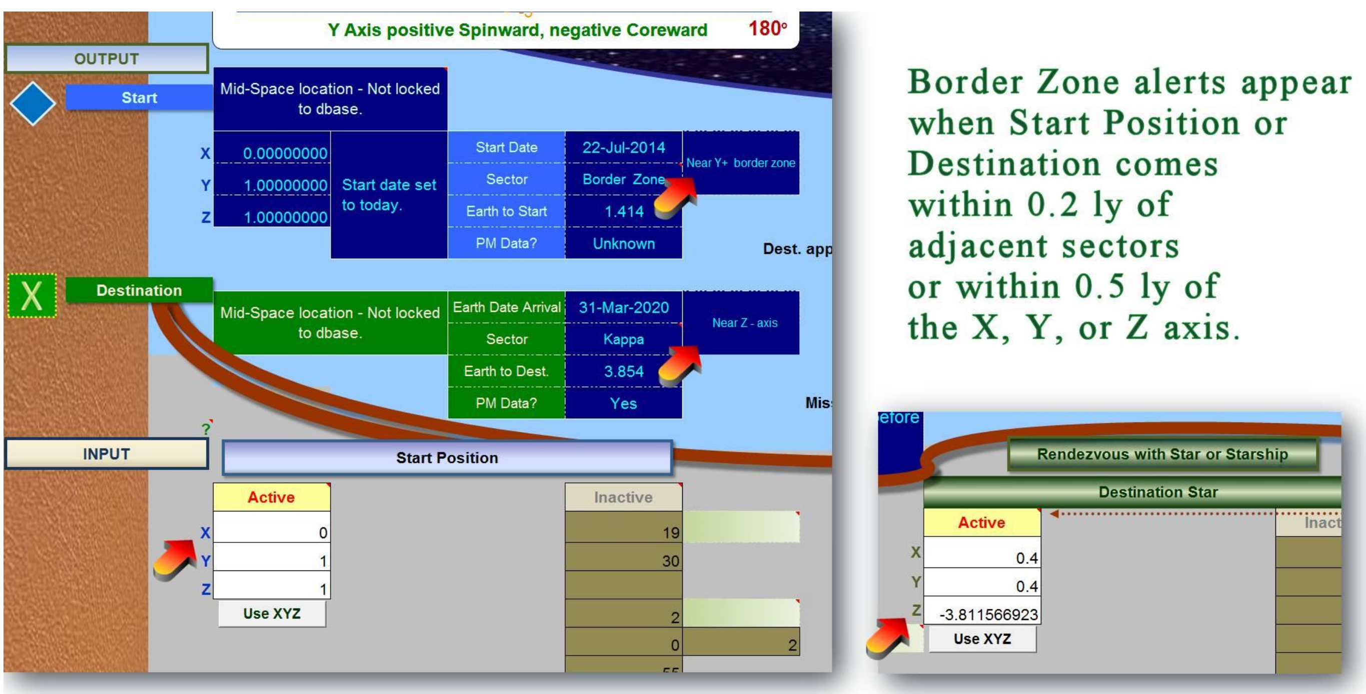
Tracking information about the Start Position and Destination is shown.



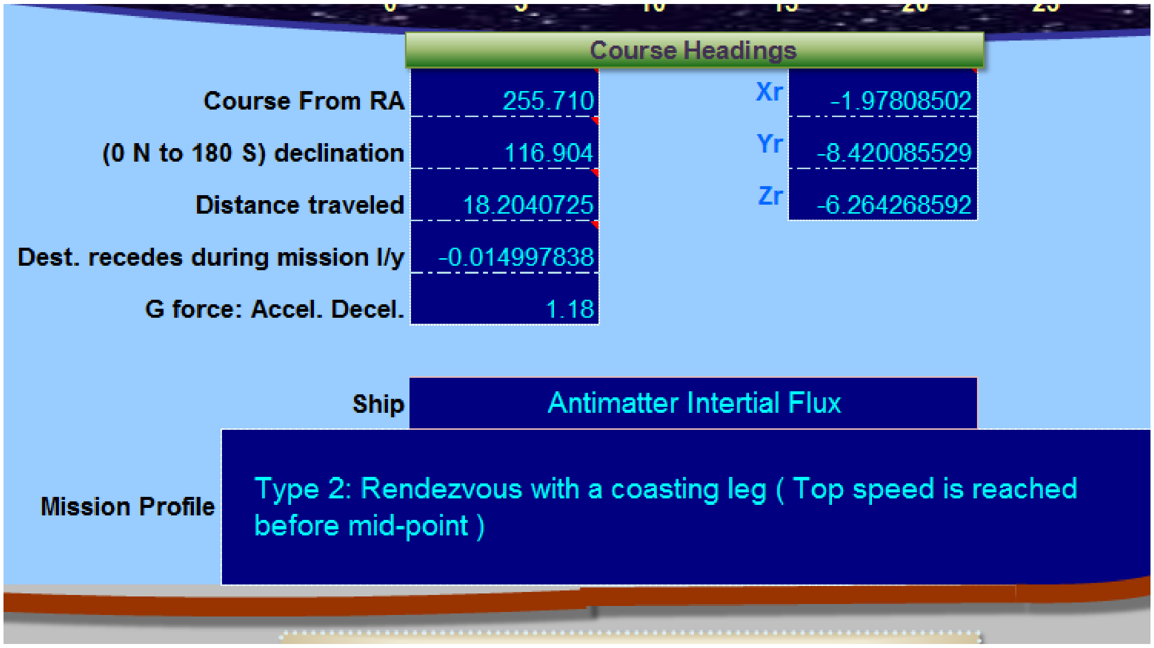
If Auto Adjust is on and “Use Today as Start Date“ is on, the MP Navigator auto updates a start location to the current computer time. The Start position in the below example has X, Y and Z values, Sector is now Alpha, PM (Proper Motion) Data is Yes. The Earth to Start Position distance is now 7.780, even though Earth is not part of this mission profile. Notice that Earth to Destination distance is also given to be 10.68 light years.



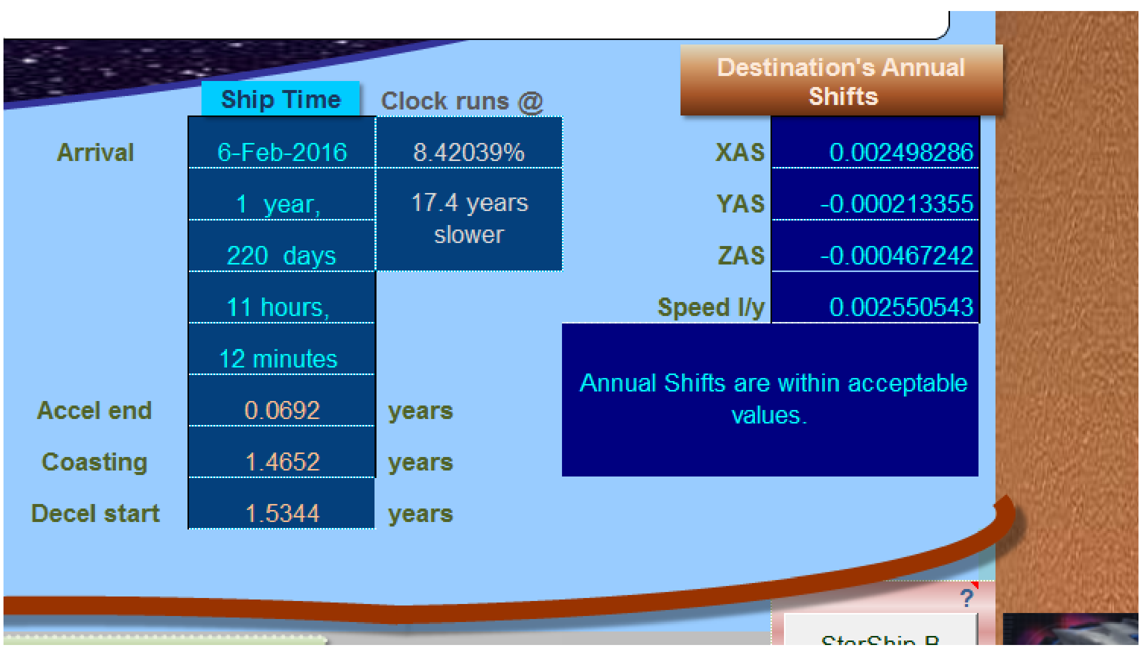
If your Start Position or Destination comes close to the Border Zone of a Sector or to a X, Y, or Z Axis, you will get an alert update.



Looking at the center of the Output area now, we see that the Distance traveled is 18.2… light years. This is the distance between the two stars and is not related to the Earth to Start or Earth to Destination distances. The Xr, Yr, Zr represent the Real coordinates of the Destination star at Rendezvous, at the end of the mission.



The Annual Shifts for each coordinate of the Destination are listed on the right of the Output Area, next to the Ship time. Also listed is the speed of the destination star and a readout info area about the Annual Shifts.

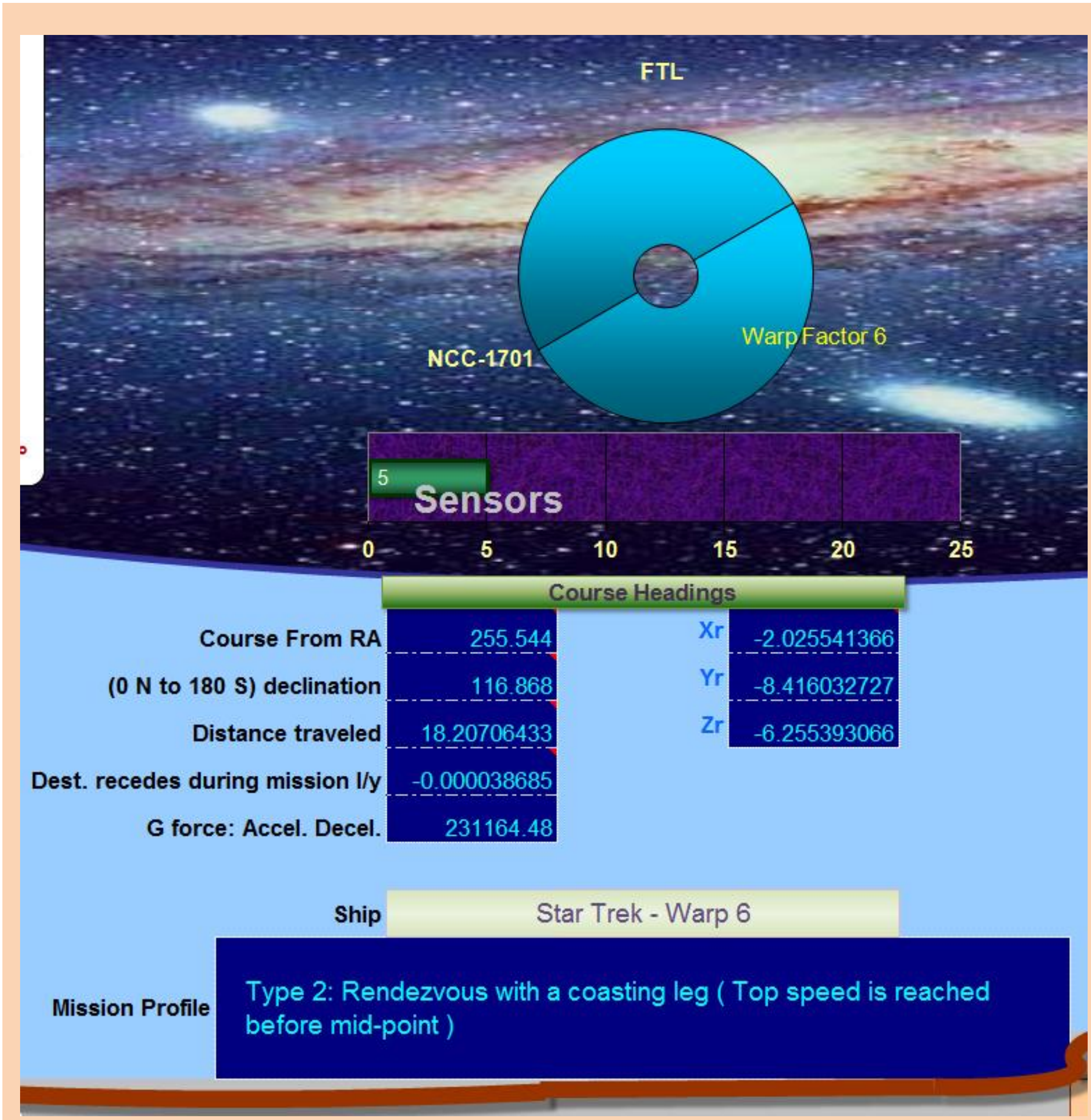


Looking closely at the Ship time info, we see that if the calendar was kept to strict Ship time, a ship arrival date would be only in February 2016, just a little over 1 year and

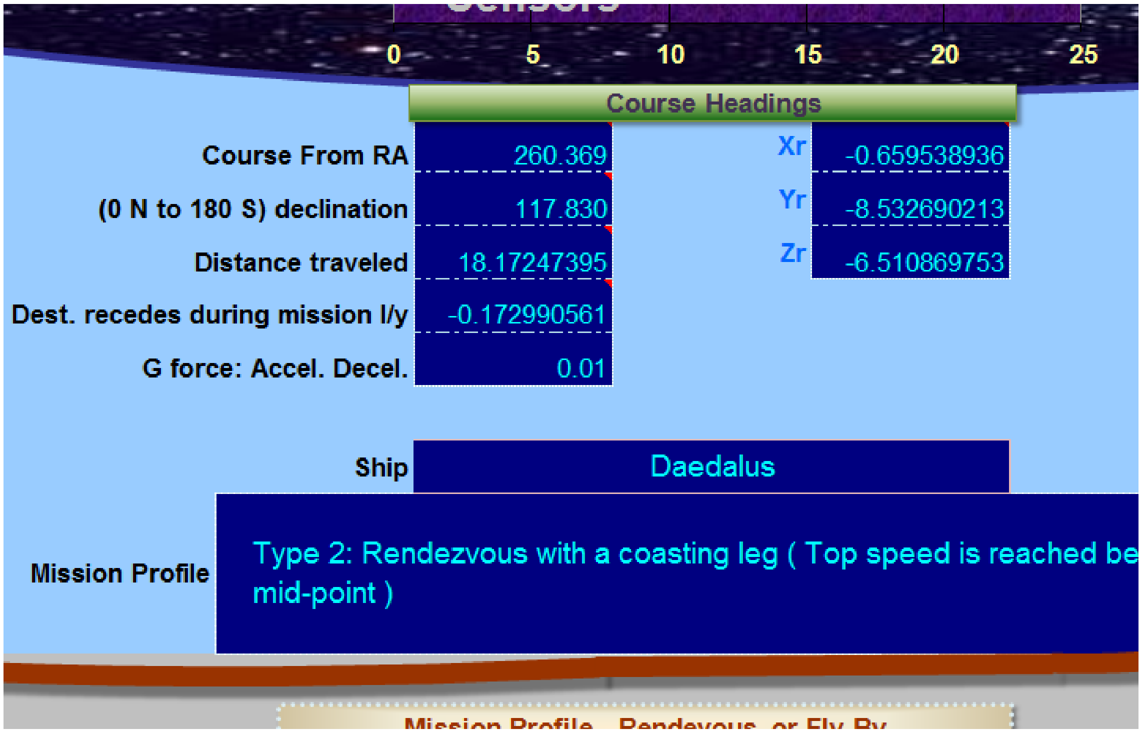
220 days into the mission. The ship's clock is running at 8.4% of Earth Time and this represents 17.4 years slower.

How does this compare to Earth time? We see that the Earth time of the voyage was just over 19 years. Ship time differences are due to relativistic time dilation caused by the extremely fast ship speed.

On the same mission, if we choose a fictional Starship, say a Federation Constellation class, traveling at Warp 6, we see some changes in the Output Area. Notice changes in declination and Distance traveled and Xr, Yr, Zr values change.



Finally, if we pick a much slower Starship like the Daedalus with top speed at 0.0334 c. All the readings change to track the slower ship on a longer mission to Lacaille 9352, which moves further away during this longer voyage.



And the mission duration for the slower Starship is also longer and not much of a time shift between Earth and Ship due to the slower speed.

4. Mission Types

Rendezvous

Acceleration and equivalent Deceleration legs with a possible Coasting leg.

Fly-By

Acceleration with a possible Coasting leg. Fly-by destination is at top speed or as near as possible to top speed, depending on the time to top speed.

Cannot catch fast moving Destination

Ship speed is not sufficient to rendezvous or Fly-by destination due to destination's speed.

Hit a moving target problem

Details of the ship's acceleration, deceleration and top speed gives you a total mission time, but the first mission iteration is just an estimate. It cannot be accurate because by the time it takes to make this journey, the Destination star will have moved to a new position that is also either closer or further away. The Starship will need less or more time to make the journey.

Solving the "Hit a moving target problem", using mission iterations only applies to stars where their Proper Motion is known or with a rendezvous with another Starship B.

The MP Navigator makes 5 mission iterations to resolve this "Hit a moving target" problem down to a much smaller percent of error, usually less than 0.001%.

Stellar Proper Motion is known, fairly accurately, for stars up to about 40 light years away. After that the accuracy drops to about + - 10%. This has been improved buy Milky Way surveys recently. Usually, the measurement of exact distance is our current weakest link to accuracy for interstellar missions.

5. Mission Legs

- Acceleration leg - Start to full speed
- Coasting leg at full speed
- Deceleration leg - Top speed to relative stop

You may click a Ship Type button or enters in the Top speed and time to top speed. From this, we can find:

- The acceleration slope
- Where the Starship is at different points in the acceleration leg

This allows us to compare the Starship's location with nearby star locations.

Acceleration leg

Acceleration leg Top speed and Time to top speed is entered by you or with a preset Ship Type. Let's say Top speed is 0.5 c and Time to top speed is 300 days. Let's assume a constant, smooth acceleration.

Finding how far the Starship will travel during the acceleration leg is pretty straight forward.

```
½ top speed * duration = distance
```

But, pinpointing the Starship's location at specific slice points is a little more involved, because the ship is constantly speeding up.

1st Slice

For example, let's divide the 300 day acceleration leg into 10 equal slices of 30 days each. We know the top speed at the end of the acceleration is 0.5 light speed. So what happens in the first slice? .

What part of the year is a 30 day slice?

```
30 / 365.25 (Julian year) = 0.0821355
```

Assuming uniform acceleration, (we don't have to worry about shifting gears.) The first 30 days, gets us to 10% of the top speed 0.5c by the end point of the first slice.

```
0.5c * 10% = 0.05c
```

To find the distance traveled in this slice, we next find the average speed for that slice:

```
0.05c / 2 = 0.025c
```

Then multiple this average by the distance traveled.

```
0.025c * 0.0821355 = 0.002533 light years
```

2nd Slice

The next slice, you start at speed 0.05 and reach 0.1 by the end which means your average is .075. The next slice is still 30 days long or .0821355 of a year.

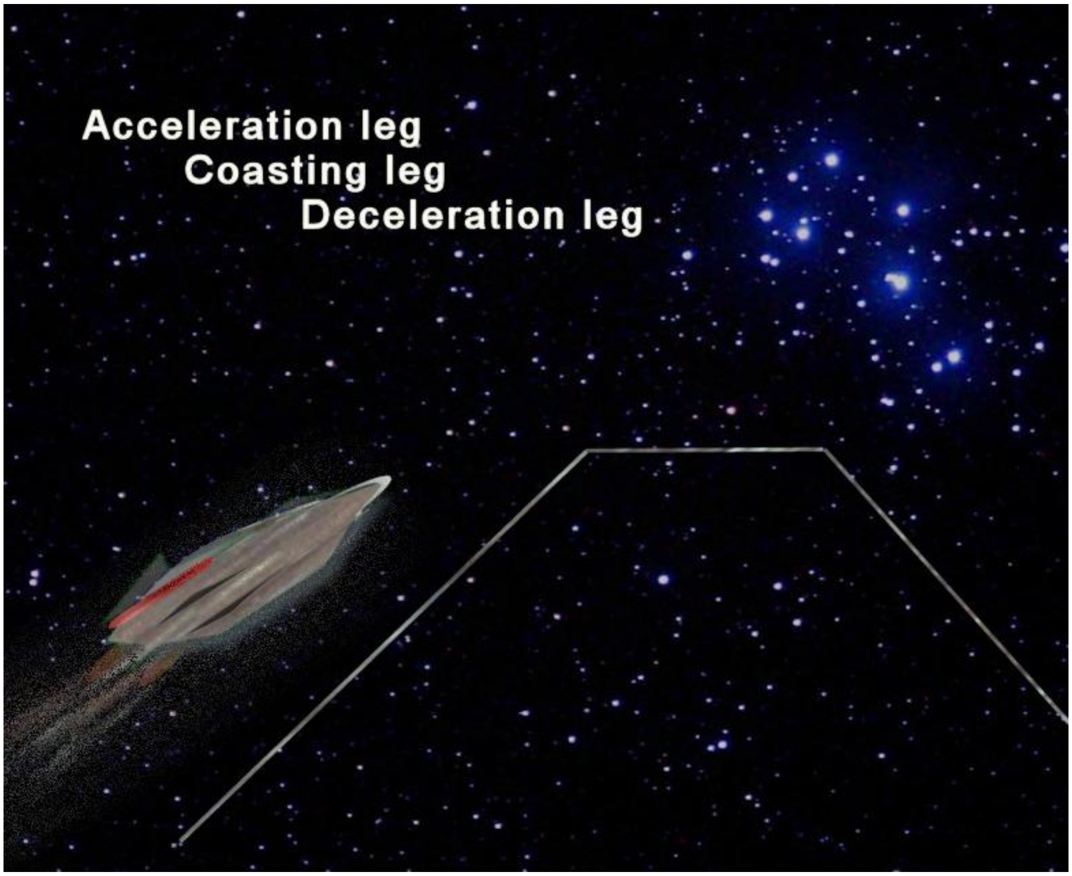
In the second slice of 30 days (days 30 to 60), the distance traveled is:

```
0.075c * 0.0821355 = 0.0061601625 light years
```

Our speed is picking up. Total distance traveled is the sum of the two:

```
0.002533 + 0.0061601625 = 0.0086931625 light year
```

This type of slice math is important to find the exact position of the Starship at the mission slice points.



Coasting leg

Top speed of the Starship during the coasting leg is the easiest leg to track. It's simply

```
Speed * Slice Duration (Earth time) = Distance.
```

Deceleration leg

The opposite of acceleration, so all the same math applies.

Issues with long missions

Long missions with normal Starship Types should work well with the following issues:

A. **For every 10,000 years mission duration**, nearby stars will experience about a 7.4 second arc of their galactic orbit. In our local area, inside the Orion Spur, this would cause a distance shift toward the center of the galaxy and the direction of our galactic orbit:

- ✓ Galactic X = 0.00000084 = (Earth Polar coordinates) : In the direction of our Galactic Orbit which is: 11 hours 45 minutes 6 seconds, declination 0 degrees, 26 minutes

- ✓ Galactic Y = -0.00000084 = (Earth Polar coordinates) : In the direction of the Galactic Center which is: RA 17 hours 45 minutes 6 seconds, declination -28 degrees, 56 minutes

(This small shift is about 120,000 times smaller in a 10,000 year mission, than our weakest link measurement of stellar distances. In other words, if we improve our accuracy in stellar distances by 120,000 fold, then this galactic orbit deviation will have some meaning. Until then, it does not really matter.)

Being a galactic orbit, this deviation will constantly change according to orbital math. We do not know the precise nature of our galactic orbit. It will probably get us back in approximately the same galactic location after one galactic year of about 290 million years. These deviations are ignored by the MP Navigator. An alert will appear if the mission exceeds 10,000 years.

B. **Mission with very long time to top speed** will have some inaccuracies because:

I. If the Time to top speed exceeds 50% of the mission for rendezvous type missions, the MP Navigator will auto truncate the top speed to whatever is reached at the Mid-point and start immediate to decelerate to allow a rendezvous with the Destination star. Since there are 5 mission iterations to adjust for a moving Destination star, the value of the Mid-point top speed needs to be adjusted, five times, as well. There is an auto adjustment formulae that kicks in when this happens. These type of rendezvous missions with extremely long times to top speed will get a warning alert next to the “Time to top speed” entry.

II. Mission with many years to top speed or slower Ship Types can have a Starship that moves too slowly to catch stars that have high Proper Motion. Barnard’s Star is the current speedster, locally. Attempting a mission to rendezvous with this star can fail with long accelerations or slow engine types. When this happens, an alert warning appears in the top center Mission Profile readout under the Ship Type.

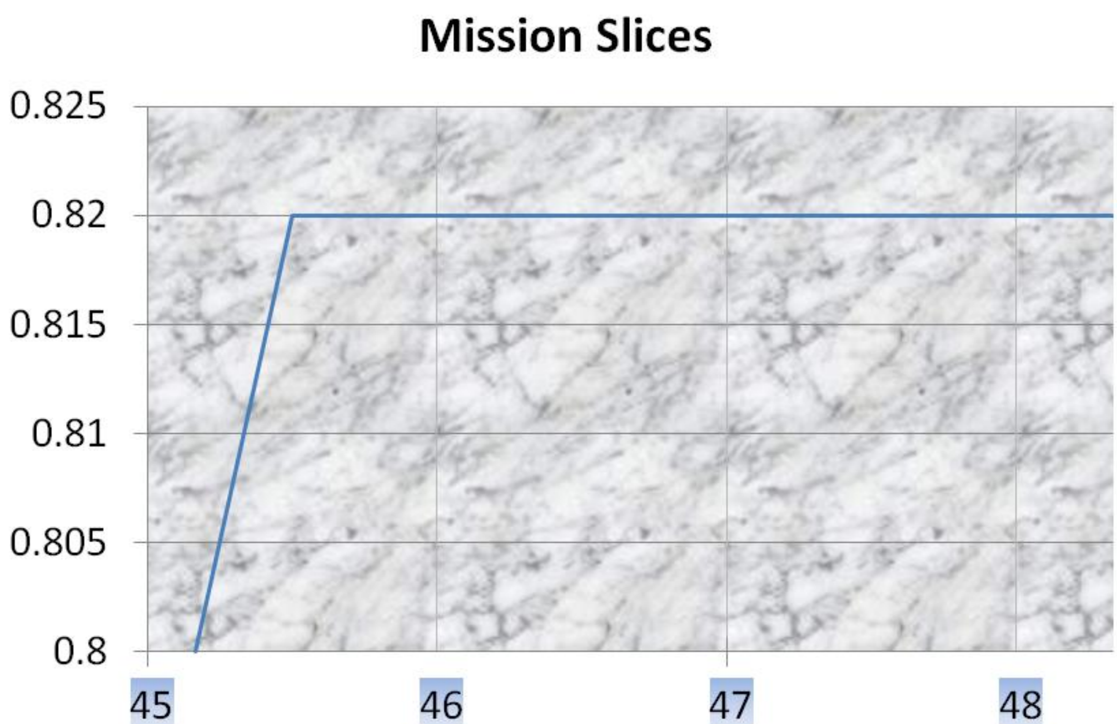
6. Mission Slices

In order to find the distance between the Starship and nearby stars, we need to find the Starships exact positions at different points in the mission. Let's look closer at how to make precise measurements, as accurate as possible.

The Mission Profile Navigator divides the mission into 200 slices of equal Earth Time. The previous chapter shows some of the math needed to find the Starship's location in the acceleration leg.

Special case Slice problem

The last part of an acceleration leg has an unusual problem. The entire Acceleration and Coasting legs are different lengths of time. Dividing them into equal slices that fall exactly on the end of each leg is not possible. There is always going to be some slice where the Starship changes speed in the middle of a slice.



If we used thousands of slices, this problem would diminish to such a small amount that it could be ignored. But using 200 slices, we have to deal with it. The last acceleration slice, (number 45 in the above example), needs to be treated differently to find how much distance is covered by the Starship. This slice has a 1st segment that is acceleration and a 2nd segment that is full coasting speed. The MP Navigator automatically finds this problem slice and adjusts it correctly for the distance it covers.

It is easier to understand if you consider it this way. The last acceleration slice will have the Starship hit top speed and continue at that speed inside the slice. This will always cover further distance than if the Starship took the whole slice to reach top speed. The last acceleration slice adjustment, always adds a little distance.

If the mission is a rendezvous type, the same math is used in reverse to treat the 1st deceleration slice.

Without this tweak for these two problem slices, the math would be off and the rendezvous would not end the mission with 0 relative velocity. The automatic adjustment works perfectly to fix finding the correct distance traveled in these two problem slices.

The formulae for the fix is in the Fly By Calculator worksheet tab and will covered in detail in Chapter 15, for all the Excel gurus who enjoy mathematical punishment.

Slice math logic:

We know:

- Exact Start Position and Destination, end of mission X, Y, Z coordinates.
- Exact distance of the mission.
- Total shift for X, Y and Z values for entire mission.
- Exact start and end speed of the Starship for each slice.
- Distance covered in each individual slice.
- Accumulated distance covered by the end of each slice.

We need to then:

- Convert accumulated distance to accumulated percent of mission covered to the end of each slice.
- Progress each Starship X, Y, and Z coordinates by that accumulated percentage of mission to get the exact Starships coordinate X,Y, Z values for each slice point.

This is not an average coordinate shift, this is a, per slice, changing value to find the new X, Y, Z coordinate for the Starship at the end of each slice point.

7. Where are the stars?

Now that we know where, precisely, the Starship will be at each slice point, how do we find exact position of each of the nearby stars at the same slice point times?

Stars move along their own galactic orbits. In a 50 year mission to the Groombridge 40 star system, the Starship might pass close to Barnard's Star, but if the Starship has a slower propulsion and takes 200 years to get to Groombridge 40, Barnard's Star may be long gone and never be in Sensor Range. A traveling star could, in the worst case scenario, cross the Starship's path on a collision course. That last bit of info seems to be rather important. To track this we have to step up the level of accuracy a lot and not just use static locations for stars.

Here is how the MP Navigator does it.

To find the Real coordinates of each star, the XYZ coordinates are progressed by Annual Shifts, which are derived from the Proper Motion of the star. There are two parts of this position adjustment for stars.

1. Slice point date difference from Epoch 2000 (January 1, 2000 – Noon in London, England)
2. Distance to the star from Earth

Remember Epoch 2000 is the standard that the star is listed in astronomical databases. This is where the star was, exactly, at that moment at the beginning of the year 2000.

So if the star like Epsilon Eridani is 10.5 light years away and our date today is July 1, 2014, the star's annual coordinate shift values: XAS, YAS and ZAS are used to progress along it's galactic orbit by (10.5+14.5) * XAS, (10.5+14.5) * YAS and (10.5+14.5) * ZAS. This finds the new Xr, Yr, Zr, real coordinates of the star which is its true location and starting point on day one, of our mission.

```
Given star XAS = 0.0000012
(10.5 + 14.5) * XAS = 0.00003
```

Wait, why do we need the adjustment for the distance from Earth, as well? The original Epoch 2000 location was apparent position of the star and not its real position, because the astronomer on Earth measured, where the star appeared to be on January 1, 2000. But the astronomer was seeing where it was in July 1989, 10.5 years before, because it takes that long for the light from the star to reach us. If we want to be accurate, we have to move Epsilon Eridani along its galactic orbit another 10.5 years of Annual Shift just to make its position real for Epoch 2000.

Now, back to our mission. For simplicity, let's make each slice last just 30 days So, for each slice, 30 days of annual shifts are added to the star's position to find the star's real location. We already know the exact location of the Starship at that slice point. (See Mission Slices above.)

Given the star's movement in X coordinate in one year is XAS = 0.0000012 light year. It moves far less for the 30 day mission slice duration.

```
30/365.25 * 0.0000012 = 0.00000009856263
```

We can also find its movement for YAS, ZAS and then add these changes up, per slice, to find the exact location of a nearby star for each 200 slice points.

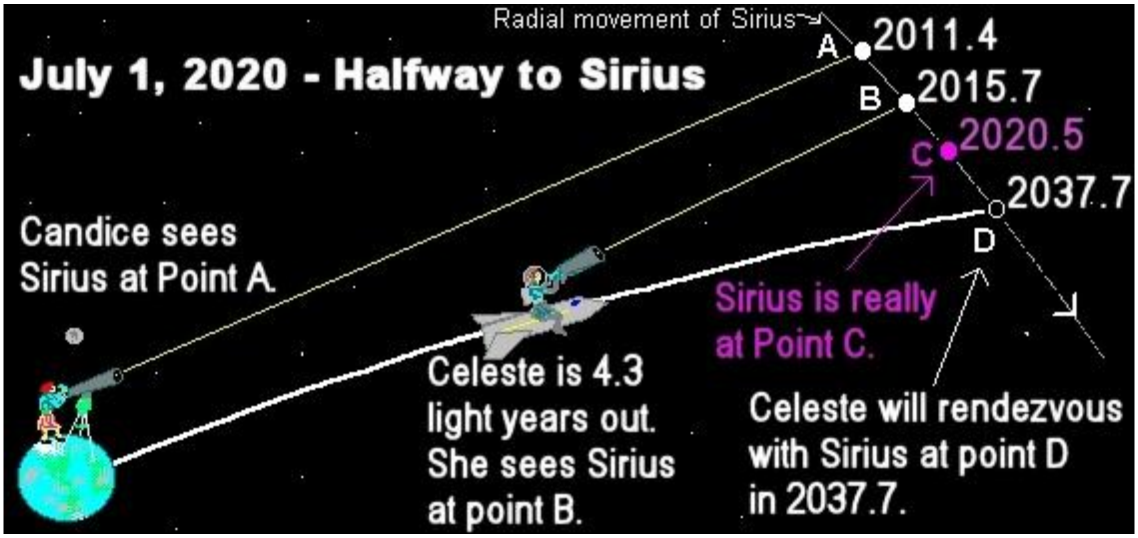
With exact coordinates for the star on each 200 slice points and exact Starship coordinates for the matching 200 slice points, we can now find the distance between the Starship and each nearby star using coordinate trigonometry 3D Pythagorean. This is just a 3D version of the Pythagorean hypotenuse length.

For each Slice Point:

$$\Delta_1 = \sqrt{(Sx-(Px+(T1(XAS))))^2} + (Sy-(Py+(T1(YAS))))^2 + (Sz-(Pz+(T1(ZAS))))^2$$

- Where distance between Ship and Star is Delta 1 (Δ_1)
- Sx, Sy, Sz are the Ships position
- Px, Py, Pz are the Epoch 2000 coordinate position of the star
- T1 is the number of years since Epoch 2000 (Jan 1, 2000 Noon GMT) to Earth time for that exact slice point.
- XAS, YAS, ZAS are the Annual Shifts in coordinates for that star's Proper Motion (given from the Stellar Dbase, found from the star's Proper Motion.)

The following illustration shows why these adjustments for distance to a destination star are important.



Halfway to Sirius

More details on how this is done in Excel are covered in:

[Chapter 15. Other Navigator worksheets – Under the Hood When is a star closest to the Starship.]

8. Sensor Report

Syncing the Starship's position with the Real Coordinates of nearby stars at all 200 Slice Points allows us to find many interesting measurements in the Sensor report;

- How close does the Starship get to a star
- When the star enters and leaves Sensor Range.
- When Sensor events happen in Earth time and Ship time, the relativistic time shift caused by the Starship's velocity.

Sort buttons can resort these nearby stars in the report.

As the mission pilot, you can set your Sensor Range in the middle Input Area. The larger the range, the more stars will pass within range. If the mission is on a slow ship and takes a long time, the stars that pass, and how close they pass will automatically change, just like in reality.

Sensor Report Notes:

Top ship speed = 0.999, Destination speed = 764.63 Km/sec

Sensor range: Years and light y

First in Sensor Range

Recalculate Sensor Report

Sort

Stars in sensor range during mission

Stellar Real coordinates are auto-shifted to adjust for years from mission start date to Epoch 2000 14.49

Ranking	Primary star	2nd star in system	Type	Alerts	Earth Years	Ship Years
1	Solar System Sol		G2V	Your Starting position is Earth	0.00	0.00
2	Draconis Psi1 Dra	Dzi	F5 IV-V		0.00	0.00
3	Boötis Kappa2	(delta scuti vari	A8 IV		0.00	0.00
4	Leporis Lambda Lep		B0.5IV		0.00	0.00
5	Pictoris Eta2 Pic		M2III var		0.00	0.00
6	Centauri Proxin	(red dwarf in Al	M5.5 V		0.00	0.00
7	Centauri Alpha	B C	G2 V		0.00	0.00
8	Piscis Aus Lac	10th nearest st	M0.5V	Destination	6.04	0.67
9	Piscis Aus Lac	(Lacaille 9352	M1.3 V	No Proper Motion data. Collision possible on close approach	6.10	0.67
10	Aquarii EZ Luyt	B C (red dwarfs	M5.5 V		8.12	0.89
11	Andromedae G	(Groombridge	M1.3V		8.46	0.93
12	Indi Epsilon Inc	(orange dwarf)	K5V		9.55	1.05
13	Sculptoris CD-3	(GL 1) (red dwa	M2.0 V		10.25	1.13
14	Microscopium L	(Lacaille 8760)	K5.5 V		10.88	1.20
15	Ursae Majoris H	b Jupiter sized	K4		Never	Never
16	Ophiuchi Barna	(fastest stellar	M3.8 V		Never	Never

Sorted by Distance at mission start

Sensor range: Years and light years

First in Sensor Range		Closest approach to star or rendezvous Starship B			Last in Sensor Range		Ship Time within Range	Distance at mission start	
Sort		Sort	Sort		Sort		Sort	Sort	
Earth Years	Ship Years	Light Years	Earth Years	Ship Years	Earth Years	Ship Years	Ship Years	Light Years	
0.00	0.00	0.00	0.00	0.00	5.41	0.60	0.60	0.00	Very close
0.00	0.00	0.00	0.00	0.00	5.41	0.60	0.60	0.00	Mid Range
0.00	0.00	0.00	0.00	0.00	5.41	0.60	0.60	0.00	Edge Range
0.00	0.00	0.61	0.00	0.00	5.64	0.62	0.62	0.61	Out of Range
0.00	0.00	0.60	0.69	0.08	5.64	0.62	0.62	0.67	
0.00	0.00	4.07	1.61	0.18	4.49	0.49	0.49	4.24	
0.00	0.00	4.20	1.61	0.18	4.32	0.48	0.48	4.36	
6.04	0.67	0.00	11.51	1.27	11.51	1.27	0.60	10.68	
6.10	0.67	0.06	11.51	1.27	11.51	1.27	0.60	10.74	
8.12	0.89	4.13	10.99	1.21	11.45	1.26	0.37	11.30	
8.46	0.93	4.46	10.76	1.18	11.45	1.26	0.33	11.25	
9.55	1.05	4.70	11.51	1.27	11.51	1.27	0.22	11.83	
10.25	1.13	4.34	11.51	1.27	11.51	1.27	0.14	14.22	
10.88	1.20	4.94	11.51	1.27	11.51	1.27	0.07	12.87	
Never	Never	Out of range			Never	Never	0.00	5.87	
Never	Never	Out of range			Never	Never	0.00	5.93	

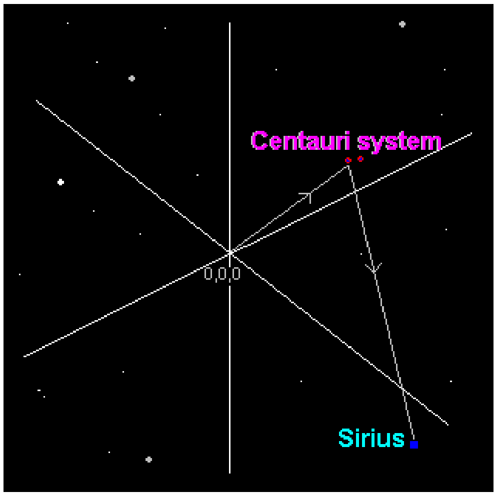
Sorted by Closest approach in Light Years

Sensor range: Years and light years

First in Sensor Range		Closest approach to star or rendezvous Starship B			Last in Sensor Range		Ship Time within Range	Distance at mission start	
Sort		Sort	Sort		Sort		Sort	Sort	
Earth Years	Ship Years	Light Years	Earth Years	Ship Years	Earth Years	Ship Years	Ship Years	Light Years	
6.04	0.67	0.00	11.51	1.27	11.51	1.27	0.60	10.68	Very close
0.00	0.00	0.00	0.00	0.00	5.41	0.60	0.60	0.00	Mid Range
0.00	0.00	0.00	0.00	0.00	5.41	0.60	0.60	0.00	Edge Range
0.00	0.00	0.00	0.00	0.00	5.41	0.60	0.60	0.00	Out of Range
6.10	0.67	0.06	11.51	1.27	11.51	1.27	0.60	10.74	
0.00	0.00	0.60	0.69	0.08	5.64	0.62	0.62	0.67	
0.00	0.00	0.61	0.00	0.00	5.64	0.62	0.62	0.61	
0.00	0.00	4.07	1.61	0.18	4.49	0.49	0.49	4.24	
8.12	0.89	4.13	10.99	1.21	11.45	1.26	0.37	11.30	
0.00	0.00	4.20	1.61	0.18	4.32	0.48	0.48	4.36	
10.25	1.13	4.34	11.51	1.27	11.51	1.27	0.14	14.22	
8.46	0.93	4.46	10.76	1.18	11.45	1.26	0.33	11.25	
9.55	1.05	4.70	11.51	1.27	11.51	1.27	0.22	11.83	
10.88	1.20	4.94	11.51	1.27	11.51	1.27	0.07	12.87	
Never	Never	Out of range			Never	Never	0.00	5.87	

9. Course Headings

Earth Polar vs. Galactic Polar



Earth polar is different from galactic polar. Earth polar puts Polaris as the North Star. Galactic polar, however, would be straight up, at a right angle to the galactic plane which runs to the center of our Milky Way Galaxy. Galactic polar happens to be about 27 degrees off of Earth Polar in a particular part of the sky, not near any bright star. The closest star to galactic Polar is 14 Comae Berenices. Galactic polar is at approximately Right ascension 12h 49m, declination +27°.4.

Using galactic polar would make sense because we could set Z positive to aim straight up, out of the Galaxy and 0 RA or Y -, could be directly at the galactic center Then, the XY plane would be along the Galactic Plane. However, for our needs, we don't need this. Earth Polar gives the same accuracy for all the mission profile data, sensor range, travel time, etc. And staying on Earth Polar, allows you to enter into the MP Navigator with the "Use RA" button, the Earth Polar based Right Ascension, declination, values that all astronomers use. So, for the sake of one less complicated transformation, I've left the Stellar Dbase in Earth Polar.

Standard declination changed for MP Navigator use

Declination is normally set to 0 at Earth's equator, rising to 90 degree to the North Pole and –90 degrees to the South Pole. While that helps for Earth dwellers, I find that it causes unnecessary confusion by introducing negative values into a course heading when you are on an interstellar mission. I've changed the convention for MP Navigator Course Headings, for this project to 0 degrees as North to Polaris and 180 degrees as South to the Southern Cross.

Right Ascension hours changed to degrees

The Right Ascension that divides the sky rising to the right if you are standing in the Northern hemisphere, facing north and waving your arm to the right. Staying with Earth Polar coordinates, I simply translate 24 hours to 360 degrees.

MP Navigator Course headings converted back to standard RA, dec

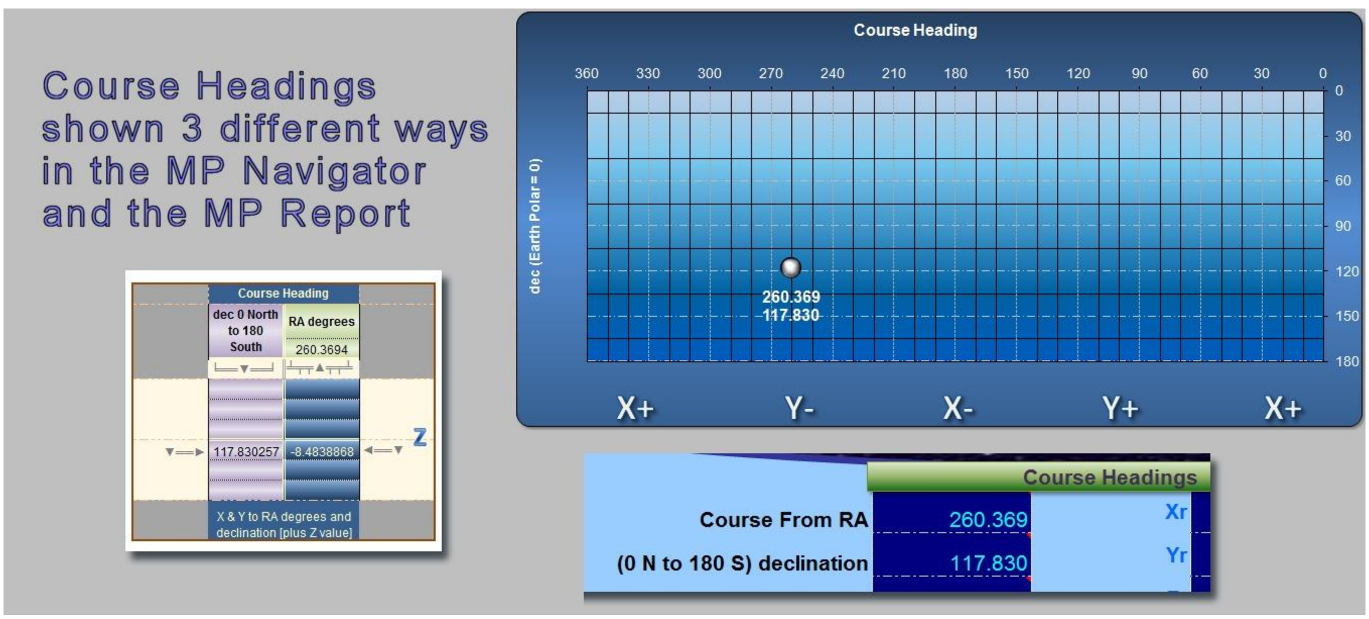
A course heading for the MP Navigator of RA 120 degrees, declination 110 into traditional Right Ascension and declination Earth Polar is:

```
120 * 24 / 360 = Right Ascension 8 hours
90 - 110 = -30 declination
```

Course headings between two stars

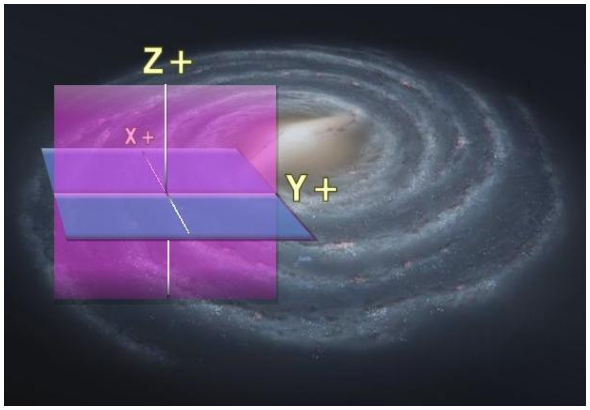
Course headings work, no matter if the Start Position is our Solar System, or some other star, or even a mid-space location. The MP Navigator takes the coordinates of the Start Position, compares them to the Destination coordinates and pulls the Course Heading from the difference. The math is a little more complex to adjust correctly in case the mission passes from a positive coordinate value to a negative or vice versa. The math looks at the change in values to correctly adjust the course heading.

Course headings are presented three different ways in the MP Navigator and the MP Report.



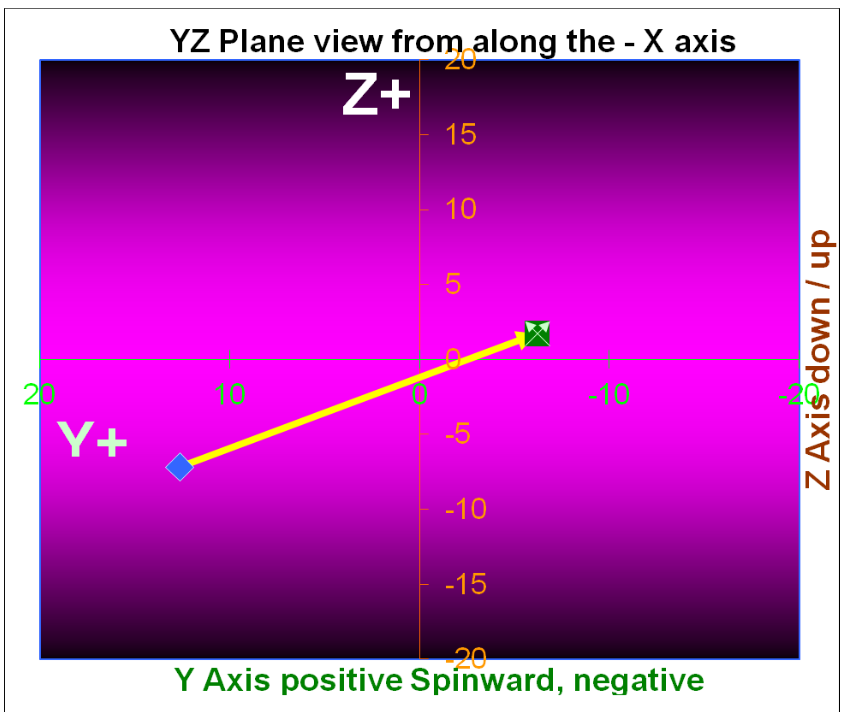
10. Mission Graphs and Charts – In Detail

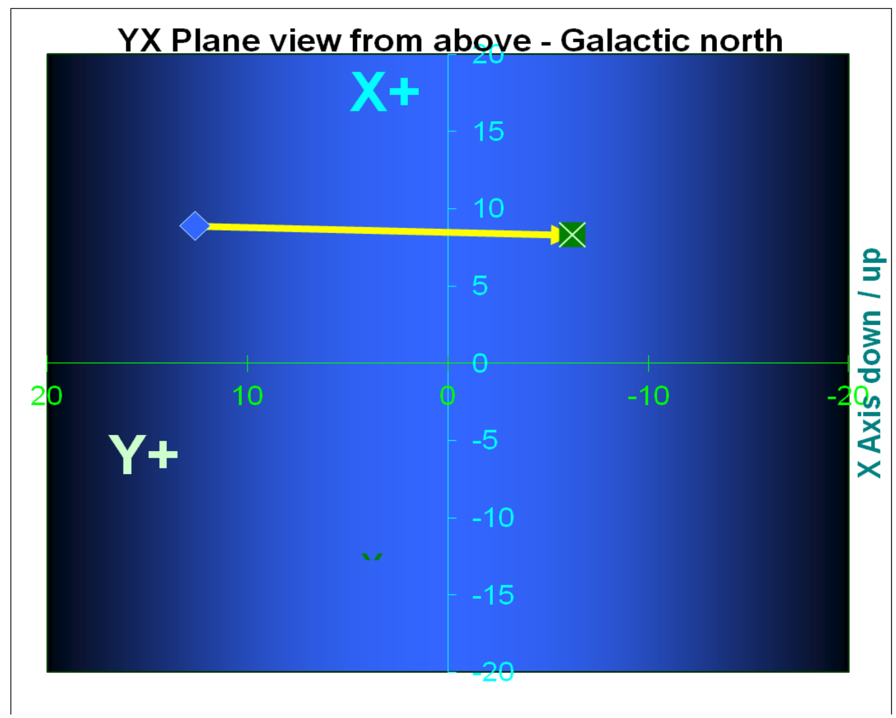
The Mission Planes Charts



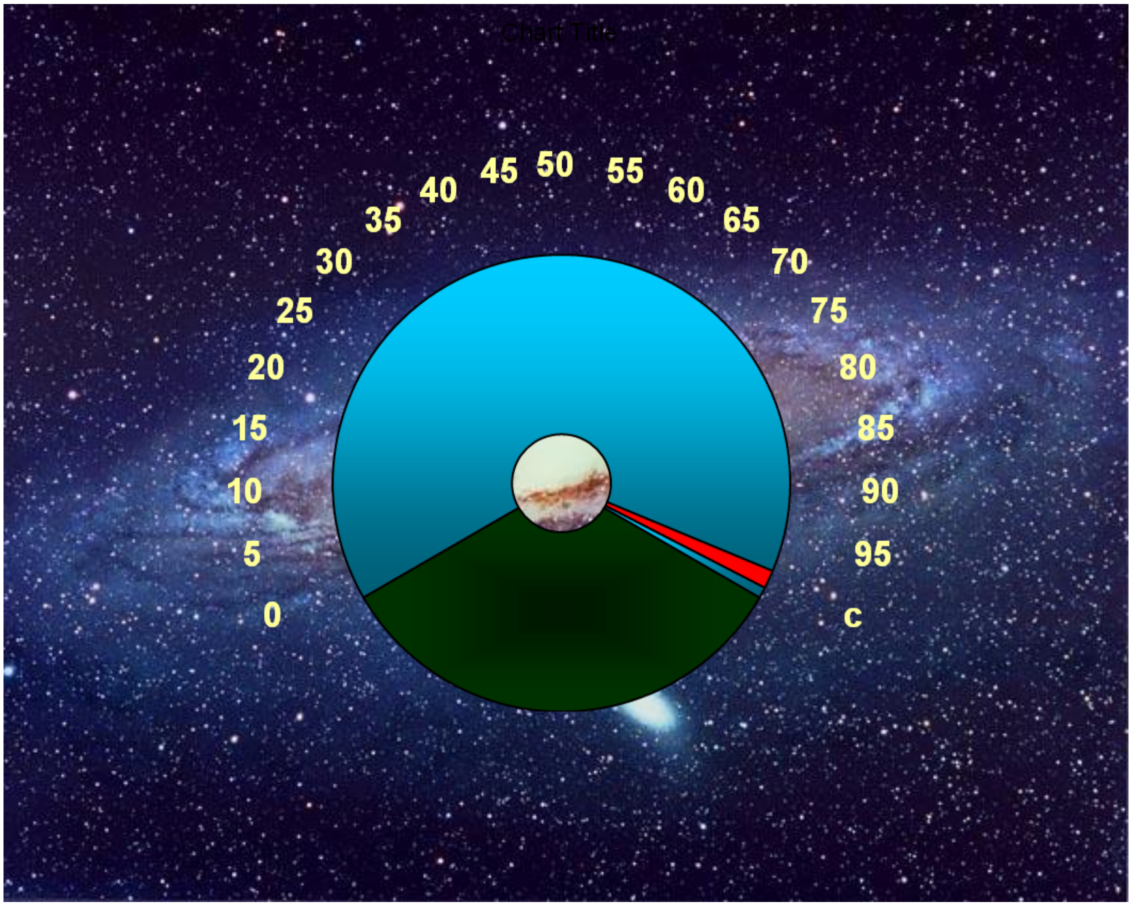
XY Plane and YZ plane are shown. Our Solar System (Sol) is always where the axis intersects.

Try thinking of the blue plane as looking down at a pond of water from above, and the purple plane to be just under the surface looking forward.





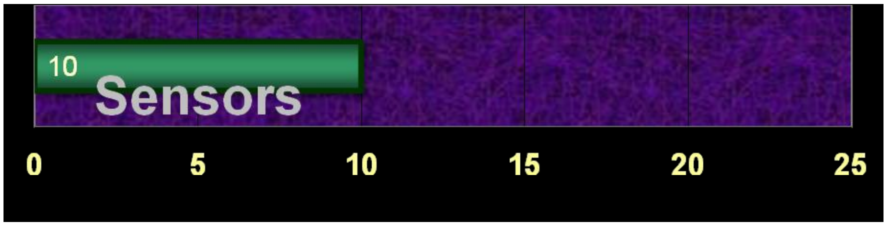
Speedometer graph



Both speed and Sensor Range are controlled by user input. Starship Types and Warp speeds buttons automatically update the speed. Speeds using realistic physics of slower than light speed are measured in percent of light speed (c). Any speeds faster than light shows an alert that the speed is FTL and the matching warp factor from Star Trek appears.

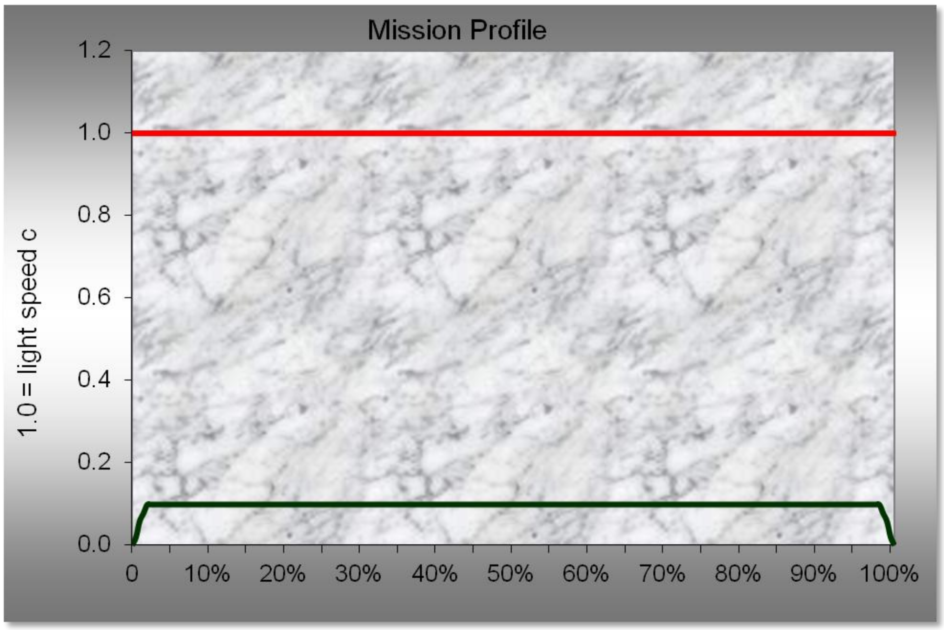
Sensor range value, set by you, adjusts the light year range that the Fly-by sensor seeks for nearby stars.

Sensor Range graph



The Mission Profile graph

Rendezvous mission with 0.1 c top speed. Y Axis is speed which has a red line for the speed of light (c). Percent of mission duration is the X Axis



Review of Mission types used to adjust formulae by the MP Navigator:

Fly By missions types

1 Normal Fly by, Top speed is achieved in 1st half of mission

3 Fly by with extended Time to top speed reached in 2nd half of mission

5 Fly by where “Time to top speed” is longer than entire mission

Rendezvous mission types

2 Normal Rendezvous where top speed is achieved in 1st half of mission. Coasting leg occurs almost always unless top speed is exactly at mission mid-point

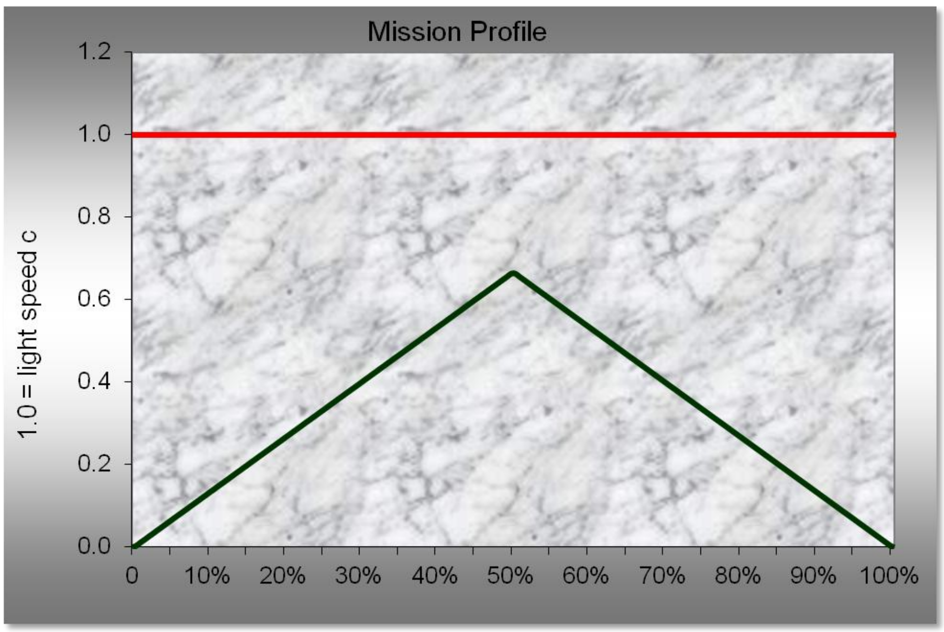
4 Rendezvous where “Time to top speed” exceeds 1st half of mission. Top speed is not reached. Auto deceleration at slower speed happens.

Cannot catch Destination

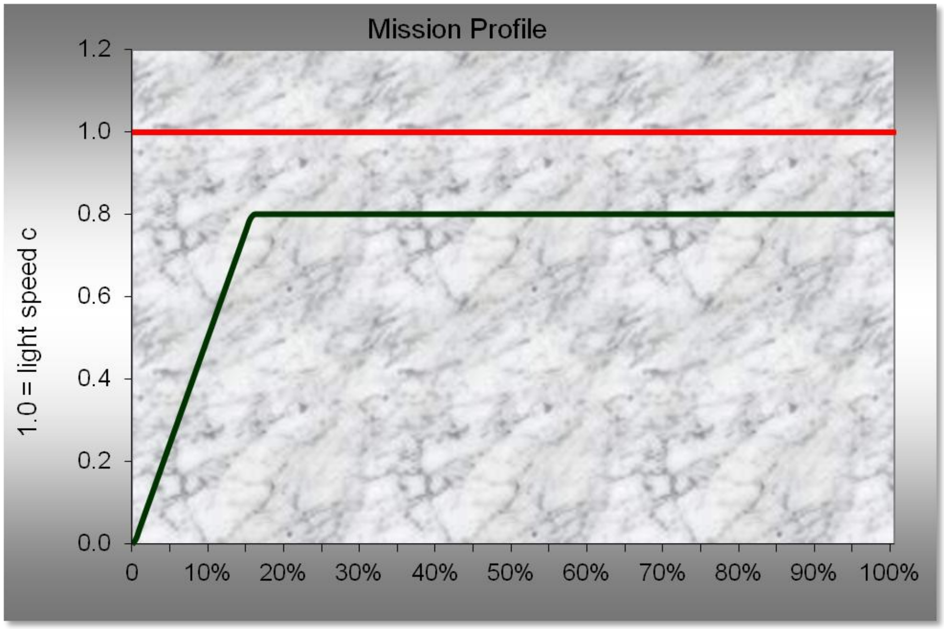
6 Destination travels at a speed, greater than Starships top speed. Rendezvous or Fly by is not possible.

Example graphs

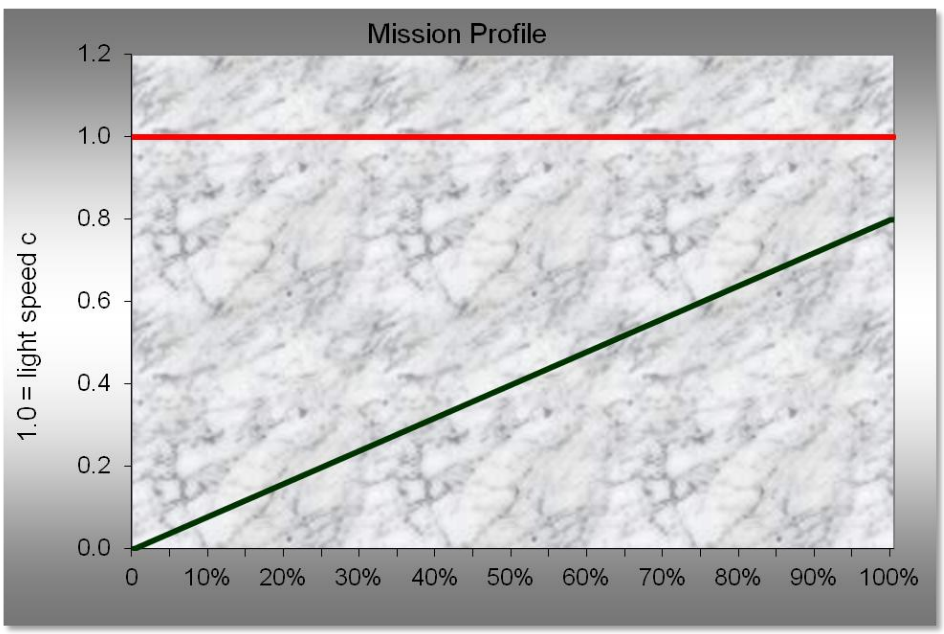
Rendezvous Type 4 top speed requested, but not achieved because the missions Mid-point is reached first. An alert in the Mission Profile read out informs you of this adjustment.



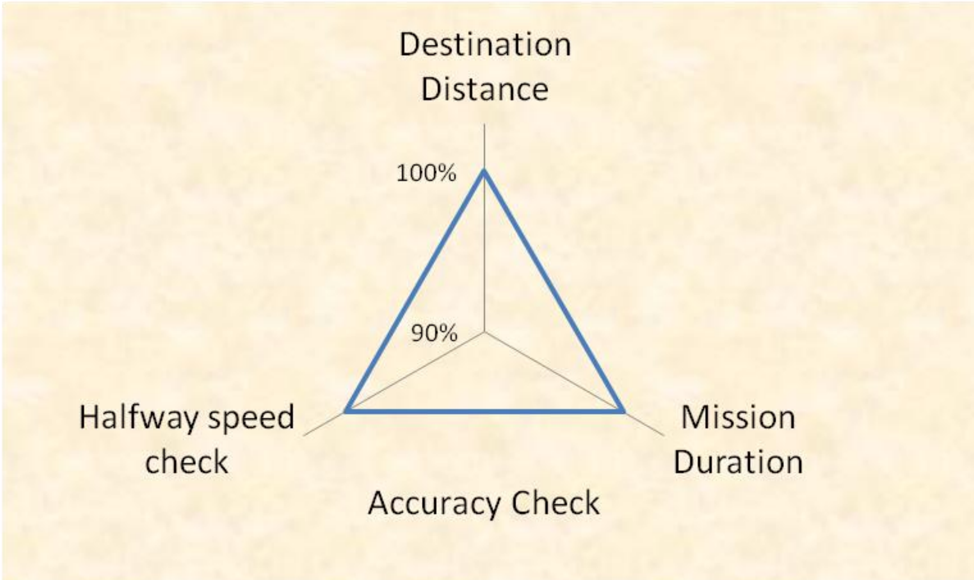
Fly by Type 1 (Normal) where requested top speed 0.8 c is reached in the first half of the mission.



Fly-by Type 5 where top speed of 0.9c is not quite reached by end of mission. . An alert in the Mission Profile read out informs you of this mission failing to reach top speed.



The Accuracy Triangle graph

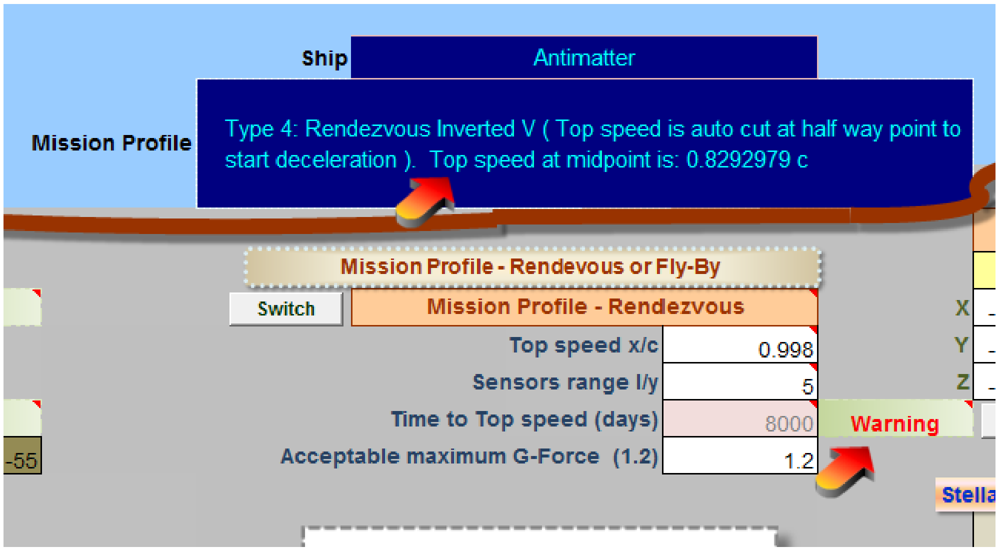


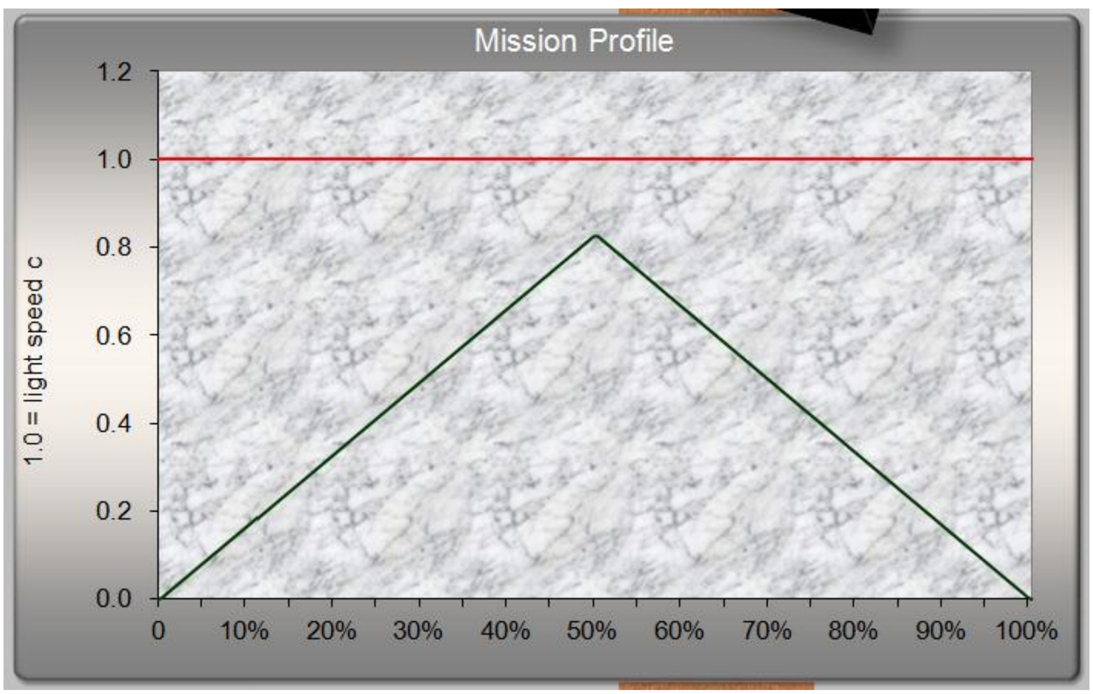
Three cross check accuracy values are tracked. The triangle top is expected distance vs. Fly-by Chart totaled distance, bottom right is expected duration vs. Fly-by Chart totaled duration and bottom left is user top speed entry vs. actual mid-point Fly-By Chart mid-point top speed achieved.

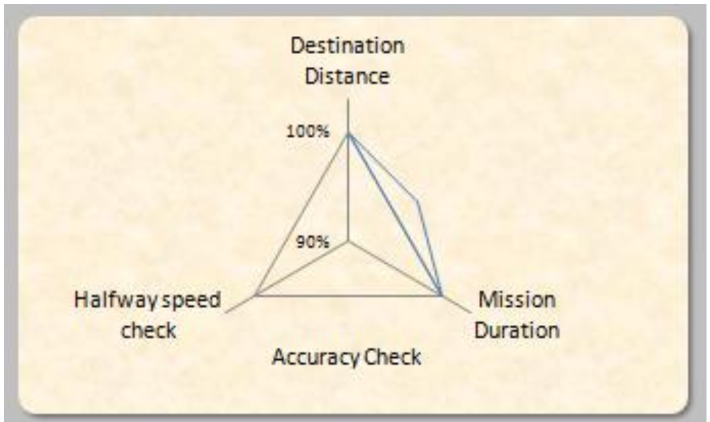
Very long “Time to top speed” – Auto correction for Rendezvous missions

The Top speed accuracy can deviate from 100% for a Rendezvous Mission Type 4, if you pick a very long Time to top speed, past the mission mid-point. If this happens, the MP Navigator automatically truncates the top speed at mid-point and immediately starts deceleration. This allows the Starship to rendezvous with the destination at 0, relative velocity. When this type of mission happens, an alert appears in the Mission Profile readout that the top speed has not been reached. The Triangle Accuracy Graph will also show this deviation.

Example: A fast Antimatter ship with a long, 8000 day, Time to top speed can result in the top speed not being reached before the mid-point of a rendezvous mission between two stars 18 light years apart. When this happens these alerts show up:







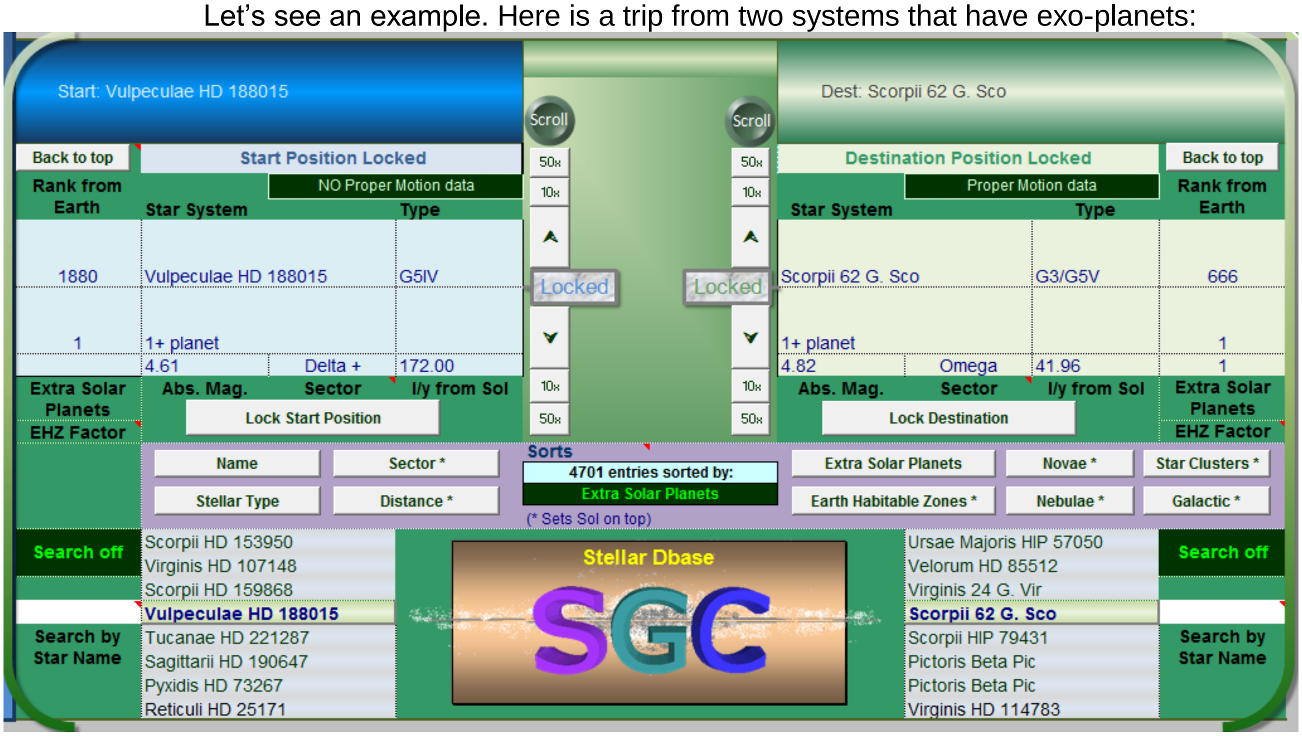
Destination Distance	100.00%
Halfway speed check	82.68%
Mission Duration	100.00%

The Accuracy Graph now shows Halfway Speed Check is only 82.68% of expected (0.998). This is due to the long time to top speed, set by you.

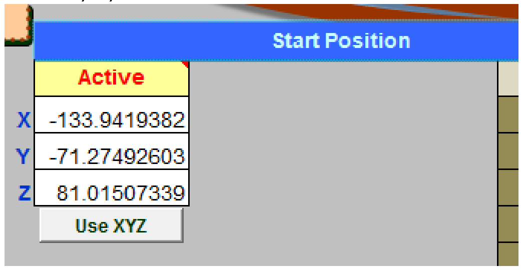
3D Sectors Charts - in detail

The 3D sector charts are auto dynamic and change axis values to match each star's location.

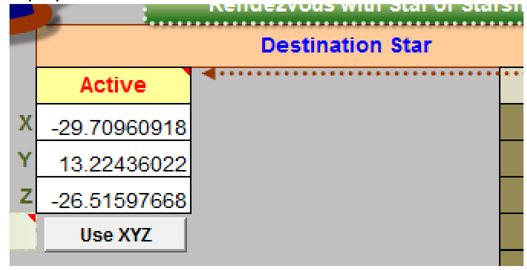
Let's see an example. Here is a trip from two systems that have exo-planets:

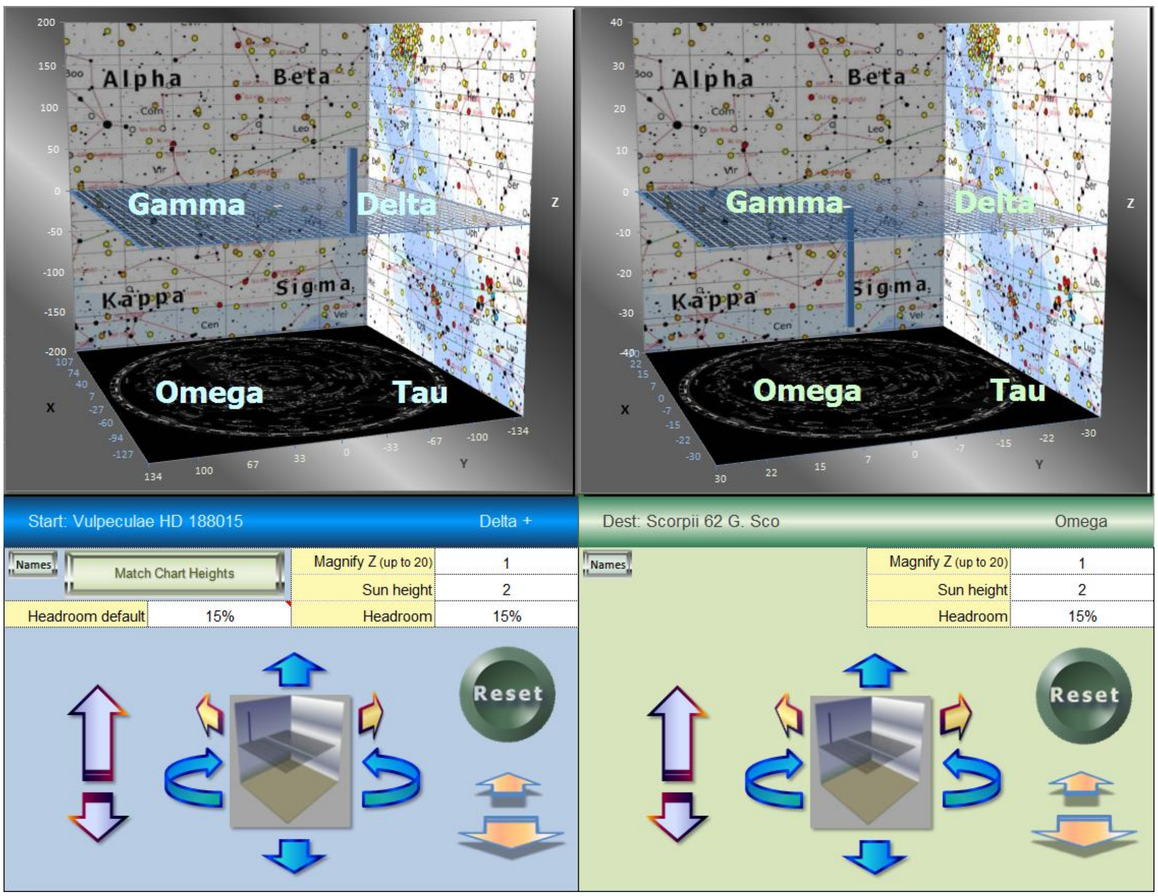


The X,Y,Z of the start:



X,Y,Z of Destination:



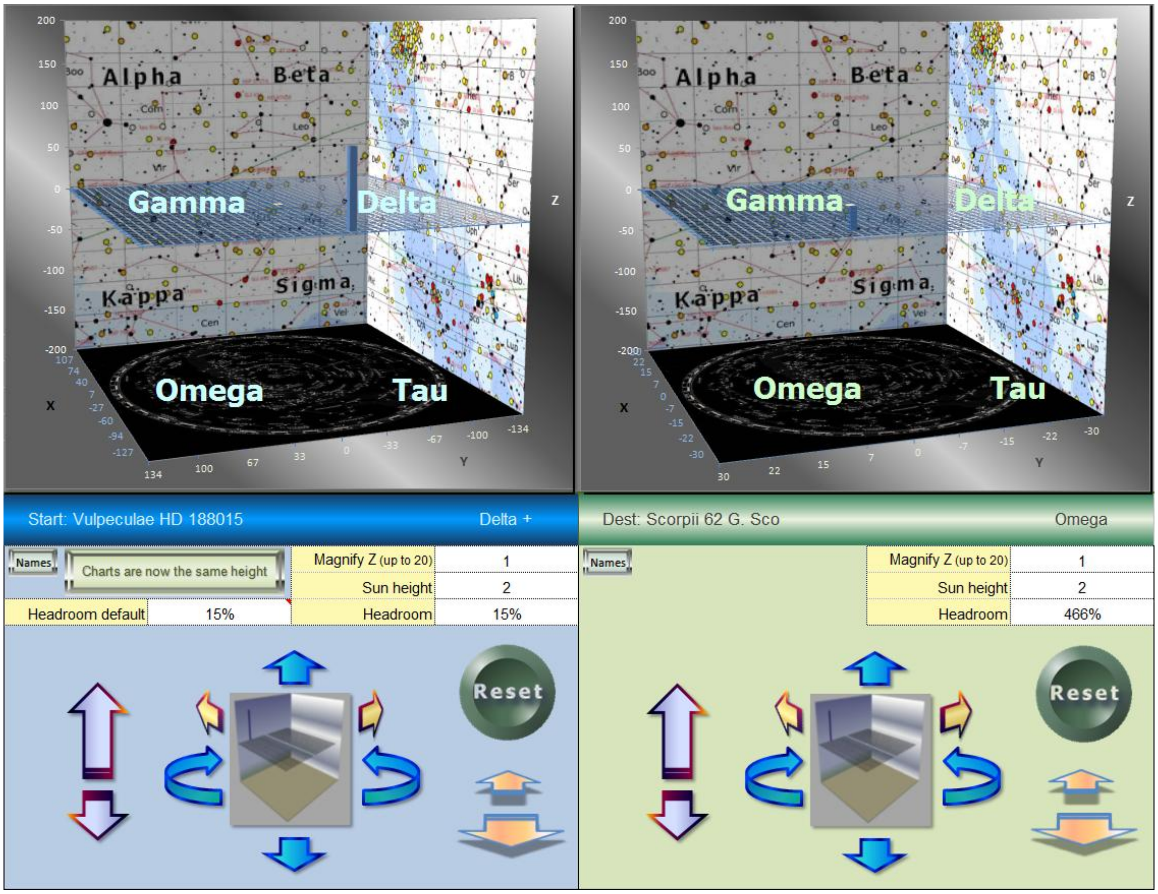


This is how the 3D Sectors first appear:

Notice that the Start Position Star, Vulpeculae HD 188015 with a Z value of 81, in the Delta + Sector. (+ means total distance from earth is greater than 50 light years, ++ is greater than 100 ly.). The axis on The Start Position has automatically larger values to accommodate and still keep the headroom default of 15%. Headroom is the space above the largest absolute value of X, Y or Z to the top edge of the chart.

The destination star Scorpii 62G has a Z value of -26.5. Its pillar goes below the middle XY plane just into the Omega Sector.

You can leave the two 3D Sector charts mismatched in height, or you can make them both similar heights by clicking the “Match Chart Heights” button.



After clicking, the heights of both charts now match. With identical proportions, you have a better overview of the mission. The “Headroom default” value is used to set the minimum headroom and now both charts have the same Z axis height of 200 light years. The button that used to read “Match Chart Heights” becomes “Charts are now the same height”. Notice the Destination chart gets a lot more headroom and the pillar for the destination Scorpii 62G, under the mid plane is smaller and more difficult to see.

Center Axis yellow dot is our Solar System

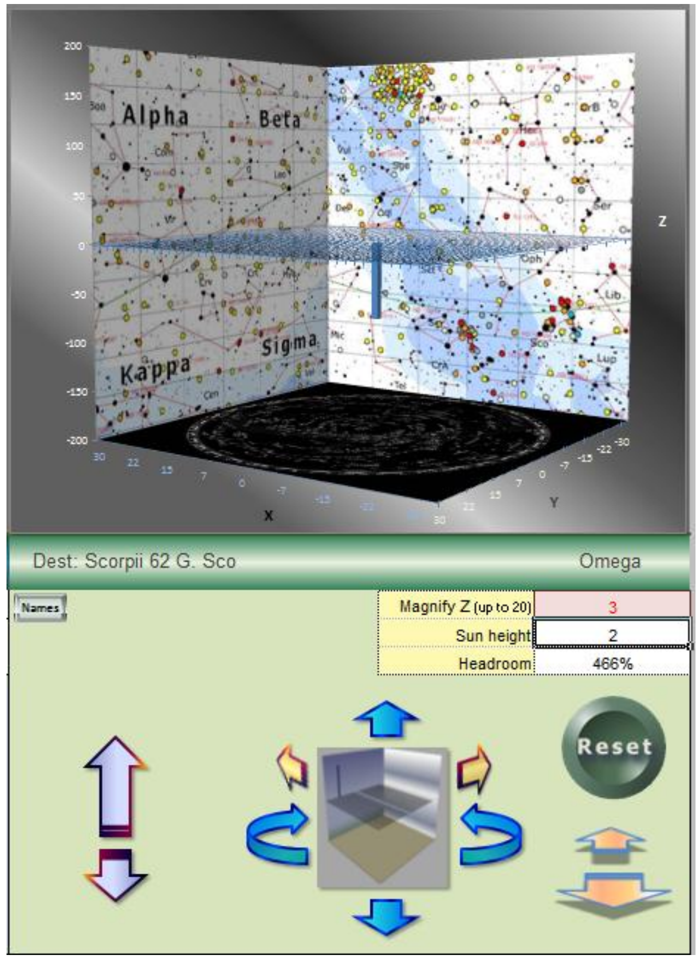
If a star happens to be directly above or below our Solar System, then that value overrides the Solar System and a center pillar for the star will appear, instead of the Sun. If the Solar System is the Start Position, then the Start 3D sector graph will not have a pillar.

Adjusting the 3D Sectors Charts

You can adjust the rotation, perspective, height, width and length of each chart. You can also turn the floating front Sector names off, Magnify Z (the height of the pillar) and increase the center yellow cube that shows the Sun’s position.

Click the Names button to remove the floating front sector names.

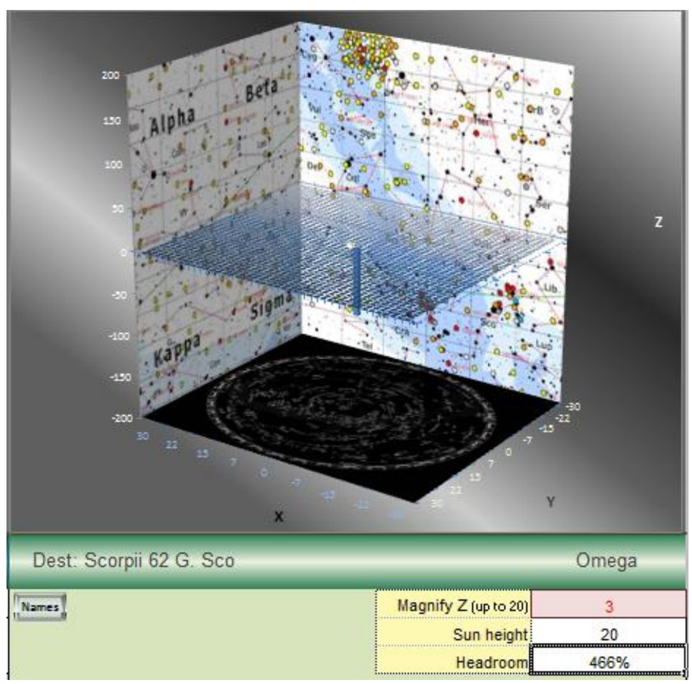
Adjust the Magnify Z value and rotate the chart with the arrows, the pillar for the star becomes more visible.



More adjustments. Adding in Sun Height and changing the depth, angle and perspective.

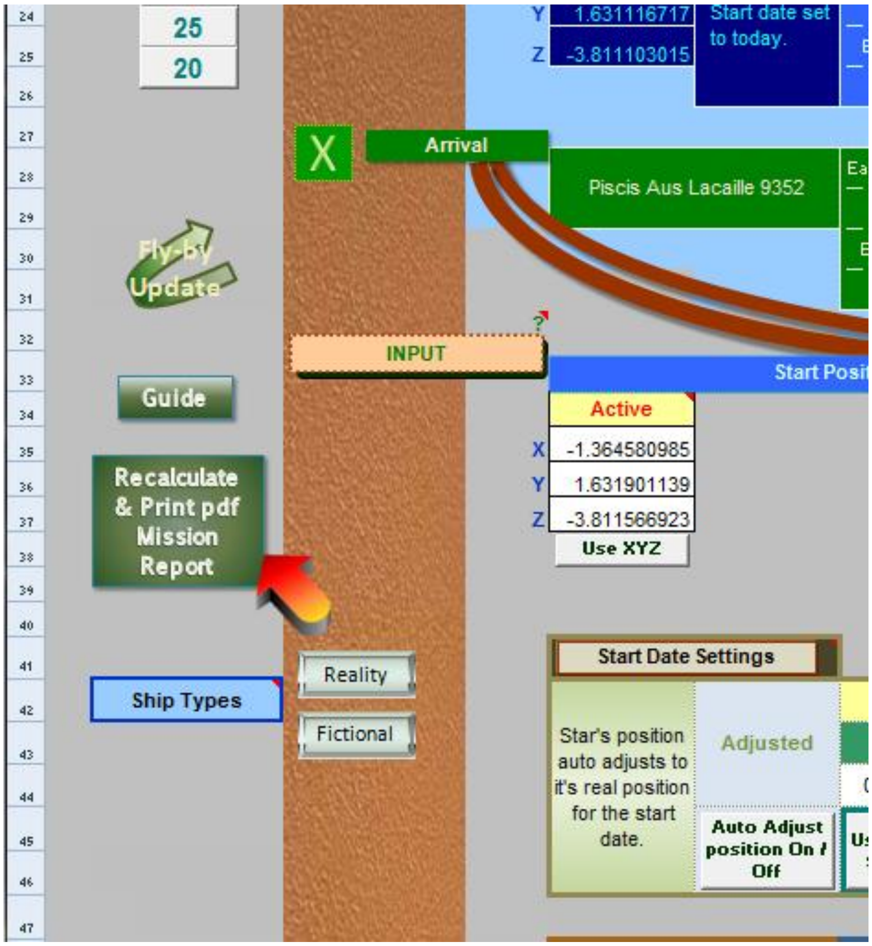
Clicking Reset brings the Chart rotation back to the default.

You still have to click the sectors names back on, and adjust Magnify Z, Sun Height to reset everything.



Mission Report - in detail

The mission report is meant to be an easily printable or save as pdf record of any mission profile. The macro button on the Main MP Navigator page, in the left column will auto update the fly-by chart and then print the mission report to a pdf file.



You need to rename the default name to match the Mission profile. Suggested names could be:

```
Wolf_359_Lacaille_9352_Antimatter_July-1-2014.pdf
```

Example report:

Interstellar Mission Profile for SGC Navigator - Report - Printable ver 1.1

Start: Leonis CN Leo Wolf 359	Dest: Piscis Aus Lacaille 9352
Mission Profile - Rendezvous	**Earth date arrival:** Wednesday, February 11, 2037
Ship Type: Antimatter	**Ship date arrival:** Sunday, October 13, 2019
Type 2: Rendezvous with a coasting leg (Top speed is reached before mid-point)	

Start Position:				Start Date:	30-June-2014	
Star System				Earth Polar		
Primary Star:	Leonis CN Leo Wolf 359				RA hours:	inactive
Type:	M6.5	Planets:	0		RA min:	inactive
Binary:	(red dwarf)				RA sec:	inactive
Type:	0				dec. degrees	inactive
Rank from Earth:	5	Abs Mag.:	13.25		dec. minutes	inactive
					dec. seconds	inactive
			Galactic SGC			
Stats		Distance l/y	Sector	X	Y	Z
Earth to Start Position:		7.84000922	Alpha	2.02898827	7.31137161	1.9730171

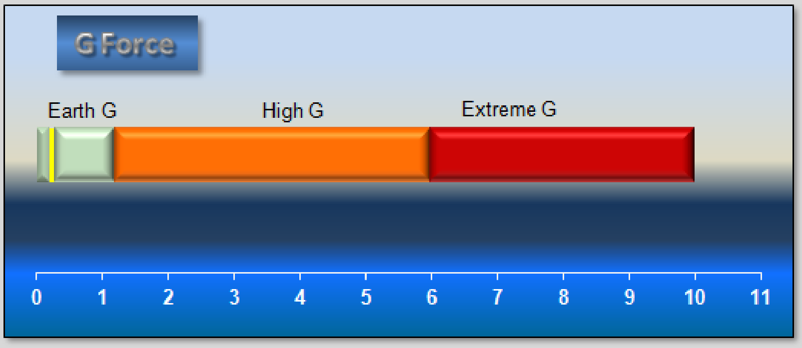
Destination:				Arrival Date (Earth time):	11-February-2037	
Star System				Earth Polar		
Primary Star:	Piscis Aus Lacaille 9352				RA hours:	inactive
Type:	M0.5V	Planets	0		RA min:	inactive
Binary:	10th nearest star system				RA sec:	inactive
Type:	0				dec. degrees	inactive
Rank from Earth	13	Abs Mag.:	9.75		dec. minutes	inactive
Course Headings SGC decimal					dec. seconds	inactive
RA: (0 <360)	255.7408924	dec: (0-180)	116.910769	Galactic SGC		
			Sector	X	Y	Z
Destination: Apparent position | Start of Mission			Tau	-2.0256615	-8.4160225	-6.2553706
Destination: Real position | Start of Mission			Tau	-1.9894499	-8.419115	-6.2621431
Destination: Real position | End of Mission			Tau	-1.9691489	-8.4208487	-6.2659399
Shifts in distances of Destination			Distance l/y	X	Y	Z
Change in Apparent vs. Real position at Start of Mission			0.03696901	-0.0362116	0.00309249	0.00677247
Change in Real positions, Start to End of Mission			0.02072571	-0.0203011	0.00173372	0.00379681
Stats		Distance l/y				
Start to Destination:		18.2035235				
Earth to Destination:		10.68		Annual shifts of Destination		
Accuracy improvement after mission profile iterations:		-0.0177428		XAS	YAS	ZAS
Notes				0.00249829	-0.0002134	-0.0004672
Sub-light velocities are within normal space physics. Warning: Your time to top speed is longer than 4.3 years. Mid-Point Mission Speed is 0.998 c. Annual Shifts are within acceptable values.				Proper Motion of Destination (if available)		
					Proper Motion	inactive
					Angle of Proper Motion	inactive
					Radial Motion km/sec	inactive

Notes:

- Destination Apparent position | Start of Mission: Position star appears from Earth.
- Real position | Start of Mission: Actual position of star adjusted for Epoch 2000 to mission start date and distance to star from Earth.
- Real Position | End of mission: Rendezvous position of star at rendezvous with Starship.
- Sectors are listed for each, but rarely change unless the star is very near a Sector border and a mission is very long.

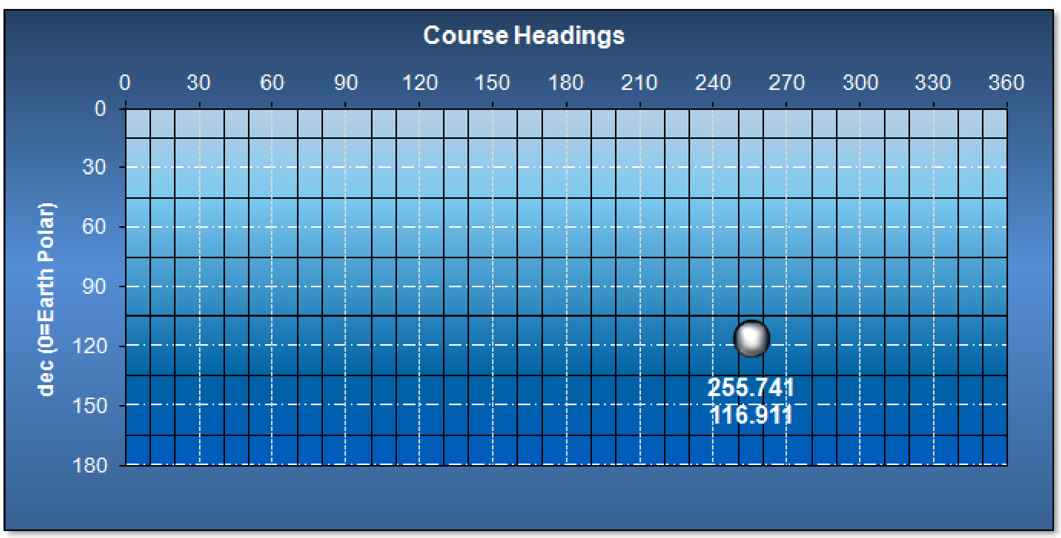
More example graphs from the Mission Report:

Mission Parameters:		
Distance traveled by Starship l/y:	18.2035235	'Use Today's Date' ON: Stellar movement based on Epoch 2000 and adjusted to today's date.
Stellar positions adjusted to start date from Epoch 2000:	Auto Adjusted	
Number of years Auto Adjusted to start date:	14.5	
Mission Start Date:	30-Jun-2014	
User input top speed (1=c):	0.998	
Actual top speed matches User input - No adjustment needed.	0.998	
Days until top speed:	1600	
G force experienced in acceleration and deceleration legs:	0.22	G-Force is acceptable for crew.

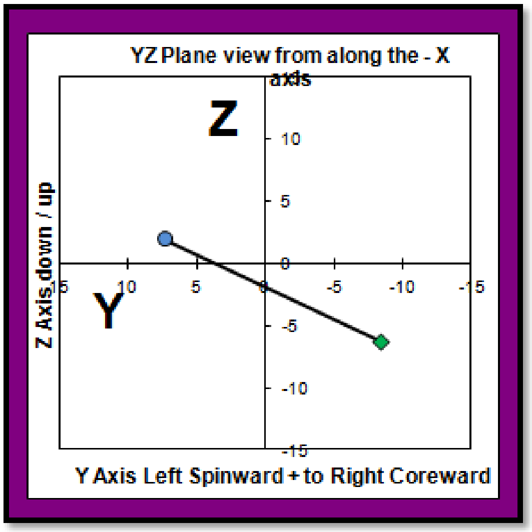


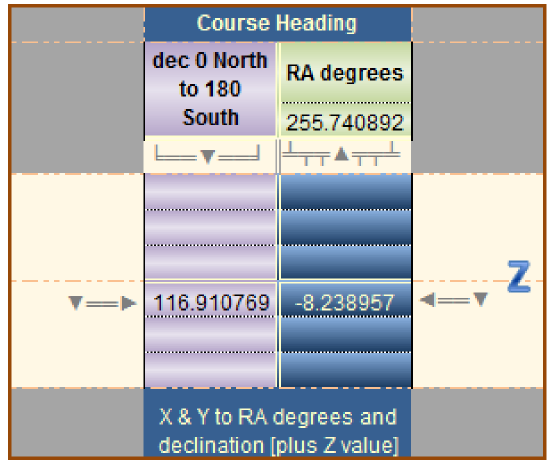
Destination Notes	Destination motion:	Total change /c	k/sec	1/c
	Towards Start position:	-3.175E-05	-9.517423	
	Destination actual speed		764.633542	0.00255054

Mission duration							
	Arrival date	Years	Days	Hours	Min	Years spent coasting:	Years to retroburn
Earth time	11-Feb-2037	22	227	16	52	13.86	18.24
Ship time	13-Oct-2019	5	104	7	5	0.88	1.15
Onboard clock runs for the coasting leg of the mission (100% = no slowing):						6.32%	
Ship time mission duration slows, compared to Earth Time:						17.3 years slower	

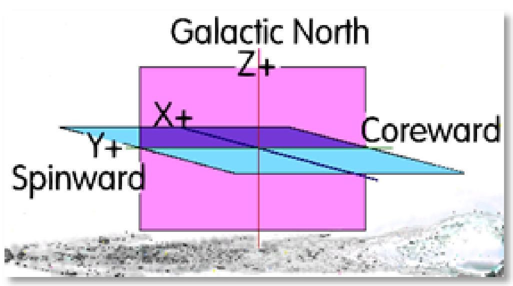


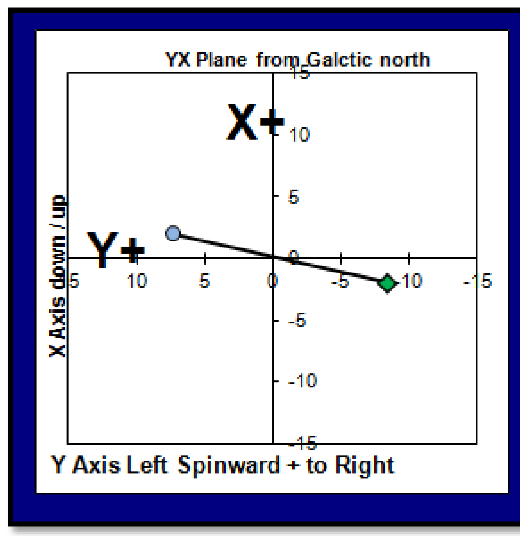
The Mission Report Course Heading dial shows only in here.





Circle = Start Position = Alpha Sector
Diamond = Destination = Tau Sector



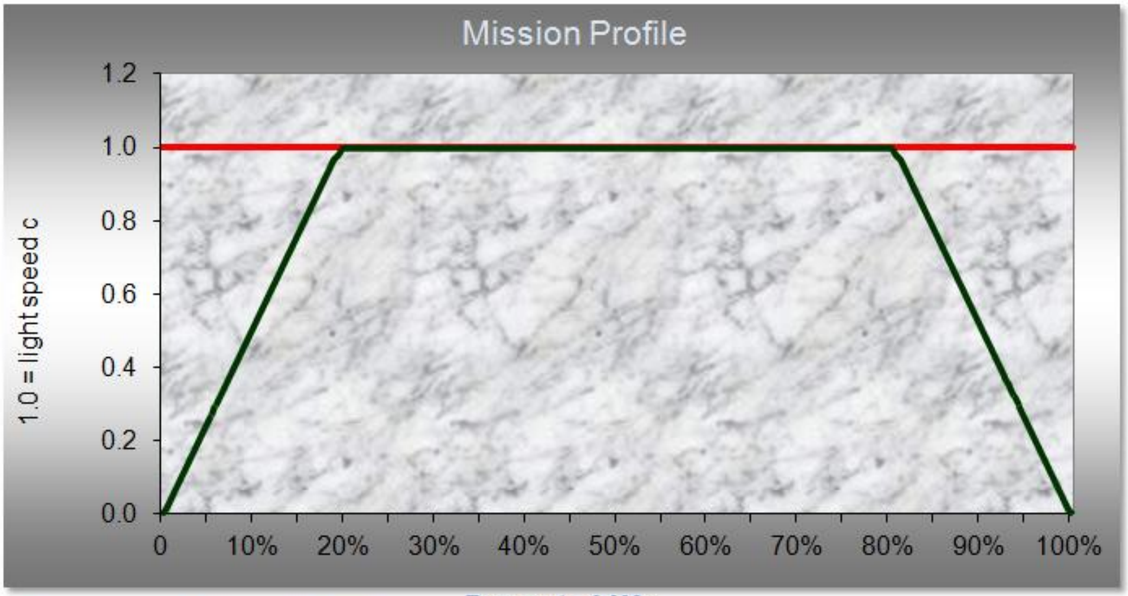


	Twin Paradox	Dialation at Top Speed 0.998
	Earth Time	**Ship Time**
	1 hour	14 minutes, 1.1 seconds
	1 day	5 hours, 1 minute
	1 month	7 days, 20 hours, 10 minutes
	1 year	85 days, 14 hours, 1 minute
	1 Way & Round Trip	
1 Way	22 years, 226 days	5 years, 104 days
Round Trip	45 years, 88 days	10 years, 208 days

Both twins start at 20 years old. After a round trip, Earthbound Alice will be 65. Space traveling, Celeste will be 30 years old. You'd better give Celeste a suspended animation bunk for her long trip or she will not be a happy camper.

The above page includes the Course Heading graph, unique to the Mission Report.

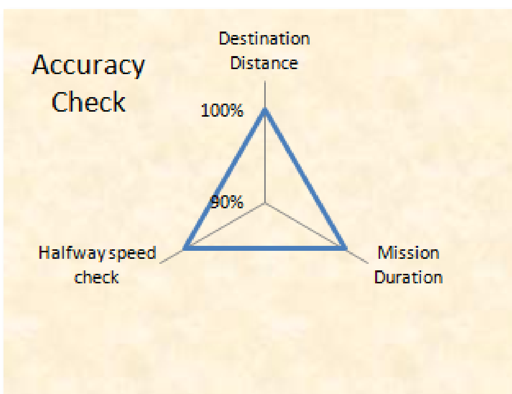
Mission Report includes Profile graph and the Accuracy Check:



Top speed = 0.998 c

Start: Leonis CN Leo Wolf 359

Dest: Piscis Aus Lacaille 9352



Accel. leg travel l/y	2.18590007
Accel. leg % mission	12.0081%
Acceleration slope	12.8343342
Years to reach first l/y	3.19228464
Coasting leg travel l/y	13.8317234
Coasting leg % mission	75.9838%
Average mission speed /c	0.80473338
Earth date arrival	Wednesday, February 11, 2037
Ship date arrival	Sunday, October 13, 2019
Destination Distance	100.0149%
Mission Duration	100.0000%
Halfway speed check	100.0000%

Data from the sensor report goes to top 28 stars in the Mission Report:

	Sensor Range Report Range 5 ly				Distance at mission start
	Star	Type	Star #2 or info	Alerts	
1	Leonis CN Leo Wolf 359	M6.5	(red dwarf)	Start Postion	0.00
2	Ursae Majoris Lalande 21185 BD+36°2147	M2.1 V	B flare star?		3.04
3	Solar System Sol	G2V			7.84
4	Draconis Psi1 Dra Dziban Adh-Dhi'ban	F5 IV-V		0	7.84
5	Boötis Kappa2 Boo	A8 IV	(delta scuti variable)	0	7.84
6	Pictoris Eta2 Pic	M2III var		0	7.98
7	Leporis Lambda Lep	B0.5IV		0	7.83
8	Centauri Proxima	M5.5 V	(red dwarf in Alpha Cen)		8.75
9	Centauri Alpha Cen Rigil KenTauri Rigil Kent Toliman	G2 V	B C		8.79
10	Piscis Aus Lacaille 9352	M0.5V	10th nearest star system	Destination	18.21
11	Piscis Aus Lacaille 9352	M1.3 V	(Lacaille 9352)	No Proper Motion data. Collision possible on	18.27
	Andromedae GQ And				

…

	First in Sensor Range		Closest Approach to Star			Last in Sensor Range		Ship time Within Range
	Ship Time	Earth Time	Distance	Earth Time	Ship Time	Earth Time	Ship Time	
1	0.00	0.00	0.00	0.00	0.00	7.46	1.74	1.74
2	0.00	0.00	3.04	0.00	0.00	5.54	1.29	1.29
3	5.09	1.19	1.68	9.84	2.30	14.48	3.38	2.19
4	5.09	1.19	1.68	9.84	2.30	14.48	3.38	2.19
5	5.09	1.19	1.68	9.84	2.30	14.48	3.38	2.19
6	5.20	1.22	1.25	10.07	2.35	14.93	3.49	2.27
7	5.32	1.24	1.08	10.07	2.35	14.82	3.46	2.22
8	6.33	1.48	2.80	10.52	2.46	14.59	3.41	1.93
9	6.33	1.48	2.97	10.52	2.46	14.48	3.38	1.90
10	15.38	3.59	0.00	22.62	5.29	22.62	5.29	1.69

11. Rendezvous with Starship B

Suppose you wish to plot a rendezvous with another fast moving Starship which leaves Star system A, en route to a Star system B. Your own Starship can start in mid-space, or in our Solar System or even at a Star system C. Where in space will Starship A and Starship B Rendezvous?

Does this sound like an impossible jumble of course plotting to figure this out? Where is my GPS?

MP Navigator can do all of these:

1. Plot Starship B's from any Start Position to any Destination or to any deep space coordinate.
2. Press the transfer button. This changes the Destination Proper Motion data to match Starship B's Course Heading and speed.
3. Pick the Start Position for your Starship A and lock it in.
4. Pick a Ship Type macro button or enter Top speed and Time to top speed for your Starship A.
5. The Mission Profile Calculator will pick the course and time to the nearest rendezvous point for Starship A and Starship B. This will be a point along Starship B's mission path or Starship's Destination if it gets there before Starship A.
6. In a real mission, you would need to communicate this rendezvous coordinate with Starship B so you can both match speeds and direction for the rendezvous. *(Of course without sub-space communication, this will be tricky.)*
7. If Starship A's speed is not adequate to catch Starship B, the mission profile will note that rendezvous is not possible.

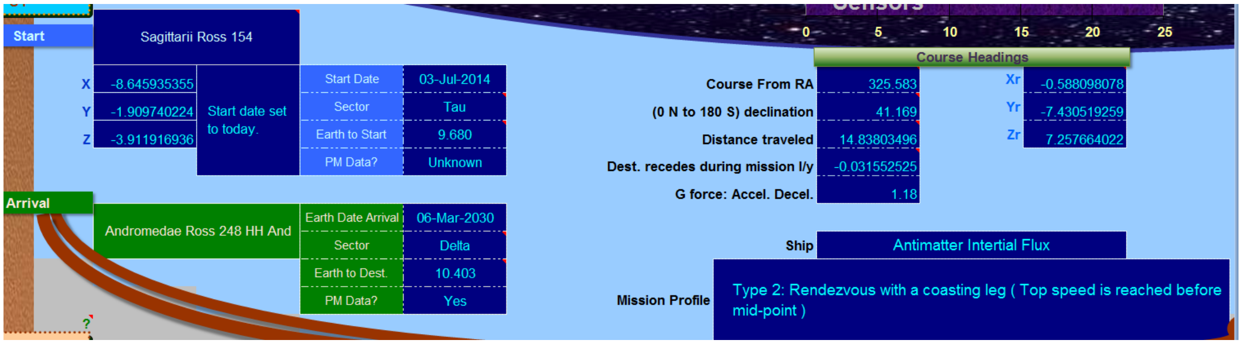
8. Accuracy limit for Starship B. The MP Navigator rendezvous with Starship B feature turns the acceleration and coasting legs of Starship B into an average speed. If Starship B gets to top speed fairly quickly, this issue is negligible. If Starship B takes a long time to top speed, then the margin of error will increase.

Rendezvous with Starship B Example:

Say we give Starship B an Antimatter Inertial Flux drive which allows higher Antimatter speeds with inertial compensation technology to take away those heavy G forces and give the ship a faster time to top speed. (Easy to describe, but it would actually take a leap of our knowledge of physics to make elimination of inertial force possible.)

Starship B is leaving Sagittarri Ross 154 in the Tau Sector to go to Andromedae Ross 248 in the Delta Sector.

Once we lock that in, we see the mission parameters and could even print out a Starship B mission report.

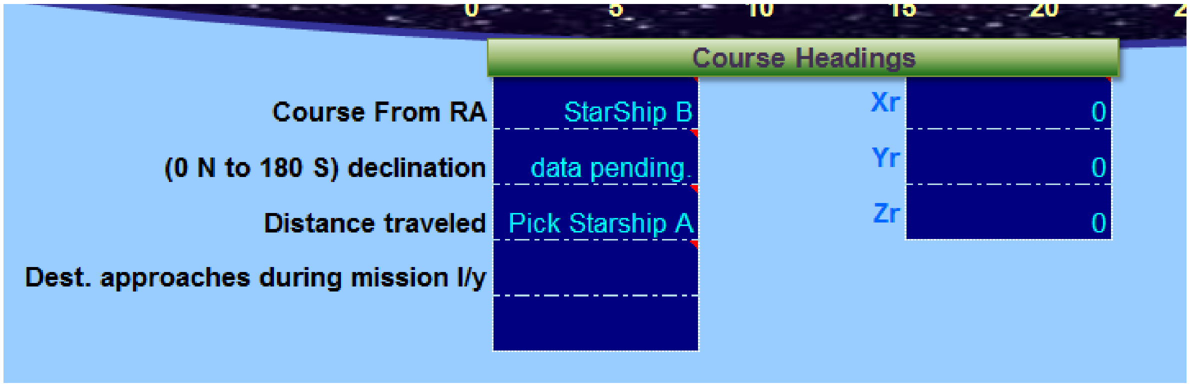


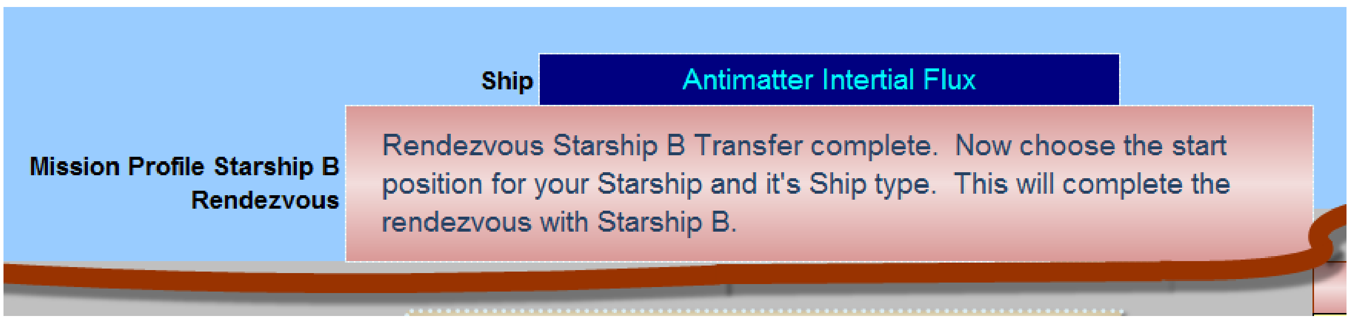
MP Navigator already adjusted Starship B's course to rendezvous with Andromedae Ross 248 and already adjusted Ross 248 to its real starting position for today's date. Proper Motion movement is listed in Stellar Dbase for both stars. Arrival at Ross 248, Earth time is 15 years 256 days, Ship time under 2 years.

Now we press the Starship B Transfer button to move this mission profile over to a Destination movement that is now Starship B.

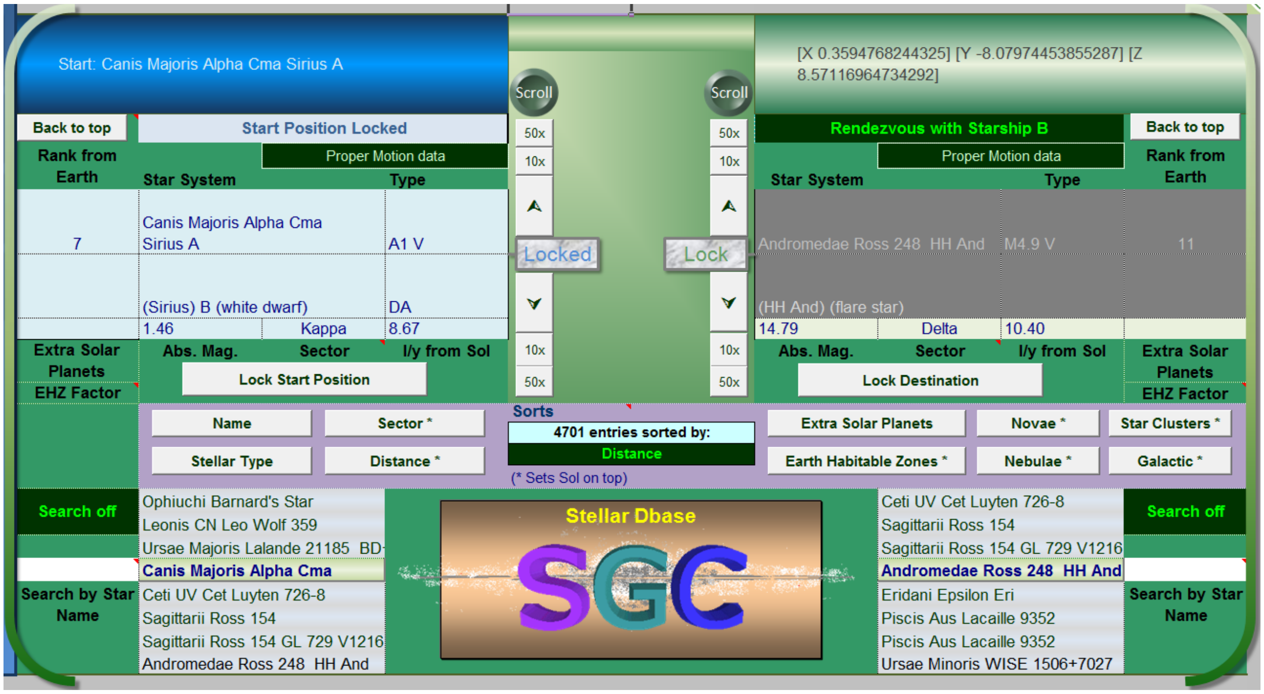
8


This causes some alerts, because now both the Start Position and the Destination are the same course heading. You have to change the Start Position to match your choice for Starship A's mission.

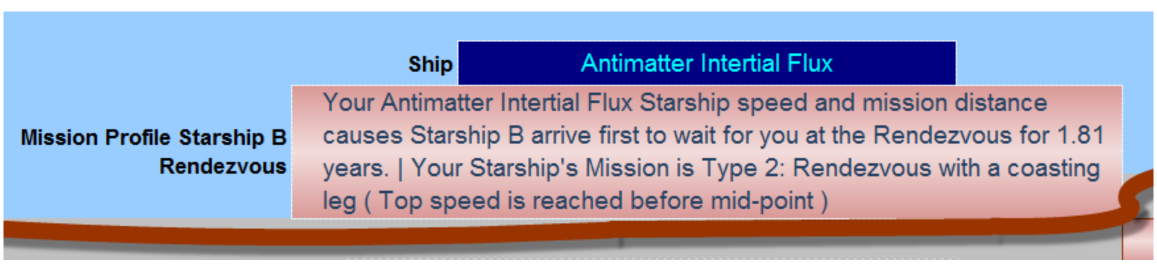




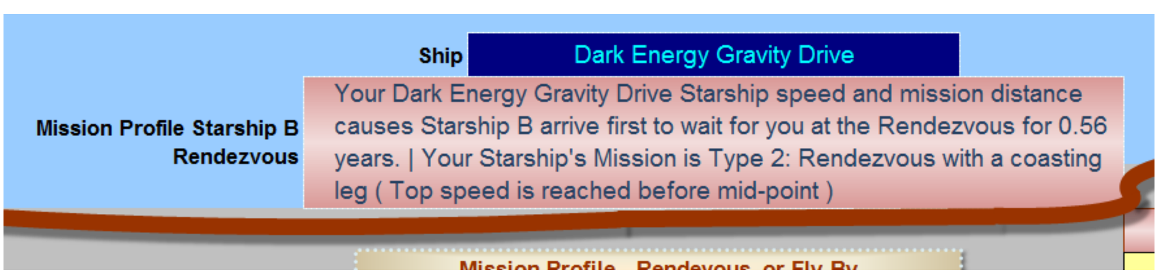
You can use the Stellar Dbase again and set the start Position with the same Ship Type for Starship A to Start Position Sirius. (2 up arrows on the left side Start Position will get you there.) Lock Start Position in by clicking the left Lock button.



The Mission Profile Rendezvous status in the Output Area turns to Starship B color style and informs you that in this case, Starship B arrives first and has to wait for you in Starship A. That is because you set Starship A further away and both Starships are the same Ship type with the same speed.

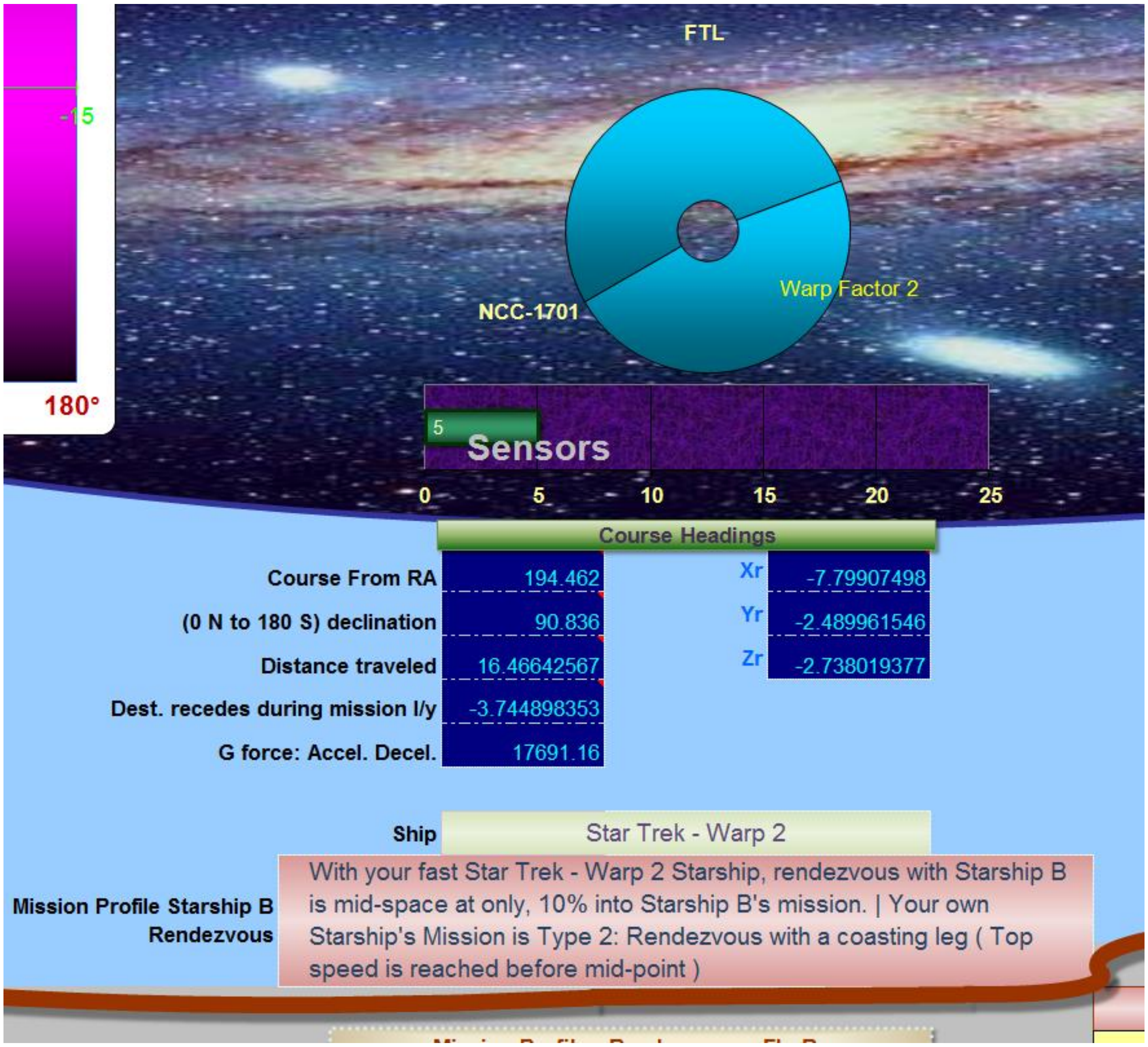


Change Starship A to a Dark Energy Gravity Drive and that’s a little better:

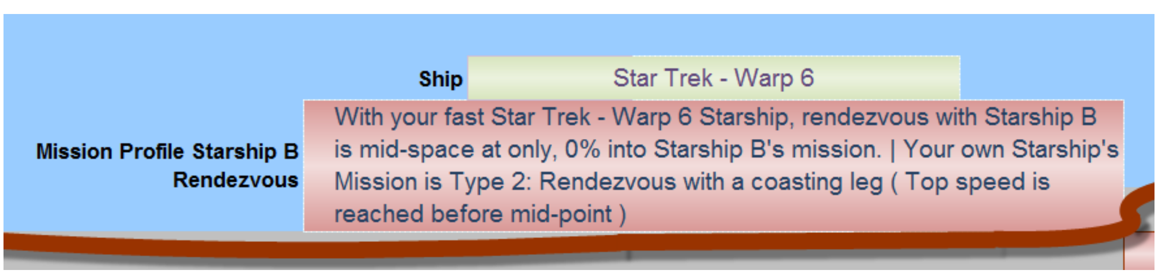


(By the way, to get out of being in the Starship B feature, just choose and lock in a new destination.)

If you change to a fictional Federation Starship at Warp Factor 2, the Mission Profile info shows a mid-space rendezvous at 10% into Starship B's mission. A FTL Ship Type changes the speedometer and Ship Type window color goes to light green.



If you really wanted to head off Starship B, you would have to jump your speed up to, say, Warp Factor 6. You almost reach Starship B before it's made any headway. It would be 0.05% or so, into its mission on rendezvous.



Updated information will also be in the Notes

> **{ Notes }**
>
> Rendezvous with Starship B is at Antimatter Intertial Flux Faster than light travel. Ship time data is imaginary. You are in the Rendevous with Starship B Mission. To return to normal missions, choose another star and click Commit Destination button below. Faster than light speeds can create large G forces. ' Inertial dampeners ' are used in Sci-Fi to compensate. Mid-Point Mission Speed is 10 c. Annual Shifts are within acceptable values.

In the updated Sensor report, you can actually see the data on Starship B.

Top ship speed = 10, Destination speed = 283798.77 Km/sec

Stars in sensor range during mission

Recalculate Sensor Report

Ranking	Primary star	2nd star in system	Type	Alerts (Stellar Real coordinates are auto-shifted to adjust for years from mission start date to Epoch 2000)	14.50	First in Sensor Range (Sort): Earth Years	Ship Years	Closest approa (Sort): Light Years	E
1	Canis Majoris A	(Sirius) B (white	A1 V			0.00	0.00	0.00	
2				Starship B		0.00	0.00	0.00	
3	Leporis Lambda Lep		B0.5IV			0.31	0.00	1.49	
4	Pictoris Eta2 Pic		M2III var			0.33	0.00	2.12	
5	Solar System Sol		G2V			0.40	0.00	2.66	
6	Draconis Psi1 Dra	Dziba	F5 IV-V			0.40	0.00	2.66	
7	Boötis Kappa2	(delta scuti var	A8 IV			0.40	0.00	2.66	
8	Centauri Proxir	(red dw arf in Al	M5.5 V			0.47	0.00	2.53	
9	Centauri Alpha	B C	G2 V			0.49	0.00	2.66	
10	Canis Minoris A	(Procyon) B	F5 IV-V			Never	Never	Out of range	
11	Monocerotis R	B	M4.5 V			Never	Never	Out of range	
12	Canis Minoris L	(red dw arf)	M3.7V			Never	Never	Out of range	
13	Pictorus Kapte	(sub dw arf)	M0.0 V			Never	Never	Out of range	

In the Final Mission Report for this Starship A and Starship B rendezvous. Its mid-space location is listed. Also listed below is Starship B's original flight plan and destination.

Interstellar Mission Profile for SGC Navigator - Report - Printable ver 1.1

Start: Canis Majoris Alpha Cma Sirius A	[X -7.79907498022842] [Y -2.48996154623226] [Z -2.73801937684855]
Mission Profile - Rendezvous	**Earth date arrival:** Thursday, February 25, 2016
Ship Type: Star Trek - Warp 2	**Ship date arrival:** Thursday, July 03, 2014

With your fast Star Trek - Warp 2 Starship, rendezvous with Starship B is mid-space at only, 10% into Starship B's mission. | Your own Starship's Mission is Type 2: Rendezvous with a coasting leg (Top speed is reached before mid-point)

Start Position:				**Start Date:**	3-July-2014
Star System				**Earth Polar**	
Primary Star:	Canis Majoris Alpha Cma Sirius A			**RA hours:**	inactive
Type:	A1 V	**Planets:**	0	**RA min:**	inactive
Binary:	(Sirius) B (white dwarf)			**RA sec:**	inactive
Type:	DA			**dec. degrees**	inactive
Rank from Earth:	7	Abs Mag.:	1.46439891	**dec. minutes**	inactive
				dec. seconds	inactive

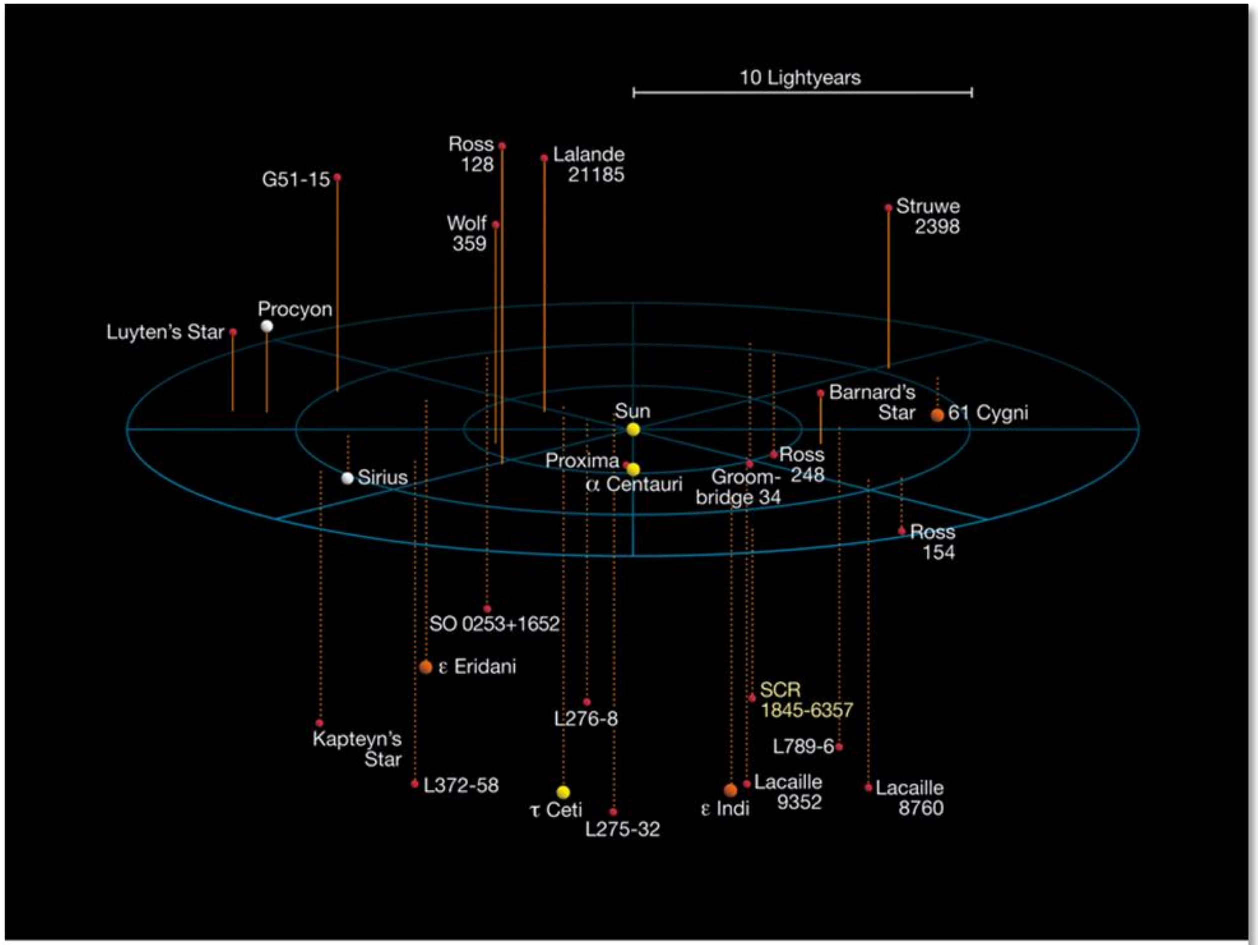
Stats	**Distance l/y**	**Sector**	**X**	**Y**	**Z**
Earth to Start Position:	8.67138154	**Kappa**	8.14388628	1.62191047	-2.4978752

(Galactic SGC: Sector, X, Y, Z)

Destination: Starship B		**Arrival Date (Earth time):**	25-February-2016
Star System		**Earth Polar**	
Rendezvous:	Starship B Start: Sagittarii Ross 154	**RA hours:**	inactive
En route:	Ross 248 HH And	**RA min:**	inactive
Ship Type:	Antimatter Intertial Flux	**RA sec:**	inactive
		dec. degrees	inactive
Rank from Earth	11	**dec. minutes**	inactive

Remember, getting out of this mode is easy. Just use the Stellar Dbase and pick a different Destination and lock it in.

12. Star Maps



Stars in the Solar Neighbourhood

ESO PR Photo 11c/06 (22 March 2006)

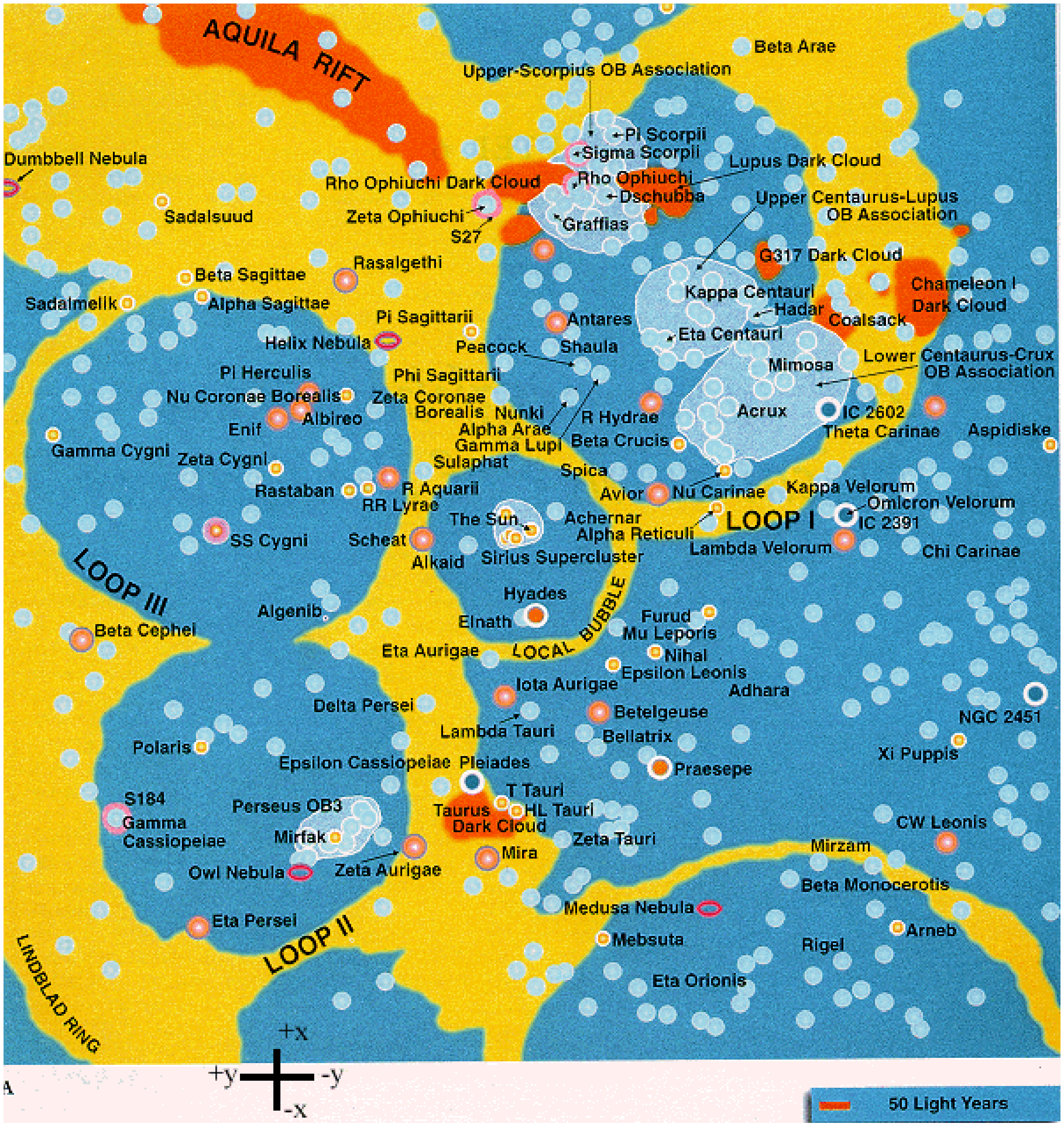
Star Map 15 light years

Center of the Galaxy is to the middle right. Ross 154 is the closest to the Galactic Center.

The Sun is moving along its galactic orbit in direction of 61 Cygni.

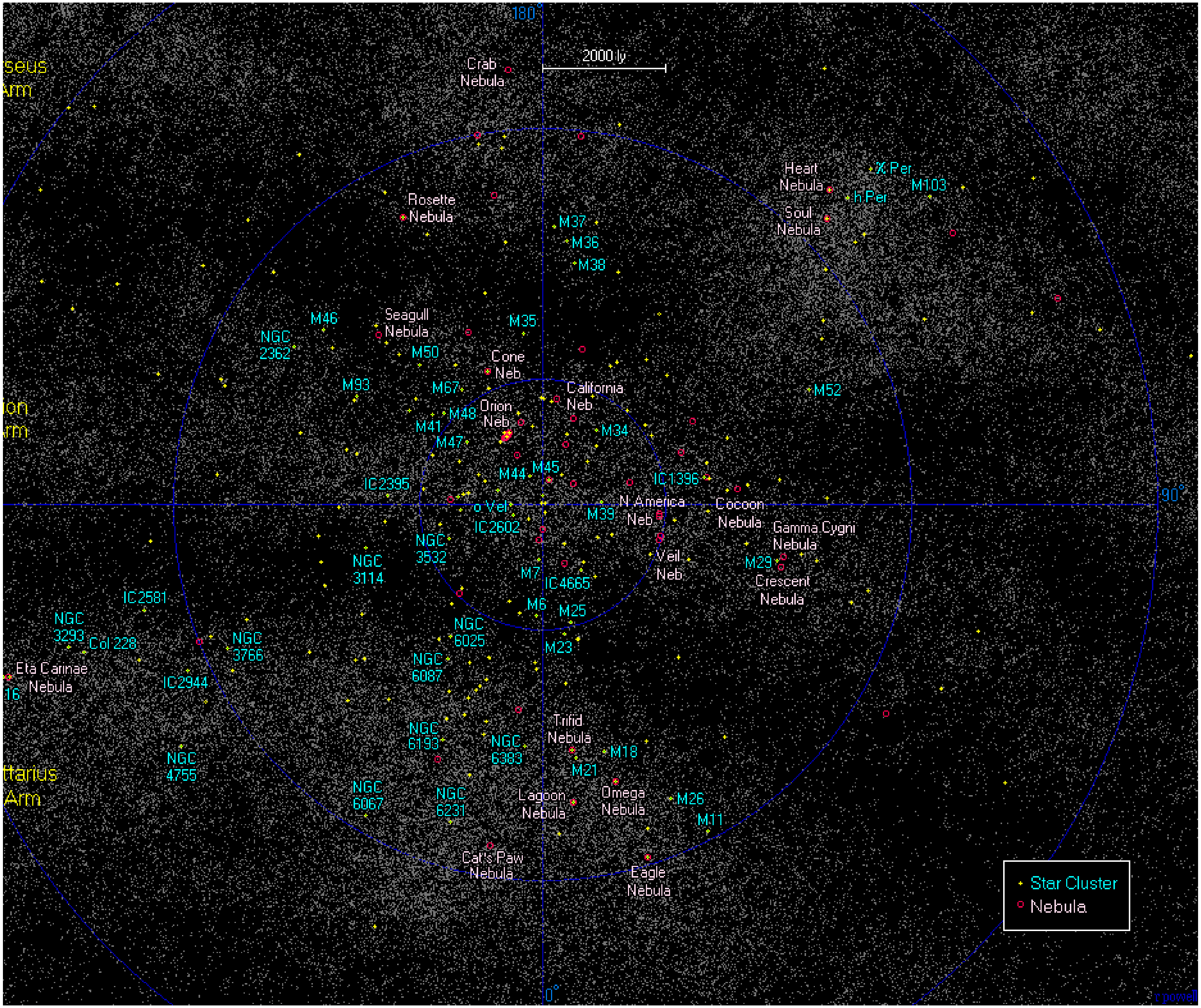
Star map 400 light years

Center of the Galaxy is to the upper left.



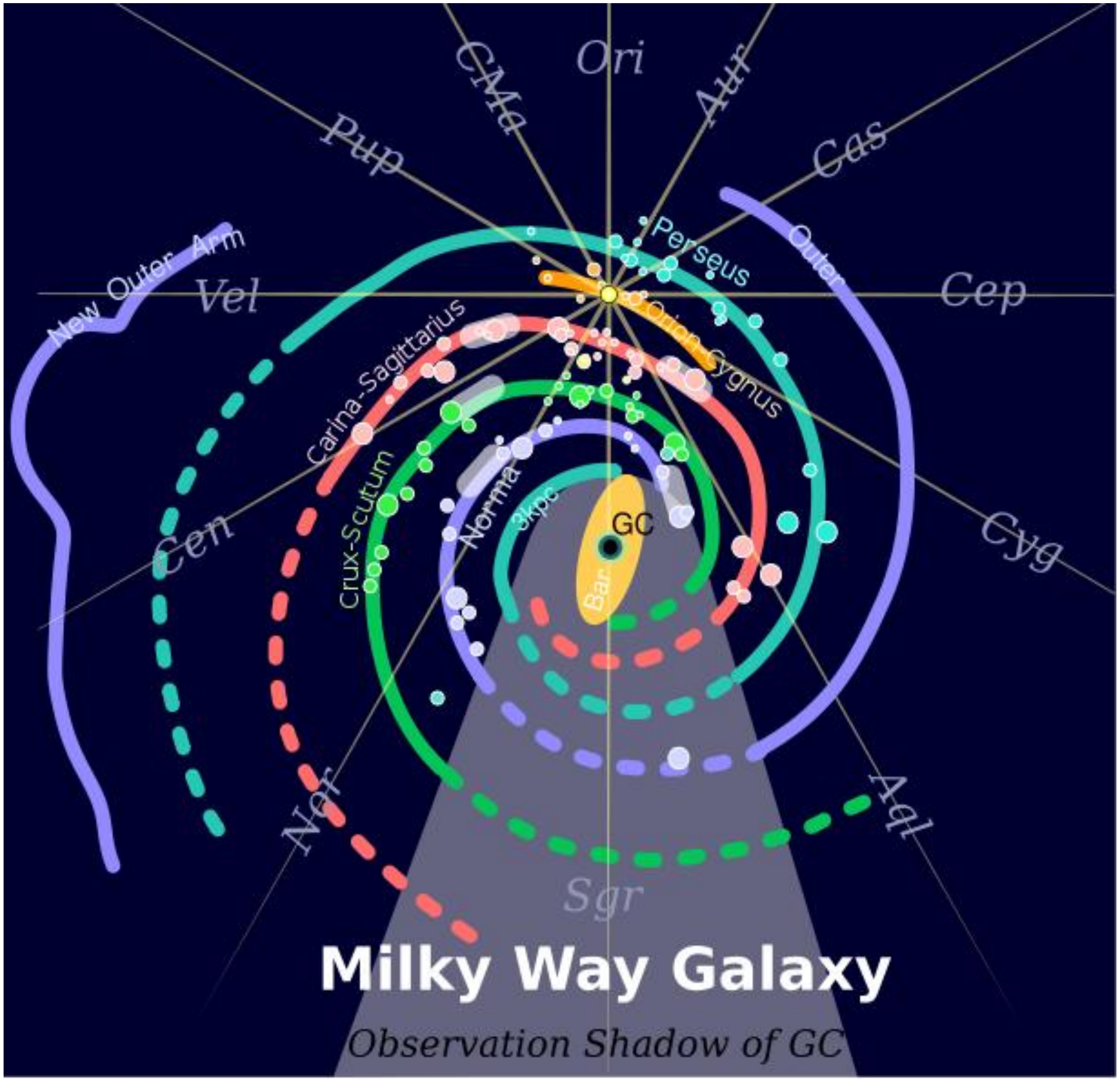
Star Map 800 light years

Center of the Galaxy is to the upper left



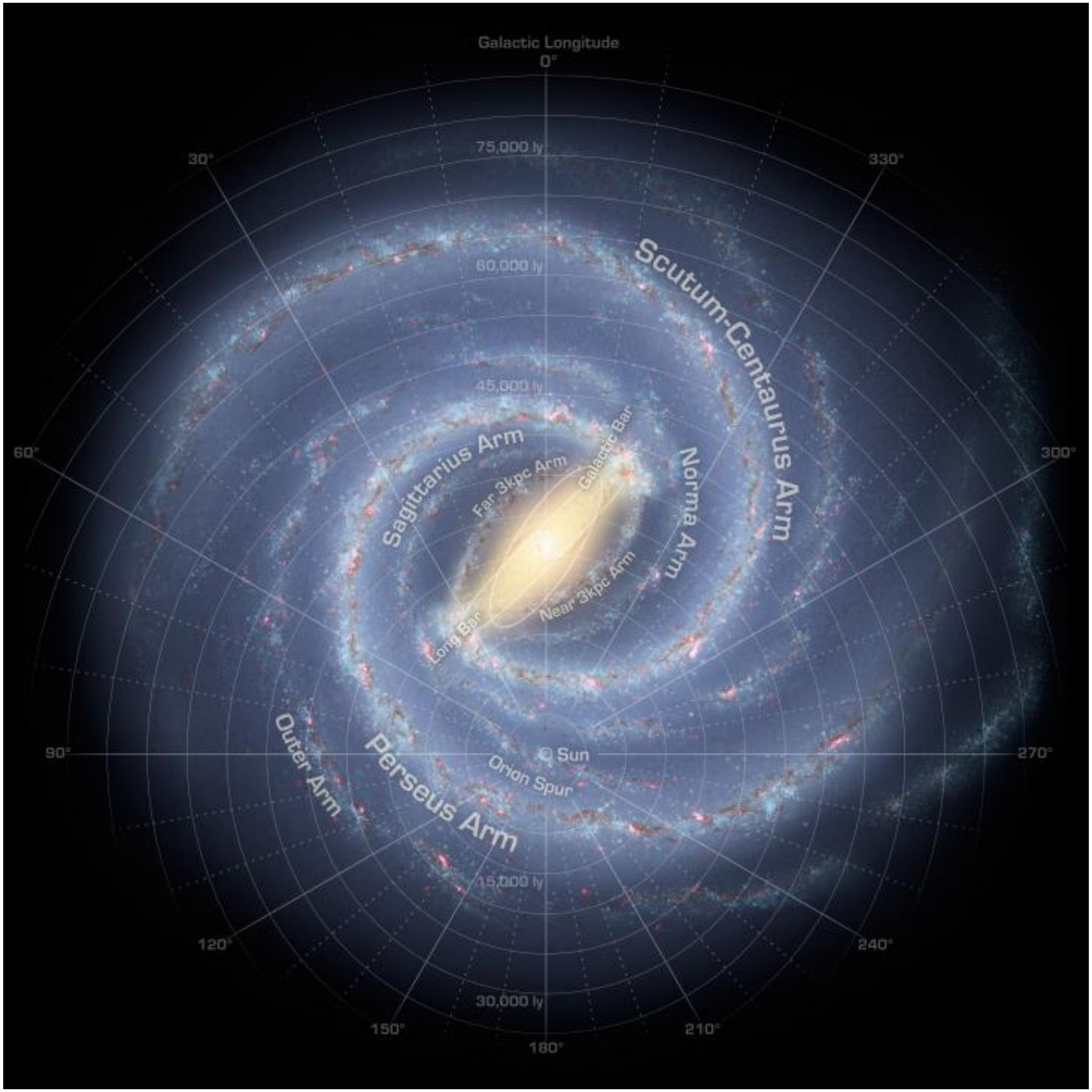
Star Map
10K
Light
Years

Center of the Galaxy is downward.



Milky Way Galaxy – Arms and Bars 80K light years highlighted

Center of the Galaxy is downward.



NASA Milky Way Galaxy with galactic locations and areas including the newly discovered New Outer Arm in the lower right area on axis 270°.

80K light years

These locations are available in the Stellar Dbase, sort on Nebulae scroll down to Names starting with Galaxy.

Milky Way Galaxy Map

Center of the Galaxy is upward.

13. Ship Types

Hydrogen-Fluorine F2/ H2

Isp=528 / Top speed = .000001

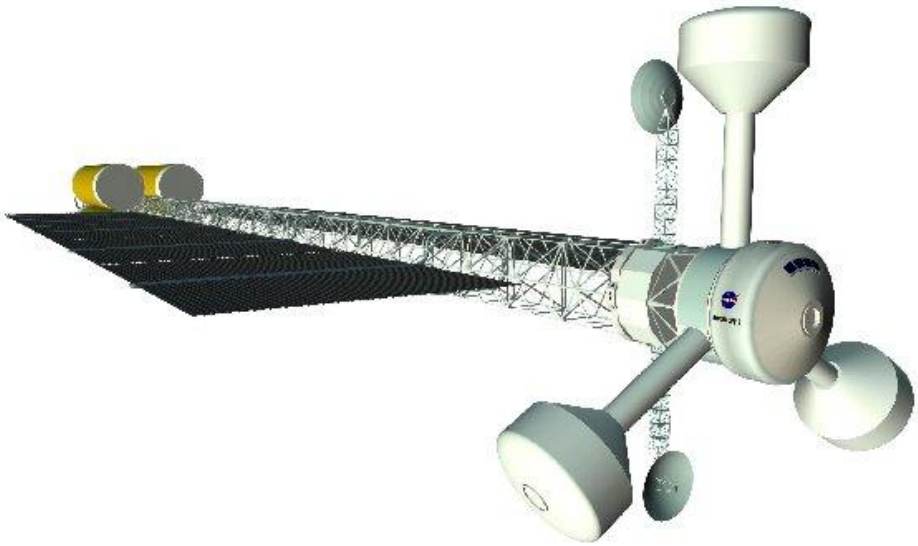
Free Radicals (H+H) -> H2

Isp=2,130 / Top speed = .00004

Image Credit

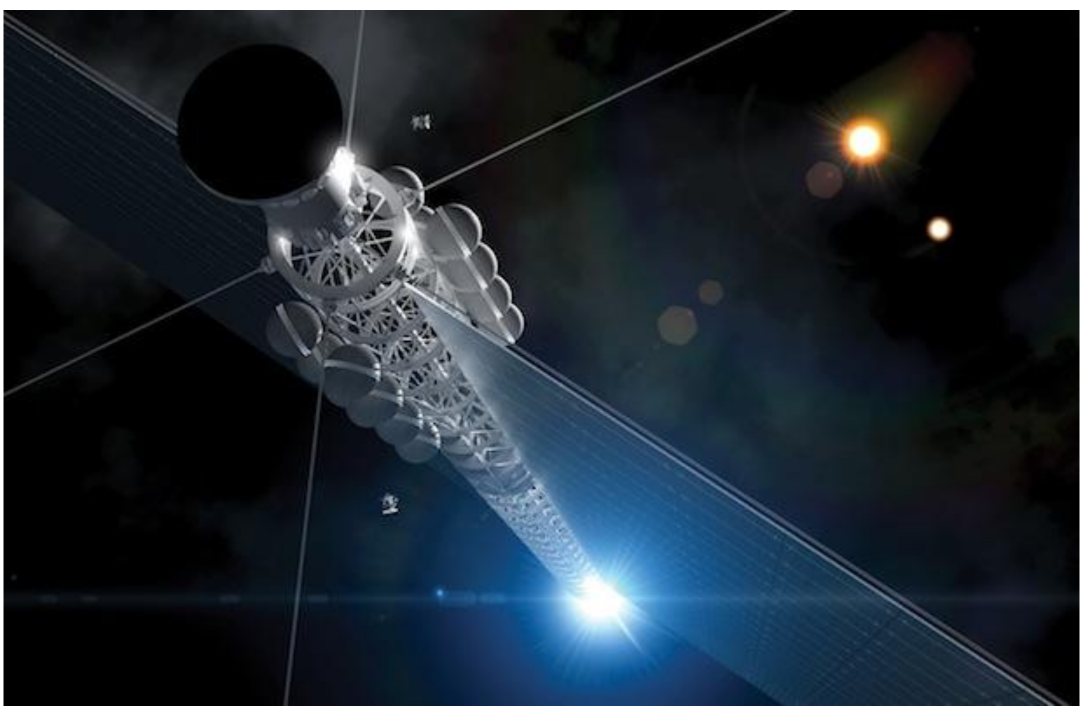
Metastable Atoms (Helium)

Isp=3,150 / Top speed = .00006



Steady-State Fusion

Isp=200,000 / Top speed = .00009 due to fuel limits



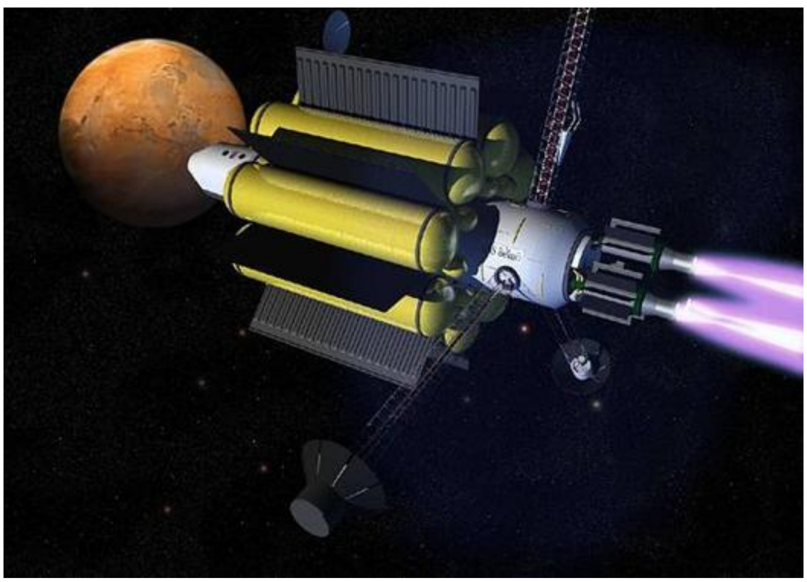
Ion Engine

Solar power operates up to 3AU from the sun - Isp=10,000 / Top speed = .00019

VASMIR NASA Ion Drive - Variable Specific Impulse Magneto plasma Rocket Propulsion

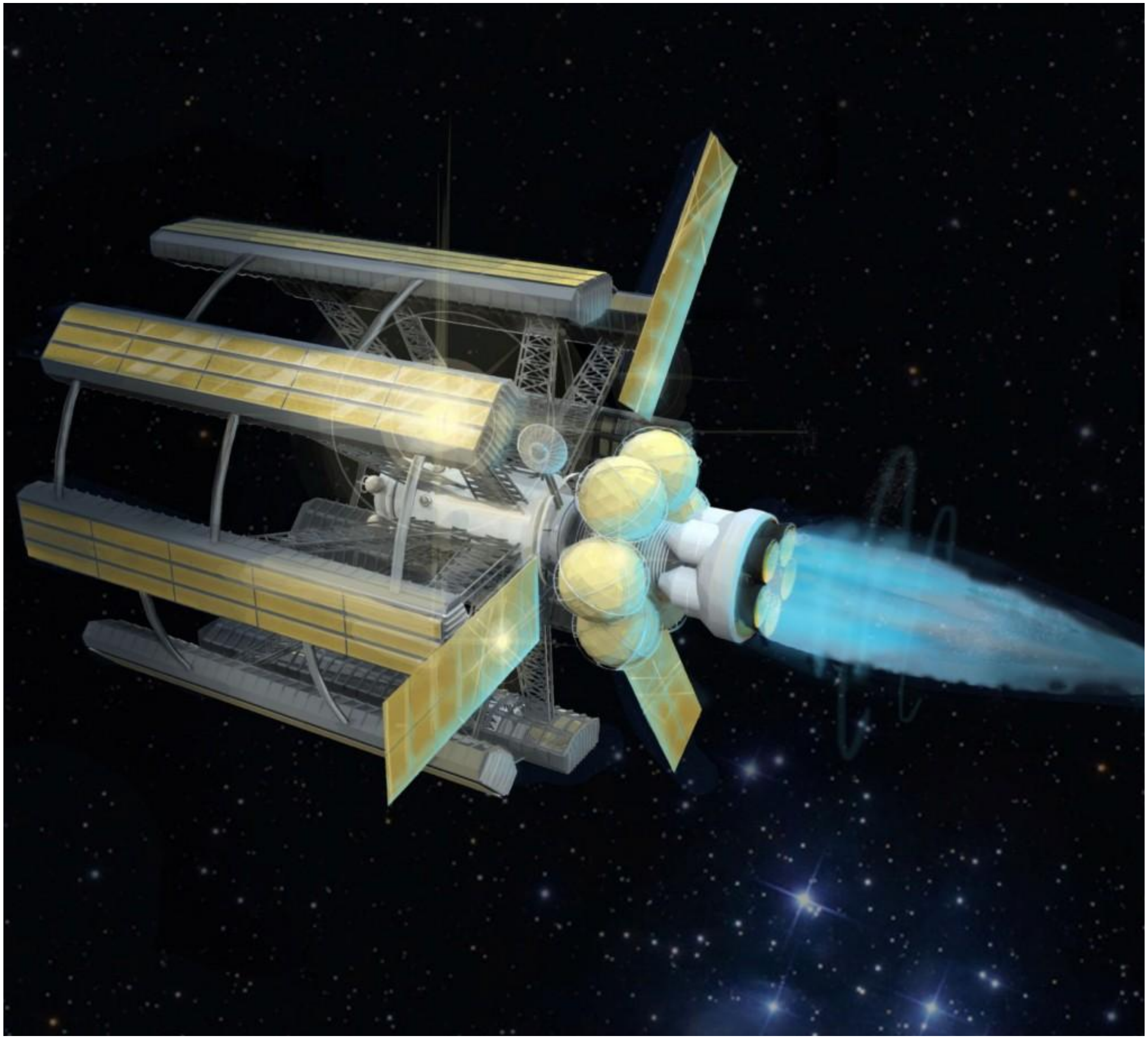
High Efficient Ion Engine

Isp=250,000 / Top speed = .00475 - *(This version rated at 123,000 mph)]*



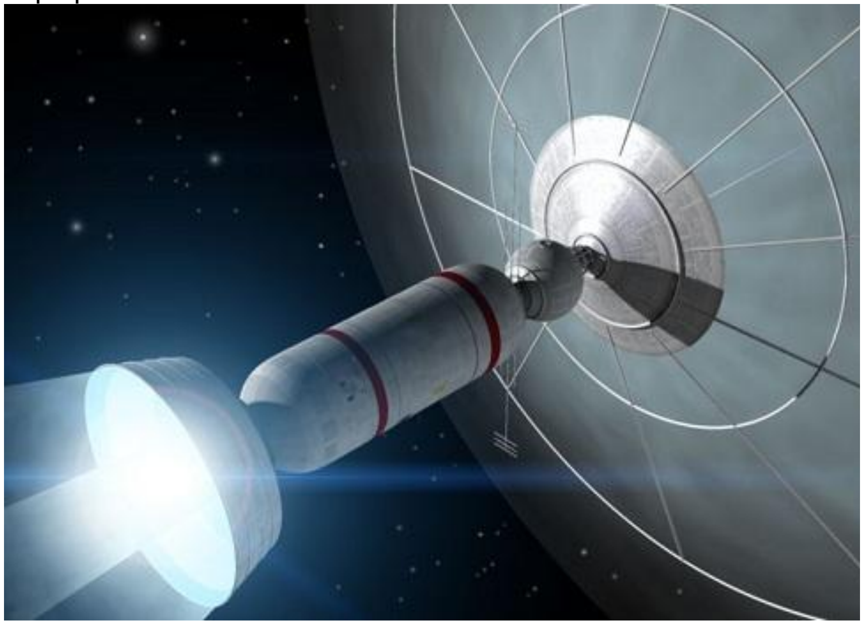
Nuclear Pulse Fusion Colony

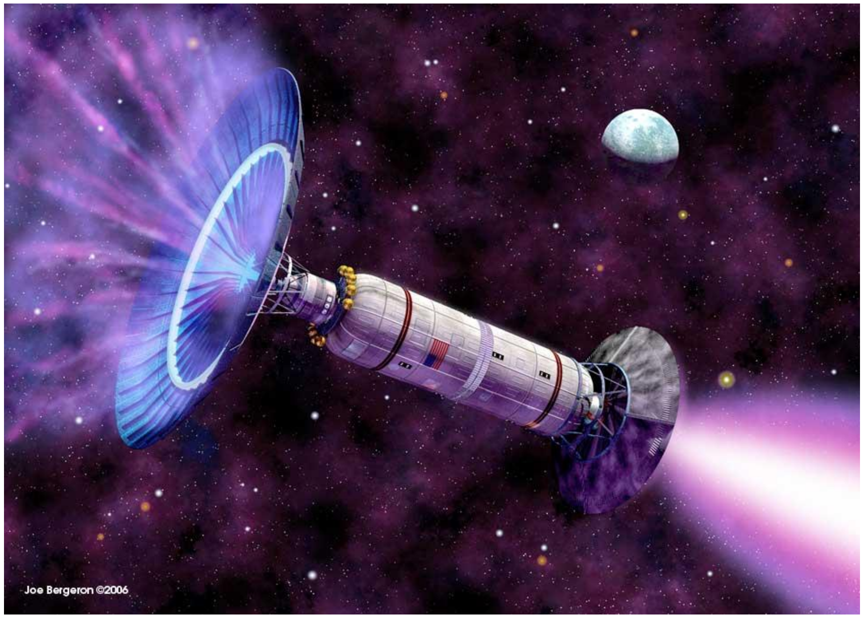
20 km diameter colony or similar , 3,000,000 bombs Isp=3,000 - Long burn 100 years / Top speed = .0033



Laser Ramjet & Solar Sail Assist

Top speed=.008 - slow acceleration





RAIR Ram - Long burn

1000 year / Top speed = .01

Daedalus / RAIR Ram Jet Combo

60 year burn / Top speed .03

Daedalus Nuclear Pulse Fusion - 100m

30,000 bombs Isp=10,000 - Short burn 10 days / Top speed = .0334

RAIR Ram - Augmented Interstellar Rocket

Deuterium / Lithium 100 person colony / Top speed = .04

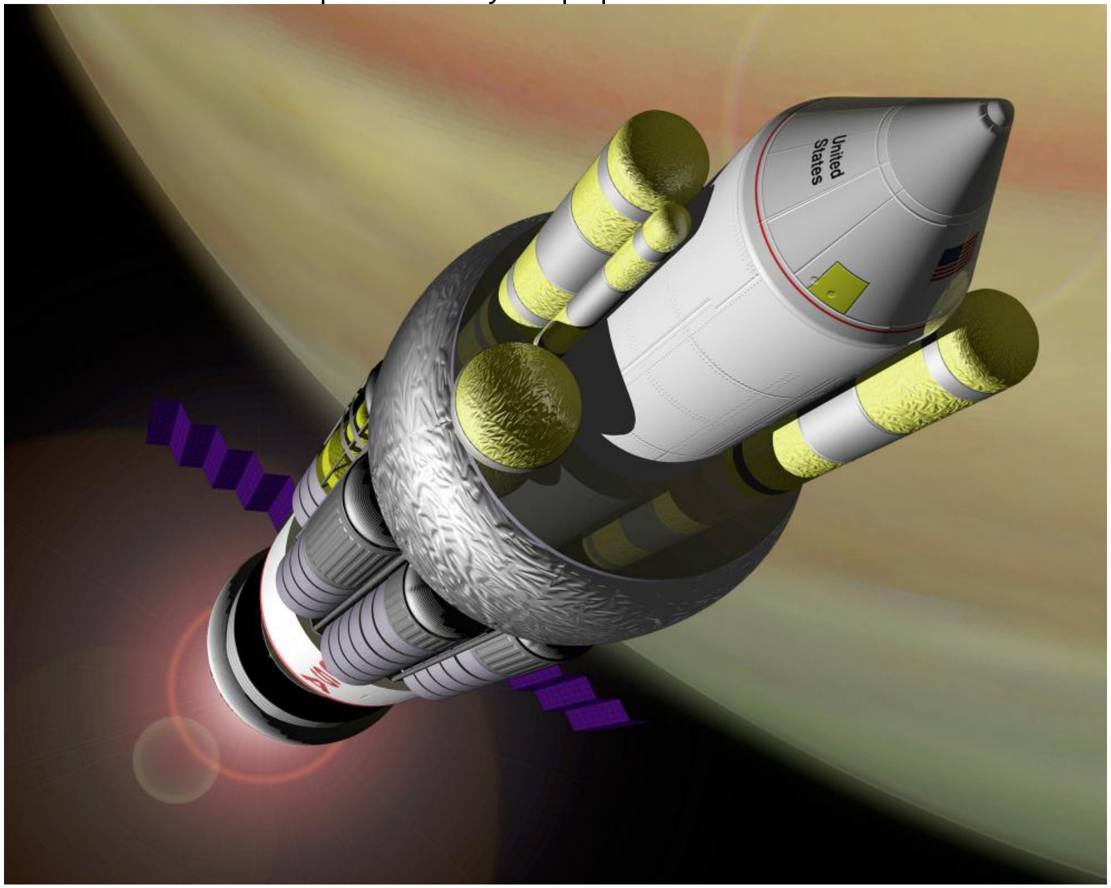


Image Credit

RAIR Goliath

20,000 tons fuel / Top speed = .098

Image credit

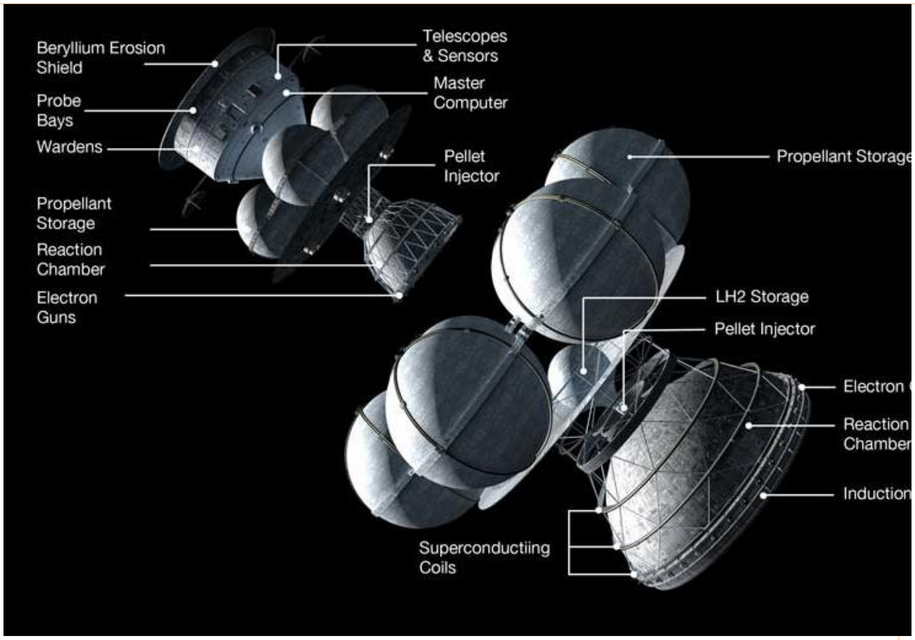


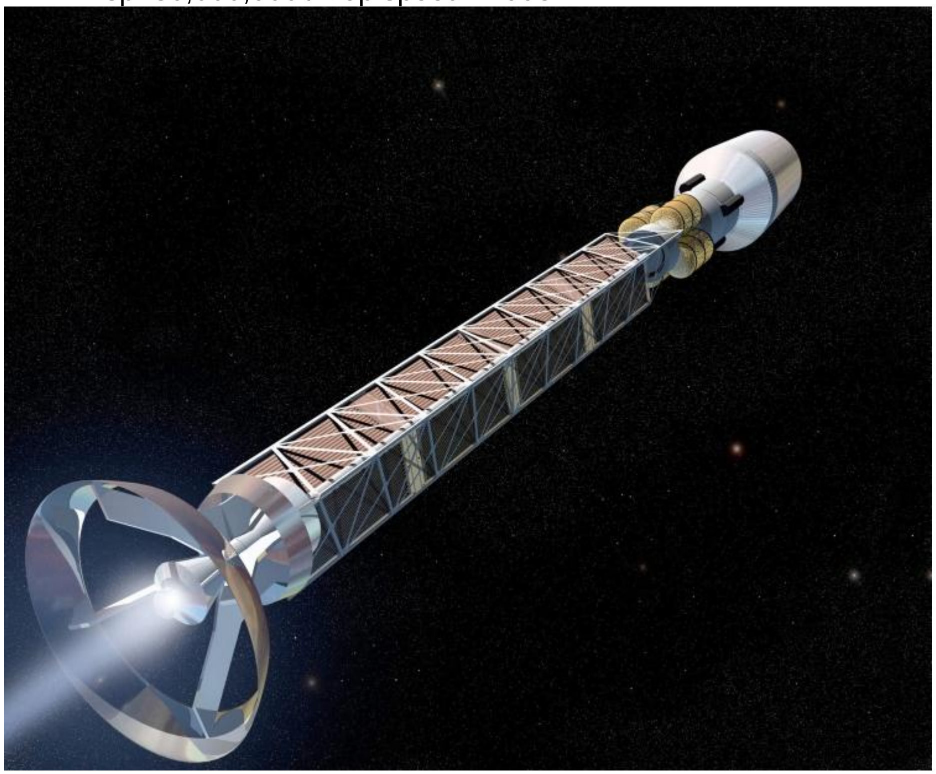
Image credit

Image credit

Scaled with people at the base of the Reaction Chamber

Antimatter

Isp=30,000,000 / Top speed = .998



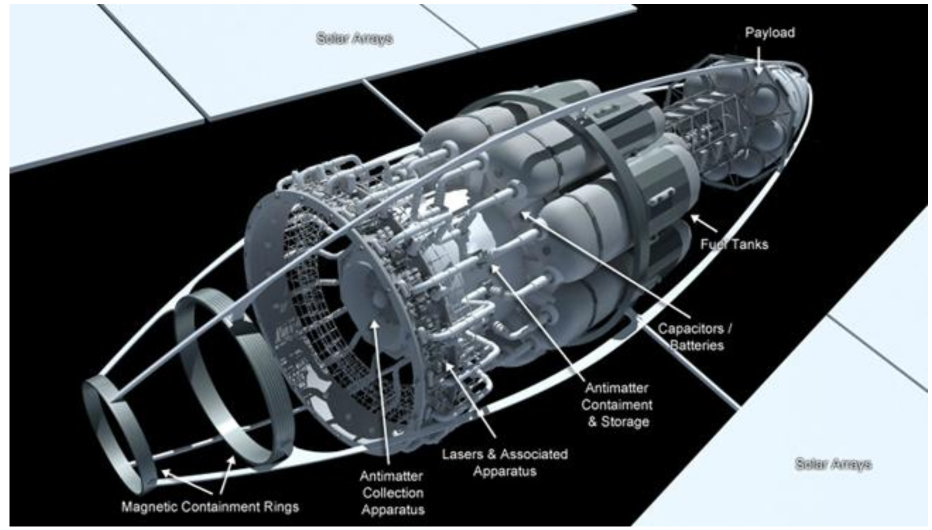


Image credit

Dark Energy Gravity – DEG Drive

Image credit

No propulsion source, converts gravity to acceleration. G-Force is cancelled by inertial dampeners up to 10G and artificial gravity is possible, deflector field for particle collision. Top speed .999999 c. Requires star system to change acceleration.

Top speed is based on maximum estimated fuel tank size.

Other custom type Starships like Ion drive / nuclear mix, Ion colloid thruster, Ion Xenon Thrusters could reach various Specific Impulse values and speeds for different payloads. You may easily create a custom engine type by entering a different top speed and time to top speed. All payload, fuel weight, Specific Impulse, relativistic mass increase is up to you to work out.

14. Starships Fictional

Image Credit

Liberator - Blake 7 - Recharging antimatter Dimensional engine. “Time to top speed” 1/2 day.
Top speed =Time Distort (TD)-12, supposedly an exponential scale. A TD-5 ship travels Earth to Cygni Alpha (Deneb), 1,550 light years in eight months at 2,300c.

Top speed TD-12 = 33,000c which allows for travel to Cygni Alpha (Deneb) in just over 17 days.

Image Credit

Firefly - Serenity - Radon Core - 36 RCS thrusters, top speed 400,000 mph (0.06c) at 4.25 G max acceleration. “Time to top speed” .5 day.

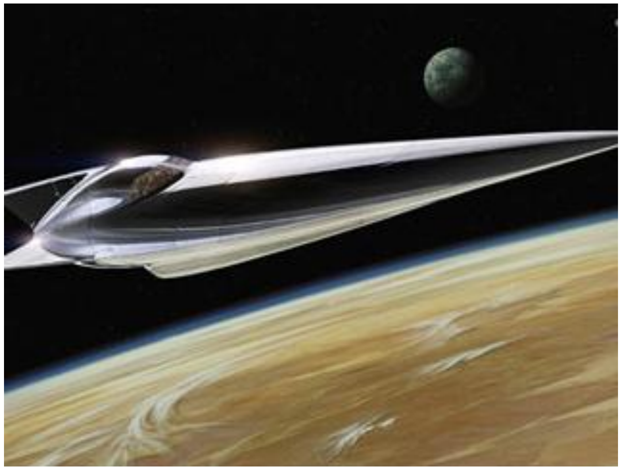
Image Credit

Venture Star - AVATAR - Two Antimatter Engines, Photon Sail, Fusion Planetary Maneuvering Engine. Laser Shielded. Radiators with unobtanium. Top speed 130,200 miles/sec (0.7c), "Time to top speed" 168 days

Image Credit 1   Image Credit 2

Nostromo - Alien - M-Class, Laretel WF-15 2.8 Terawatt fusion reactor, Yutani T7A NLS Tachyon shunt drive, 244 x 164 meters, 63K ton, Weyland-Yutani Refinery ship. Top speed 153.0c empty, 36.0c fully laden. “Time to top speed” 90 days

Millennium Falcon - 2 Girodyne SRB42 sublight engines highly customized, Top speed 105,000 c. “Time to top speed” 1/2 day.

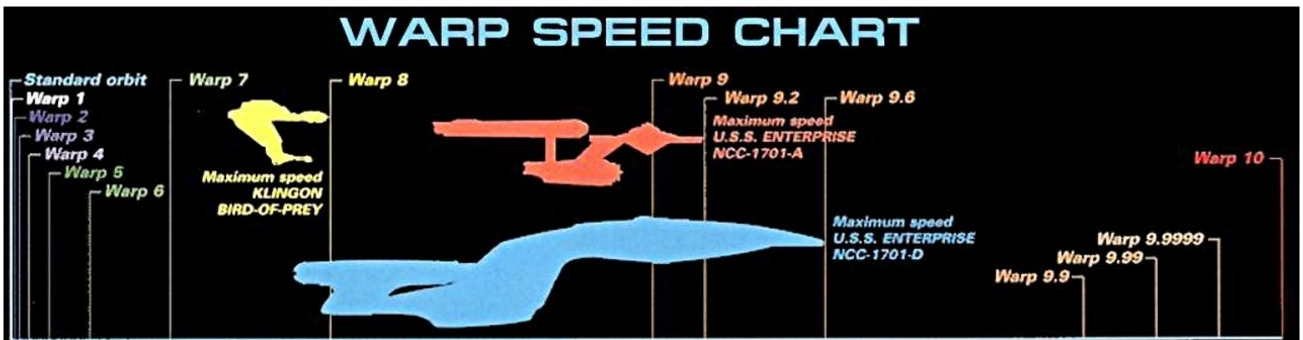


Nubian Yacht - Class 0.9 Owned by Princess Padmé - Nubian Sossen-3 ion drives, Nubian 150 hyperdrive core, Top speed 90,000 c. “Time to top speed” 2 days.

[Images Credit]

Star Trek Warps

Arbitrary Faster than light speeds based on info from the series.



APPROXIMATE TIME TO TRAVEL

SPEED	Kilometers per hour	x lightspeed	Earth to Moon 400,000 kilometers	Across Sol system 12 million kilometers	To nearby star 5 light-years	Across one sector 20 light-years	Across FEDERATION 10,000 light-years	To nearby galaxy 2,000,000 light-years	NOTES
Standard orbit	9600	less than 0.00001	42 hours	142 years	558,335 years	2 million years	1.12 billion years	223.33 billion years	Synchronous orbit around Class-M planet
Full impulse*	270 million	0.25	5.38 seconds	44 hours	20 years	80 years	400,000 years	8,000,000 years	Normal maximum impulse speed
Warp factor 1	1078 million	1	1.34 seconds	11 hours	5 years	20 years	100,000 years	2,000,000 years	Warp one = speed of light
Warp factor 2	11 billion	10	0.13 seconds	1 hours	6 months	3 years	9,921 years	198,425 years	
Warp factor 3	42 billion	39	0.03 seconds	17 minutes	2 months	1 year	2,568 years	51,360 years	
Warp factor 4	109 billion	102	0.013237 seconds	7 minutes	18 days	2 months	984 years	19,686 years	
Warp factor 5	230 billion	214	0.006291 seconds	3 minutes	9 days	1 month	468 years	9,357 years	Old cruising speed
Warp factor 6	423 billion	392	0.003426 seconds	2 minutes	5 days	19 days	255 years	5,096 years	New normal cruising speed
Warp factor 7	707 billion	656	0.002049 seconds	1 minutes	3 days	11 days	152 years	3,048 years	
Warp factor 8	1103 trillion	1,024	0.001313 seconds	39 seconds	2 days	7 days	98 years	1,953 years	
Warp factor 9	1.63 trillion	1,516	0.000886 seconds	26 seconds	1 day	5 days	66 years	1,319 years	
Warp factor 9.2	1.78 trillion	1,649	0.000815 seconds	24 seconds	1 day	4 days	61 years	1,213 years	Old normal maximum speed
Warp factor 9.6	2.06 trillion	1,909	0.000704 seconds	21 seconds	23 hours	4 days	52 years	1,048 years	Maximum rated speed, can be maintained for 12 hours
Warp factor 9.9	3.29 trillion	3,053	0.000440 seconds	13 seconds	14 hours	2 days	33 years	655 years	Auto-shutdown of engines after 10 minutes
Warp factor 9.99	8.53 trillion	7,912	0.000169 seconds	5 seconds	6 hours	22 hours	13 years	253 years	Nearly infinite power required
Warp factor 9.9999	215 trillion	199,516	0.000006 seconds	0.2 seconds	13 minutes	53 minutes	6 months	10 years	Maximum subspace radio speed (with booster relays)
Warp factor 10	infinite	infinite	0	0	0	0	0	0	Theoretically unobtainable

In theory, a starship at warp 10 would occupy all points in the universe simultaneously, though this speed barrier has been broken once, in extraordinary circumstances.

* Full impulse is equal to ¼ lightspeed.

[Images Credit]

15. Other Navigator worksheets – Under the Hood

The MP Navigator pulls data and formulae from other worksheets tabs. The second tab Charts and Ships, and third tab Mission Report are useful to you.

The remaining worksheets are all formulae or data and are not needed to view for any additional information. They should also not be edited.

Charts & Ships

A collection of Charts and Ships also featured above in this guide.

Mission Report

Auto updated per mission. Printable Mission Profile data that varies for each mission profile. You need to save each mission profile to pdf with the button in the left column of the MP Navigator page, if you want to keep track of your different missions. This page auto updates with each change you make.

Stellar Dbase

All data in the dbase is text only. There are no formulae.

							Earth Polar angles and apparent movement							RV	A
							RA		dec			PM	q		XAS
	1st Star Name	2nd Star Name	Spectral Type A	Spectral Type B	Absolute Magnitude brightest	Sector	R.A. - Hours	R.A. - Minutes	dec. °	dec. '	Distance light years	Proper Motion sec / yr	Angle of Proper Motion (delta)	Radial Vel km/sec - recession, + approach	X Annual Shift
1	Solar System Sol	Sol	G2 V			Solar System	0	0	0	0	0.0				0
2	Centauri Proxima	(red dwarf in Alpha Cen)	M5.5 V		15.49	Omega	14	29.71581	-62	-40.769	4.2	2.24157524	78.482	21.7	0.000301391
3	Rigil KenTauri Rigil Kent	B C	G2 V	K1 V	5.69	Omega	14	39.60825	-60	-50.0385	4.4	2.15816513	82.537	21.6	0.000281257
4	Ursae Majoris HAT-P-13	b Jupiter sized planet	K4		5.87	Gamma	13	44.37653	48	1.72033	5.9	0.01929743	221.0884	21.8	-2.26111E-05
5	Ophiuchi Barnard's Star	(fastest stellar motion)	M3.8 V		4.36	Gamma	17	57.9	4	41.6	5.9	6.03218896	4.418	106.8	-0.000566083
6	Leonis CN Leo Wolf 359	(red dwarf)	M6.5		13.25	Alpha	10	56.48317	7	0.86667	7.8	234.653218	2.740318	-19	0.010766928
7	Ursae Majoris Lalande 21185 BD+36°2147	B flare star?	M2.1 V	?	16.56	Alpha	11	3.336567	35	58.1925	8.3	2.79551368	186.938	-85	-0.000457842
8	Canis Majoris Alpha Cma Sirius A	(Sirius) B (white dwarf)	A1 V	DA	1.46	Kappa	6	45.14862	-16	-42.967	8.7	0.96741058	222.645	7.6	7.2933E-05

No formulae on the Stellar Dbase page. Known values from astronomical data and computed values specific to the MP Navigator:

- Star name, binary info
- Star type – Stellar Classification
- Absolute Magnitude
- Right Ascension, declination, distance
- Stellar Proper Motion data (if available)
- Exo Planets

- Distance Ranking from Sol
- Probability of Earthlike planets

Computed values entered into Stellar Dbase

- X, Y, Z coordinates
- XAS, YAS, ZAS (Annual Shifts derived from stellar Proper Motion)

Annual Shifts Calculator

All data is pulled from the SGC_MP_Navigator page.
Do not enter any data on this page.

SGC Annual Shift Calculator

	Formulae
Proper motion sec / year	0.666549242
Angle of Proper motion	168.8273731
Radial movement Km / sec	-24
Proper motion converted to degrees	0.002777289

-1

RA and dec changes after 1 year of radial and proper

New RA decimal	283.5984548
New declination decimal	18.1806086804

299792458	Speed of light Km/sec (known)
31557600	Seconds in 1 Julian year (365.25 days) (known)
86400	seconds in RA (known)
148510660.5	min of arc in 360 degrees (known)

$$4\pi\left(\frac{10,800}{\pi}\right)^2$$

Apparent Position of Star from Earth

RA hours	18
RA minutes	54
RA seconds	23.5000000000
Converted to RA decimal	283.5979
dec degrees	18
dec minutes (seconds in decimal)	11.0000000000
Converted to dec all decimal	18.1833333333
Light year distance	22.00000000000

Converts Proper motion arc sec RA and dec to angle of Proper motion & PM sec / year

	Pulls from MP Navigator	Proper Motion sec / year	Proper Motion Minutes of arc		
Motion shift in RA in arc sec	222	0.666549242	1145.7		
Motion shift in dec in arc sec	-1124	168.8273731		168.8273731	Quadrant check
		angle of Proper motion			

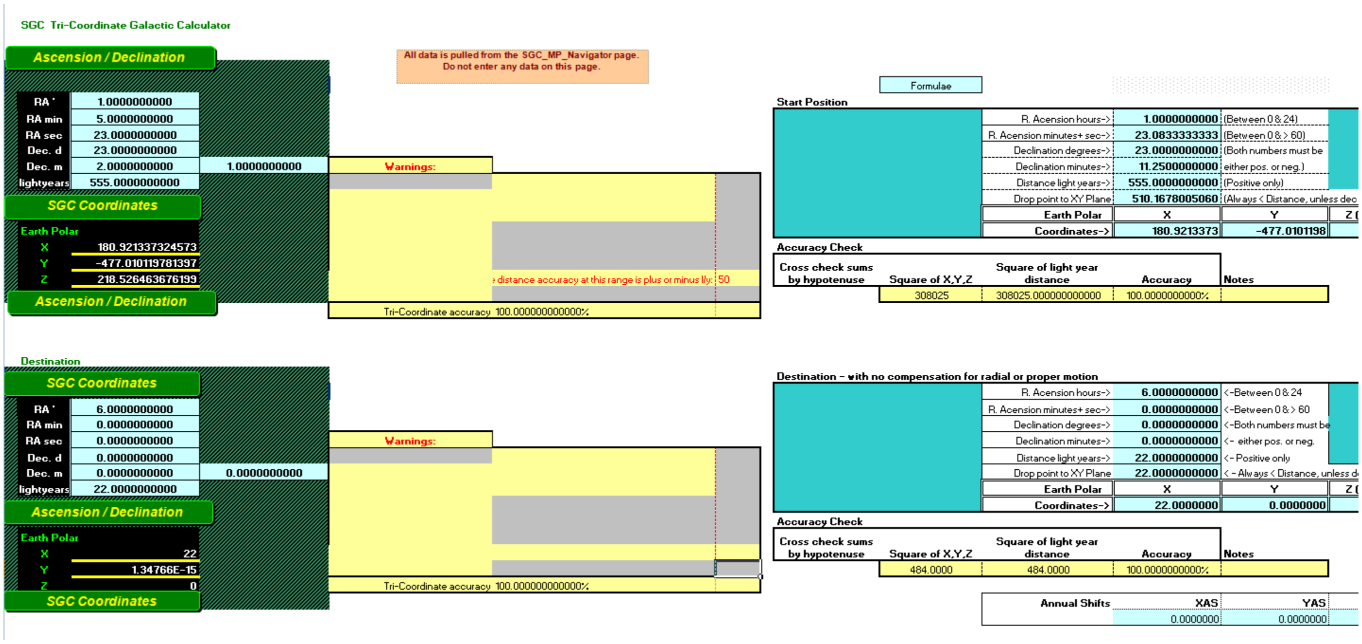
Apparent position of star from Earth, after 1 year movement

Km Radial movement in 1 year	-757382400
New light year distance after 1 year of Radial movement	21.99999991994
Change in RA seconds by star based on Proper motion and angle of proper motion	0.000538143
Change in dec seconds by star based on Proper motion and angle of proper motion	-0.002724653

XAS	0.001847124
YAS	0.0006487733
ZAS	0.005928695
Speed	0.0062435722

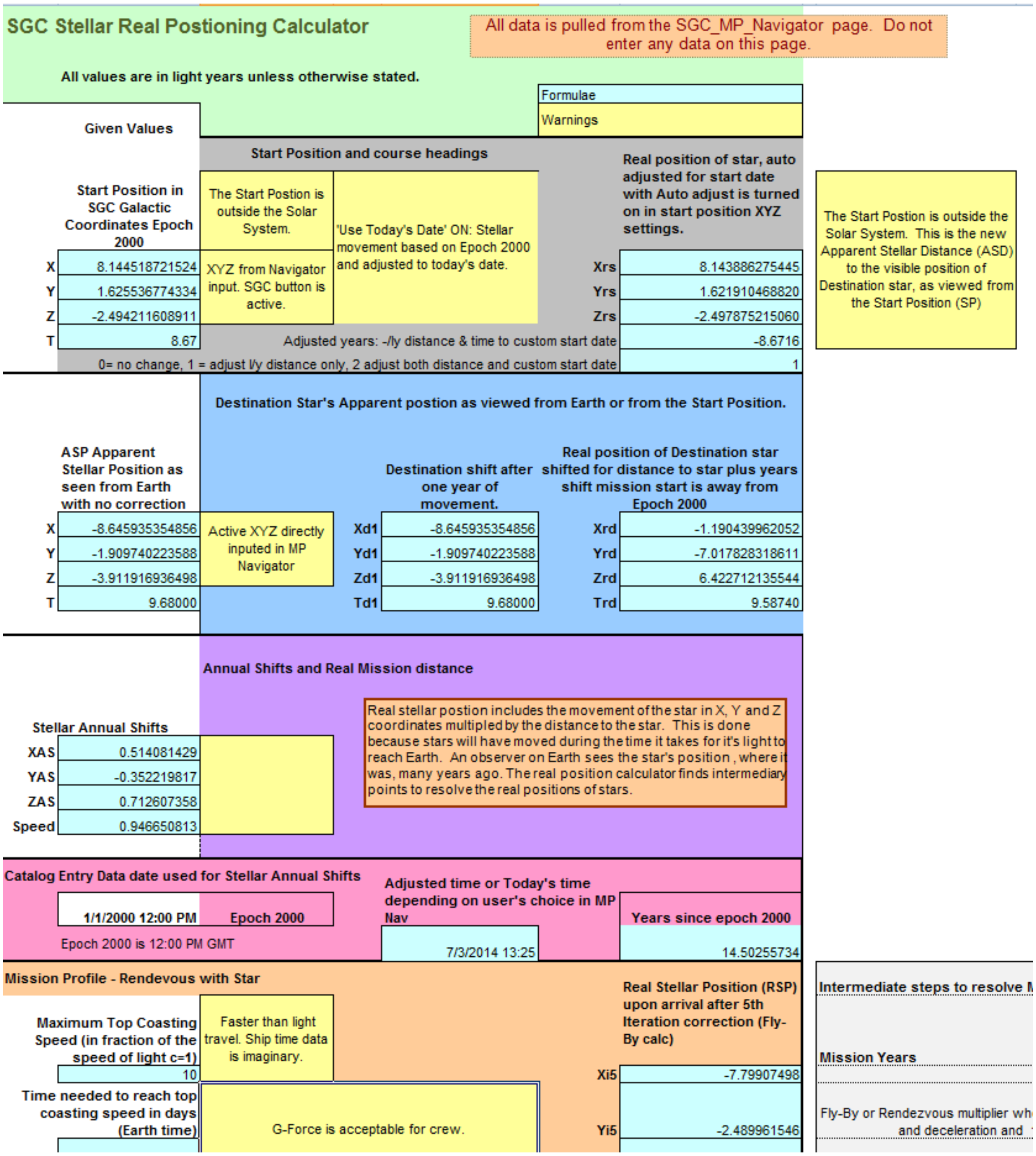
Converts Proper Motion values into XAS, YAS, ZAS (Annual Shifts)

Galactic Calculator



Converts Right Ascension, declination and distance values into X, Y, Z

Real Position Calculator



Finding the real stellar position of the Destination star is important to correctly plot a mission profile. If the Destination star's Proper Motion is known, then the Stellar Dbase should have XAS, YAS, ZAS, Annual Shift values.

You can either choose the Destination star from the Stellar Dbase, or if you have better information, the star may be entered in “Use RA” button with the RA, declination and distance in light years, Proper Motion values are Shift in RA, Shift in dec per year, speed of approach or recession. If you enter this into MP Navigator Use RA areas, the MP Navigator will calculate the Annual Shifts and that information will be used to track the Destination star’s Real positions at the mission Start Date.

This Real positions are used to feed the correct position of the Destination Star to the next worksheet, Mission Types.

Mission Types

The mission times are found by using the 5th iteration values from the Mission Type Worksheet. Here the 5 iteration data can be seen. Below that is the auto sensor table for the Mission Types. It is important to track which mission type is valid, because some formulae need to change.

Mission Types and Mission Iterations

All data is pulled from the SGC_MP_Navigator page. Do not enter any data on this page.

Mission Type

		Mission Type is Rendezvous	2	Rendezovus possible?	Yes	
Destination Movement		Destination moves towards or away from Sol	-0.65342295	Destination actual speed	0.94665081	
Iterations	1	Acceleration leg distance l/y	0.00273785	Coasting leg distance	0.00000000	Mission Type 4: Half way speed correction not in use
		Acceleration and deceleration leg years	0.00109514	Coasting leg at top speed years	0.00000000	
		Distance to destination ly	17.21540534	Mission time in Earth years	0.00109514	
	2	Acceleration leg distance l/y	0.00273785	Coasting leg distance	17.20939562	
		Acceleration and deceleration leg years	0.00109514	Coasting leg at top speed years	1.72093956	0
		Distance to destination ly	17.21487132	Mission time in Earth years	1.72203470	
	3	Acceleration leg distance l/y	0.00273785	Coasting leg distance	16.42968176	
		Acceleration and deceleration leg years	0.00109514	Coasting leg at top speed years	1.64296818	0
		Distance to destination ly	16.43515747	Mission time in Earth years	1.64406332	
	4	Acceleration leg distance l/y	0.00273785	Coasting leg distance	16.46232166	
		Acceleration and deceleration leg years	0.00109514	Coasting leg at top speed years	1.64623217	0
		Distance to destination ly	16.46779736	Mission time in Earth years	1.64732731	
	5	Acceleration leg distance l/y	0.00273785	Coasting leg distance	16.46094997	
		Acceleration and deceleration leg years	0.00109514	Coasting leg at top speed years	1.64609500	0
		Distance to destination ly	16.46642567	Mission time in Earth years	1.64719014	
		Acceleration leg = % total mission time	0.02%			
		Distance to destination from Earth ly	8.63262586			
Improved accuracy after iterations				Accuracy improved between 1st and 5th iterations	-4.54852611%	
				Change of destination star's position, after 5 iterations in trillions of kilometers	-7,085.895	
				Distance change after 5 iterations in light years	-0.748979671	

Mission Data

Sensor Range	5	Julian Year	
Given Top Speed	10		
Corrected Top Speed	10.00000000	Not used	
Days to top speed	0.2		
		De	
		Destination Annual Shif	
		2nd order correctio	
		3rd order correctio	
		4th order correctio	
		5th order correctio	
Misc. mission data		M	
		Distance to end of acceleration (could be after mission end in sl	
		Acceleration slope angle based on user inputs: speed, time to	
		Mission time i	
Rendezvous mission type 4, where top speed is not reached at half way point.		Is distance to end of	
		Halfway	
		N	
Fly-by mission type 5 with top speed not reached even when passing destination		Distance e	
		Fly-by mission doe	
Check to see if fly-by sensor data needs to be updated when the user changes some value.			

1st iteration values. All times based on Earth time.

With your fast Star Trek - Warp 2 Starship, rendezvous with Starship B is mid-space at only, 10% into Starship B's mission. | Your own Starship's Mission is Type 2: Rendezvous with a coasting leg (Top speed is reached before mid-point)

Mission Type	2	distance	time				
Mission Type (all values are based on Earth time)	Type test	Acceleration leg distance l/y	Acceleration duration years	Coasting leg distance l/y	Coast at top speed years	Accel + Decel legs in years	Mission duration (all legs) in Earth years
Type 1: Fly-by with a coasting leg (your top speed is reached before mid-point)	no	0.00	0.00	0.00	0.00	0.00	0.00
Type 2: Rendezvous with a coasting leg (Top speed is reached before mid-point)	yes	0.00	0.00	0.00	0.00	0.00	0.00
Type 3: Fly-by: Starship reaches full speed during the mission.	no	0.00	0.00	0.00	0.00	0.00	0.00
Type 4: Rendezvous Inverted V (Top speed is auto cut at half way point to start deceleration). Top speed at midpoint is: 0 c	no	0.00	0.00			0.00	0.00
Type 5) Fly-by with no coasting leg. Top speed is not reached when destination star is passed.	no	0.00	0.00			0.00	0.00
Type 6: Destination moves too fast. Your Starship cannot catch it.	no	0.00					0.00

Accuracy Checks

Destination Distance	99.97%		
Mission Duration	100.00%		
Halfway speed check	100.00%		
Check Accel + Coast + Decel	100.00%		
49.75% mission Slice 99	100.00%	Mid-Point top speed does not reach user input top speed. Type 4 or Type 5 missions	100% c
50.25% mission Slice 100	100.00%	Mid-Point top speed does does not reach user input top speed. Type 4 or Type 5 missions	100% c
Slice 200 speed compared to expected	100.00%		

The types of missions are based on real issues.
Fly-by mission type:

Type 1: Reach top speed before Mid-point
Type 3: Reach top speed after Mid-point but before mission end
Type 5: Does not reach top speed by end of mission (Destination Fly-by)

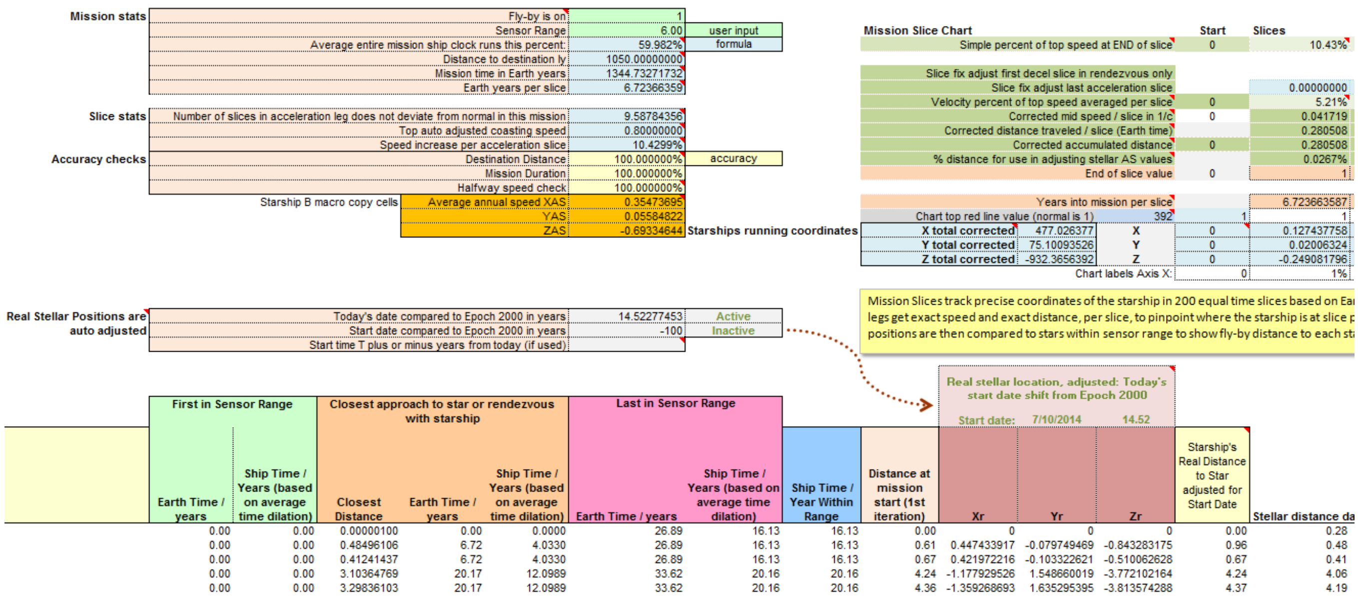
Rendezvous mission type:

Type 2: Reaches top speed before Mid-point
Type 4: Does not reach top speed before Mid-point. (This causes MP Navigator to automatically truncate acceleration to a slower top speed at Mid-point and immediately start deceleration.)

Type 6: Destination star moves too fast to catch for the Starship with the chosen Engine type and speed profile.

The Mission Type worksheet also does the 5 mission iterations to redo mission distance and legs to solve the hit a moving target problem.

Fly-by Calculator



The Fly-by Calculator worksheet is extremely complex. It is used to plot the Starship's position in 200 slice points along the mission. If nearby stars fall within Sensor Range, they are tracked for their Real Positions in coordinate space at the 200 slice points.

Examples Excel worksheet logic

The next three example problems, trace through the logic of just a few of the values found in the Fly by Calculator:

1) Fix the last acceleration inaccurate slice problem
2) How far a star is at mission start
3) When is a star closest to the Starship.

The Fly-by calculator checks 4000+ locations that could be within range on all 200 Slices points and gives sort able results. These examples are only to give you an idea of the type of complexity in this, under the hood, worksheet.

Acceleration Last Slice fix

Getting the last bit of accuracy on the acceleration leg was a tricky problem. As mentioned above in the section on Special case Slice problem, the last acceleration leg slice needs special consideration. Inside that mission slice, the ship accelerates, reaches top speed and then coasts. The distance covered is not quite a coasting leg, yet it is faster than an acceleration leg. Unless there is an adjustment for this slice, the accuracy will always be off. Let's fix it once and for all.

We need to find this last acceleration slice. You have already given us the information we need. "Time to top speed" is the length of the acceleration slice. Let's say you enter 400 days.

We can find the Earth year duration of each slice. That is simply the entire mission duration divided by 200. So if mission duration is 10 years divide by 200 = each slice is 0.2 of a year. If you put in the "Time to top speed" as 400 days, then the number of slices in the acceleration leg would be

```
400 / 365.25 / 0.2 = 5.4757
```

(365.25 is a Julian year which is used for light years and the MP Navigator).

What we are interested in is that result. 5.4757. That means the last acceleration leg is the 6th slice and in that slice:

Acceleration goes for 47.57% of the slice.

The rest of the slice is top coasting speed and that will last:

```
1 - 47.57% = 52.43%
```

Coasting goes for 52.43% of that slice.

If you add the two different distances covered in the slice, the acceleration segment + the full coasting speed segment; you will always get a further distance than if you considered the whole slice as just another acceleration slice. So, we always have to add in a little distance to this one slice and, if the mission is a rendezvous, add in the same amount to the first deceleration slice.

How do you do that in Excel?

AD10 f_x =(AD9*$T$7)+AD7

	W–Z	AA	AB	AC	AD	AE
1			Cell AD10 without adjustment		0.018121	
2						
3	**Mission Slice Chart**	**Start**	**Slices**			
4	Simple percent of top speed at END of slice	0	36.70%	73.40%	100.00%	100.00%
5						
6	Slice fix adjust first decel slice in rendezvous only					
7	Slice fix adjust last acceleration slice		0.00000000	0.00000000	0.00076515	0.00000000
8	Velocity percent of top speed averaged per slice	0	18.35%	55.05%	86.70%	100.00%
9	Corrected mid speed / slice in 1/c	0	0.146804	0.440413	0.693609	0.800000
10	Corrected distance traveled / slice (Earth time)		0.003835	0.011506	0.018886	0.020900
11	Corrected accumulated distance	0	0.003835	0.015341	0.034227	0.055127
12	% distance for use in adjusting stellar AS values		0.0930%	0.3721%	0.8301%	1.3370%
13	End of slice value	0	1	2	3	4

Look at row 7. This is the adjustment row for last acceleration slices. The formulae in row 7 only shows a value for the correct slice. In this example, slice #3 in column AD. Let's skip the formula in AD7 and look at AD10 first.

AD10

```
=(AD9*$T$7)+AD7
```

AD9 = Average velocity for that acceleration slice
T7 = Earth Years per slice

Notice that only AD7 has the number correction. The other cells in row 7 do not.

Just to show the change, I've put temporary cell info with the value of no correction in a box above in cell AD1 = 0.018121. That is the value in cell AD10 that was adjusted upward to 0.018886.

There are formulae inside the cells in row 7 that looks first for slice numbers in row 13, finds the correct slice and adds the adjustment. If it's not that special slice, it just shows 0. This is the way the one correct slice is adjusted upwards for distance covered. The same is done in reverse for the 1st deceleration slice. Both these patches solve the accuracy issue and make the Destination distance match 100% to the accuracy test for simple missions without other issues.

Fly-by Calc – Mission Stats area:

	L–N	O–S	T	U
1				
2	Mission stats	Rendezvous is on	2	
3		Sensor Range	6.00	user input
4		Average entire mission ship clock runs this percent:	59.990%	formula
5		Distance to destination ly	4.12310563	
6		Mission time in Earth years	5.22506615	
7		Earth years per slice	0.02612533	
8				
9	Slice stats	Number of slices in acceleration leg does not deviate from normal in this mission	2.72471653	
10		Top auto adjusted coasting speed	0.80000000	
11		Speed increase per acceleration slice	36.7011%	
12	Accuracy checks	Destination Distance	100.000000%	accuracy
13		Mission Duration	100.000000%	
14		Halfway speed check	100.000000%	

Last acceleration Slice adjustment Excel formula

For those die hard Excel gurus, here is the formula inside Cell AD7 that finds and adjusts upward the distance covered in the last acceleration slice, with the value: 0.00076515:

```
=IF(FLOOR($T$9,1)+1=AD13,
SUM(AD8*$T$10*$T$7*(MOD($T$9,1))
+(SUM(1-MOD($T$9,1))*$T$10*$T$7)
-AD9*$T$7)
,0)
```

T7 = Earth years per slice
T9 = Number of acceleration slices
T10 = Top speed

AD8 = Velocity percent of top speed averaged per slice
AD9 = Corrected mid speed / slice in 1/c
AD13 = Slice number

First Deceleration slice adjustment Excel formula

Over in the far end of the mission, the deceleration fix looks like this:

HQ6 =IF($T$2=2,IF(200-FLOOR($T$9,1)=HQ13,SUM(HQ8*$T$10*$T$7*(MOD($T$9,1))+(SUM(1-MOD($T$9,1))*$T$10*$T$7)-HQ9*$T$7),0))

	HP	HQ	HR	HS	HT	HU
1						
2	100.00%	100.00%	100.00%	100.00%	100.00%	Math for fly-by missions
3	100.00%	73.40%	36.70%	0.00%	0.00%	Math for Rendezvous mission
4	100.00%	73.40%	36.70%	0.00%	0.00%	Simple percent of top speed at END of slice
5						
6	0.00000000	0.00076515	0.00000000	0.00000000		Slice fix adjust first decel slice in rendezvous only
7	0.00000000	0.00000000	0.00000000	0.00000000		Slice fix adjust last acceleration slice
8	100.00%	86.70%	55.05%	18.35%	0.00%	Velocity percent of top speed averaged per slice
9	0.800000	0.693609	0.440413	0.146804	0.000000	Corrected mid speed / slice in 1/c
10	0.020900	0.018886	0.011506	0.003835		Corrected distance traveled / slice (Earth time)
11	4.088878	4.107764	4.119270	4.123106		Corrected accumulated distance
12	99.1699%	99.6279%	99.9070%	100.0000%		% distance for use in adjusting stellar AS values And error due to Exc
13	197	198	199	200	201	End of slice value
14						

Notice that Row 6 has the adjustment for the deceleration leg, while row 7 does nothing. In Cell HQ6 formula, the $T$2 = 2 tests that the mission is a rendezvous.

Row 7 still looks for the unusual situation where the last acceleration leg may actually be up around 198, 199, 200. But this only is possible for Fly-by mission types and you enter a very long time to top speed. Row 7 in the last half of the mission will always show 0 for rendezvous missions because the MP Navigator forces deceleration and maxes out the number of slices in the acceleration leg to 100 for rendezvous mission types:

That HQ6 formula is:

```
=IF($T$2=2,IF(200-FLOOR($T$9,1)=HQ13,
SUM(HQ8*$T$10*$T$7*(MOD($T$9,1))
+(SUM(1-MOD($T$9,1))*$T$10*$T$7)
-HQ9*$T$7)
,0))
```

T7 = Earth years per slice
T9 = Number of acceleration slices
T10 = Top speed

HQ8 = Velocity percent of top speed averaged per slice
HQ9 = Corrected mid speed / slice in 1/c
HQ13 = Slice number

Stellar distances at a slice point

Now let's look at another area of the Fly by Calculator Worksheet, the area with star distances from the ship.

Take an example mission from Alpha Centauri to Leonis CN Wolf 359. Sensor range is set to 6 light years. The worksheet will look to see if a star cannot be in sensor range and then not bother to make any further computations. Let's have a look at a partial Mission Profile Report on this trip. It's easier to see the data there.

Interstellar Mission Profile for SGC Navigator - Report - Printable ver 1.1

Start: Centauri Alpha Cen Rigil KenTauri Rigil Kent Tolim	Dest: Leonis CN Leo Wolf 359
Mission Profile - Rendezvous	**Earth date arrival:** Sunday, February 26, 2023
Ship Type: Antimatter Intertial Flux	**Ship date arrival:** Thursday, August 27, 2015
Type 2: Rendezvous with a coasting leg (Top speed is reached before mid-point)	

Sensor Range Report
Range 6 ly

	Star	Type	Star #2 or info	Alerts	Distance at mission start
1	Centauri Alpha Cen Rigil KenTauri Rigil Kent Toliman	G2 V	B C	Starting Position	0.00
2	Centauri Proxima	M5.5 V	(red dw arf in Alpha Cen)		0.20
3	Pictoris Eta2 Pic	M2III var			4.14
4	Solar System Sol	G2 V	Sol		4.36
5	Leporis Lambda Lep	B0.5IV			4.55
6	Leonis CN Leo Wolf 359	M6.5	(red dw arf)	Destination	8.33
7	Ursae Majoris Lalande 21185 BD+36°2147	M2.1 V	B flare star?		10.43
8	Ophiuchi Barnard's Star	M3.8 V	(fastest stellar motion)		6.45
9	Sagittarii Ross 154 GL 729 V1216 Sgr	M3.6 V	(Gl 729) (red dw arf)		8.11
10	Ursae Majoris HAT-P-13	K4	b Jupiter sized planet		8.40

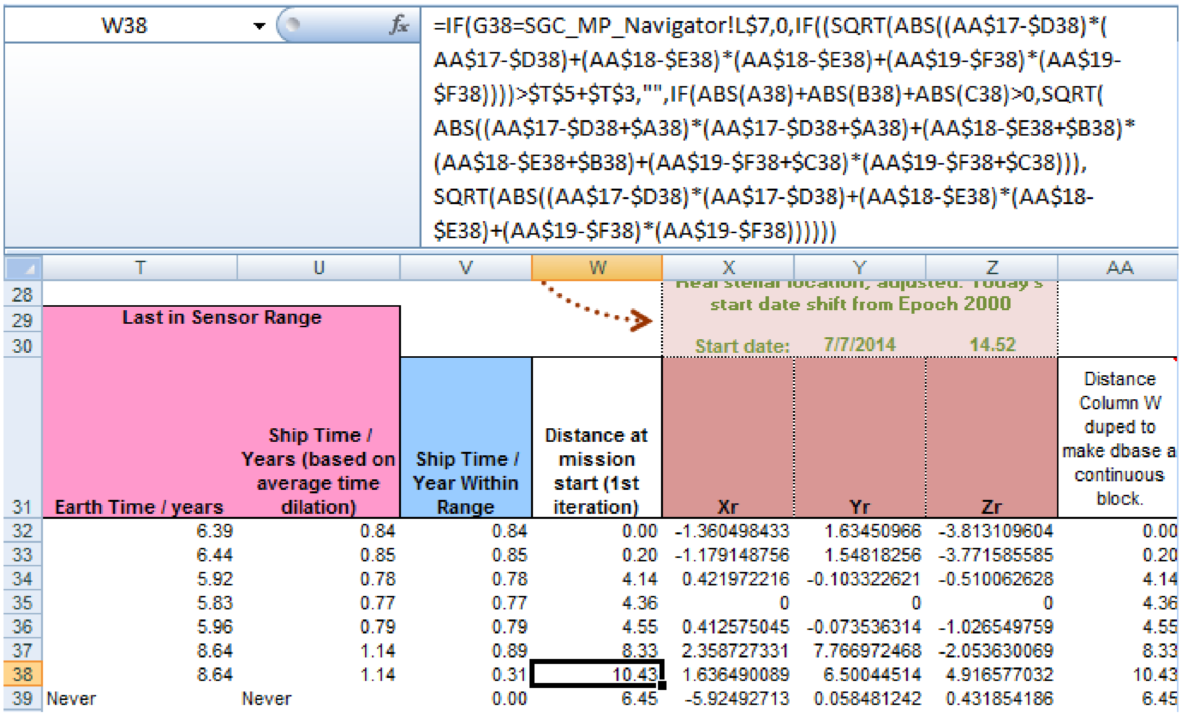
	First in Sensor Range		Closest Approach to Star			Last in Sensor Range		Ship time Within Range
	Ship Time	Earth Time	Distance	Earth Time	Ship Time	Earth Time	Ship Time	
1	0.00	0.00	0.00	0.00	0.00	6.39	0.84	0.84
2	0.00	0.00	0.20	0.26	0.03	6.44	0.85	0.85
3	0.00	0.00	4.00	1.43	0.19	5.92	0.78	0.78
4	0.00	0.00	4.21	1.56	0.20	5.83	0.77	0.77
5	0.00	0.00	3.67	1.12	0.15	5.96	0.79	0.79
6	1.86	0.24	0.00	8.64	1.14	8.64	1.14	0.89
7	6.31	0.83	5.23	8.64	1.14	8.64	1.14	0.31
8	Never	Never	Out of range			Never	Never	0.00
9	Never	Never	Out of range			Never	Never	0.00
10	Never	Never	Out of range			Never	Never	0.00

The Fly-by calculator has the formulae to find these values. Look at the two rows labeled 7 above. Ursae Majoris Lalande 21185. Mission start is 10.43 light years. In the Closest approach to Star (orange header area), we see it just gets as close as 5.23 when the ship is 8.64 years into the mission.

As an example of how the formulae works, here are the cells in the Fly-by Calculator to find those two values. Many of the “IF” functions check for the star being within Sensor range.

Distance at Mission Start

Fly_by_calc worksheet
Cell W38



W38 =IF(G38=SGC_MP_Navigator!L$7,0,IF((SQRT(ABS((AA$17-$D38)*(AA$17-$D38)+(AA$18-$E38)*(AA$18-$E38)+(AA$19-$F38)*(AA$19-$F38))))>$T$5+$T$3,"",IF(ABS(A38)+ABS(B38)+ABS(C38)>0,SQRT(ABS((AA$17-$D38+$A38)*(AA$17-$D38+$A38)+(AA$18-$E38+$B38)*(AA$18-$E38+$B38)+(AA$19-$F38+$C38)*(AA$19-$F38+$C38))),SQRT(ABS((AA$17-$D38)*(AA$17-$D38)+(AA$18-$E38)*(AA$18-$E38)+(AA$19-$F38)*(AA$19-$F38))))))

	T	U	V	W	X	Y	Z	AA
28					Real stellar location, adjusted. Today's			
29	Last in Sensor Range				start date shift from Epoch 2000			
30					Start date:	7/7/2014	14.52	
31	Earth Time / years	Ship Time / Years (based on average time dilation)	Ship Time / Year Within Range	Distance at mission start (1st iteration)	Xr	Yr	Zr	Distance Column W duped to make dbase a continuous block.
32	6.39	0.84	0.84	0.00	-1.360498433	1.63450966	-3.813109604	0.00
33	6.44	0.85	0.85	0.20	-1.179148756	1.54818256	-3.771585585	0.20
34	5.92	0.78	0.78	4.14	0.421972216	-0.103322621	-0.510062628	4.14
35	5.83	0.77	0.77	4.36	0	0	0	4.36
36	5.96	0.79	0.79	4.55	0.412575045	-0.073536314	-1.026549759	4.55
37	8.64	1.14	0.89	8.33	2.358727331	7.766972468	-2.053630069	8.33
38	8.64	1.14	0.31	10.43	1.636490089	6.50044514	4.916577032	10.43
39	Never	Never	0.00	6.45	-5.92492713	0.058481242	0.431854186	6.45

The first "IF" checks to see if the star is within range. The rest solves the 3D Pythagorean formula and makes sure there is no square root of a negative.

```
=IF(G38=SGC_MP_Navigator!L$7,0,
IF((SQRT(ABS((AA$17-$D38)*
(AA$17-$D38)+(AA$18-$E38)*
(AA$18-$E38)+(AA$19-$F38)*
(AA$19-$F38))))
>$T$5+$T$3,
"",
IF(ABS(A38)+ABS(B38)+ABS(C38)>0,
SQRT(ABS((AA$17-$D38+$A38)*
(AA$17-$D38+$A38)+
(AA$18-$E38+$B38)*
(AA$18-$E38+$B38)+
(AA$19-$F38+$C38)*
(AA$19-$F38+$C38))),
```

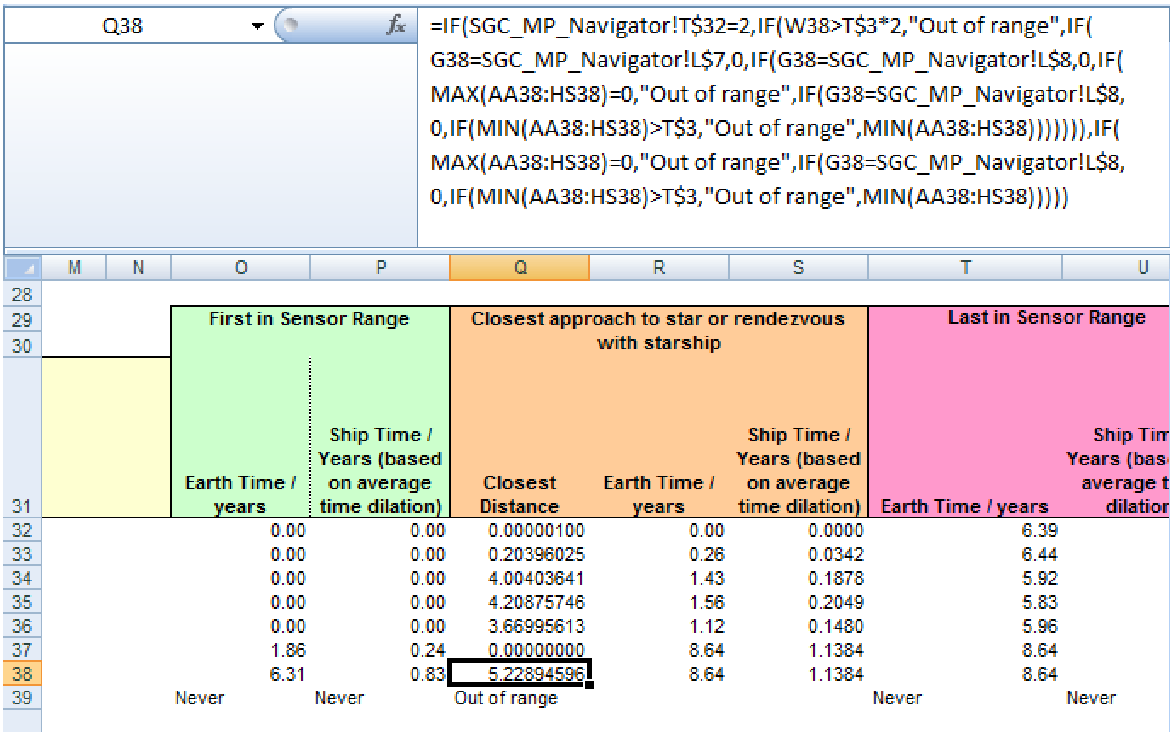
```
SQRT(ABS((AA$17-$D38)*
(AA$17-$D38)+
(AA$18-$E38)*
(AA$18-$E38)+
(AA$19-$F38)*
(AA$19-$F38))))))
```

G38 = Name of Star (If the star happens to be the Start Position, then forced 0 for Distance at Mission Start)

SGC_MP_Navigator!L$7 = (The name of the current Start Position)
AA17 = Adjusted X coordinate real Start Position of Starship
AA18 = Adjusted Y coordinate real Start Position of Starship
AA19 = Adjusted Z coordinate real Start Position of Starship
A38 = XAS Annual Shift of this star
B38 = YAS Annual Shift of this star
C38 = ZAS Annual Shift of this star
D38 = X Epoch 2000 Coordinate of Star before any Auto Shift
E38 = Y Epoch 2000 Coordinate of Star before any Auto Shift
F38 = Z Epoch 2000 Coordinate of Star before any Auto Shift
T3 = Sensor range in light years
T5 = 5th iteration distance to Destination

Finding the closest the Starship gets to the star, means looking along that star's row for all the distances the star is from the Starship for each Slice point. From AB38:HS38

This is in Cell Q38



Q38 fx =IF(SGC_MP_Navigator!T$32=2,IF(W38>T$3*2,"Out of range",IF(G38=SGC_MP_Navigator!L$7,0,IF(G38=SGC_MP_Navigator!L$8,0,IF(MAX(AA38:HS38)=0,"Out of range",IF(G38=SGC_MP_Navigator!L$8,0,IF(MIN(AA38:HS38)>T$3,"Out of range",MIN(AA38:HS38))))))),IF(MAX(AA38:HS38)=0,"Out of range",IF(G38=SGC_MP_Navigator!L$8,0,IF(MIN(AA38:HS38)>T$3,"Out of range",MIN(AA38:HS38))))

	M	N	O	P	Q	R	S	T	U
28									
29			First in Sensor Range		Closest approach to star or rendezvous with starship			Last in Sensor Range	
30									
31			Earth Time / years	Ship Time / Years (based on average time dilation)	Closest Distance	Earth Time / years	Ship Time / Years (based on average time dilation)	Earth Time / years	Ship Tim Years (bas average t dilation
32			0.00	0.00	0.00000100	0.00	0.0000	6.39	
33			0.00	0.00	0.20396025	0.26	0.0342	6.44	
34			0.00	0.00	4.00403641	1.43	0.1878	5.92	
35			0.00	0.00	4.20875746	1.56	0.2049	5.83	
36			0.00	0.00	3.66995613	1.12	0.1480	5.96	
37			1.86	0.24	0.00000000	8.64	1.1384	8.64	
38			6.31	0.83	5.22894596	8.64	1.1384	8.64	
39			Never	Never	Out of range			Never	Never

Many "IF" checks to see if the star is out of range. In Q38, we see it is in sensor range.

Notice the star on the next row down in the Mission report above, on row #8 Barnard's Star is Out of range. This corresponds with Fly by Calculator row 39.

Inside Cell Q38

```
=IF(SGC_MP_Navigator!T$32=2,
IF(W38>T$3*2,"Out of range",
IF(G38=SGC_MP_Navigator!L$7,0,
IF(G38=SGC_MP_Navigator!L$8,0,
IF(MAX(AA38:HS38)=0,"Out of range",
  IF(G38=SGC_MP_Navigator!L$8,0,
IF(MIN(AA38:HS38)>T$3,"Out of range",
MIN(AA38:HS38))))))),
IF(MAX(AA38:HS38)=0,"Out of range",
IF(G38=SGC_MP_Navigator!L$8,0,
```

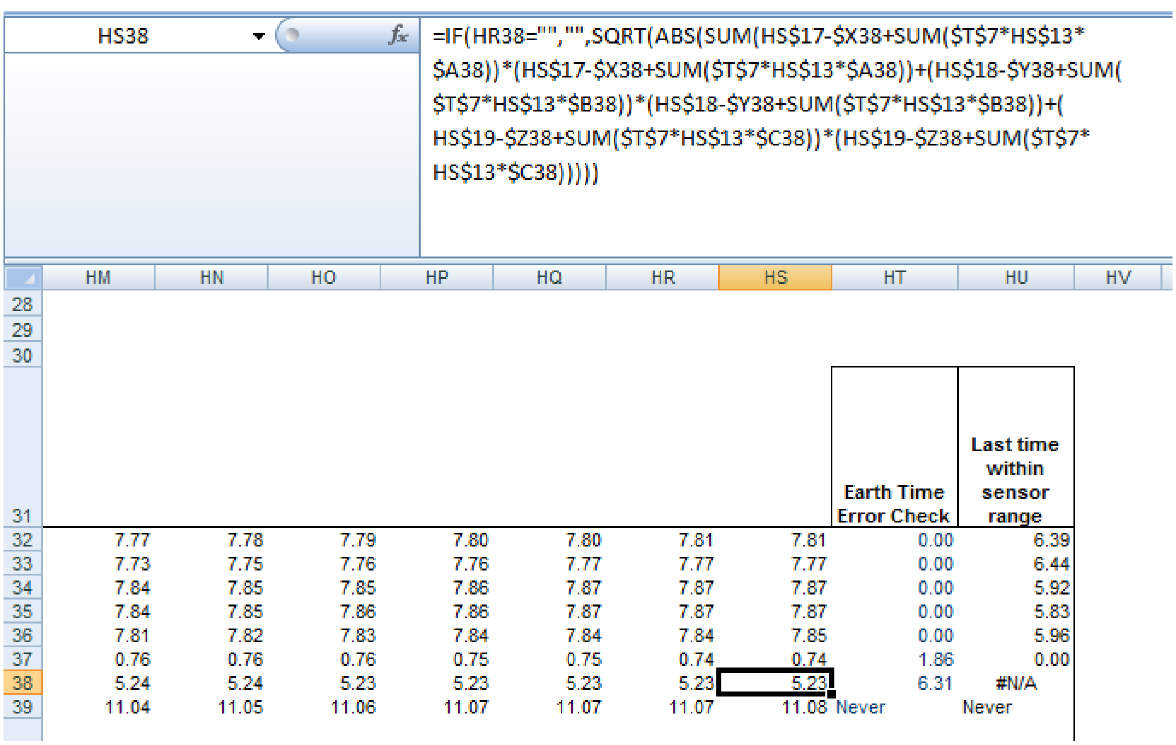
```
IF(MIN(AA38:HS38)>T$3,"Out of range",
MIN(AA38:HS38)))))
```

G38 = Name of Starting Point
SGC_MP_Navigator!T32 = Fly-by =1 or Rendezvous =2
W38 = Distance to star at Mission Start – 1st iteration
AA38:HS38 = all 200 slice point distance to star
SGC_MP_Navigator!L$8 = Name of Destination Star
F38 = Z Epoch 2000 Coordinate of Star before any Auto Shift
T3 = Sensor range in light years

The Cell that finds the closest approach.

The cell that shows the closest approach, in this case is the last cell checking the last mission slice, the Starship is on arrival to Leonis CN Wolf 359 is closest to Ursae Majoris Lalande and it is within the 6 light year sensor range, set by you.

Cell HS38



HS38

```
=IF(HR38="","",SQRT(ABS(SUM(HS$17-$X38+SUM($T$7*HS$13*$A38))*(HS$17-$X38+SUM($T$7*HS$13*$A38))+(HS$18-$Y38+SUM($T$7*HS$13*$B38))*(HS$18-$Y38+SUM($T$7*HS$13*$B38))+(HS$19-$Z38+SUM($T$7*HS$13*$C38))*(HS$19-$Z38+SUM($T$7*HS$13*$C38)))))
```

	HM	HN	HO	HP	HQ	HR	HS	HT	HU	HV
28										
29										
30										
31								Earth Time Error Check	Last time within sensor range	
32	7.77	7.78	7.79	7.80	7.80	7.81	7.81	0.00	6.39	
33	7.73	7.75	7.76	7.76	7.77	7.77	7.77	0.00	6.44	
34	7.84	7.85	7.85	7.86	7.87	7.87	7.87	0.00	5.92	
35	7.84	7.85	7.86	7.86	7.87	7.87	7.87	0.00	5.83	
36	7.81	7.82	7.83	7.84	7.84	7.84	7.85	0.00	5.96	
37	0.76	0.76	0.76	0.75	0.75	0.74	0.74	1.86	0.00	
38	5.24	5.24	5.23	5.23	5.23	5.23	5.23	6.31	#N/A	
39	11.04	11.05	11.06	11.07	11.07	11.07	11.08	Never	Never	

```
=IF(HR38="","",SQRT(ABS(SUM(HS$17-
$X38+SUM($T$7*HS$13*$A38))*
(HS$17-$X38+SUM($T$7*HS$13*$A38))+
(HS$18-$Y38+SUM($T$7*HS$13*$B38))*
```

```
(HS$18-$Y38+SUM($T$7*HS$13*$B38))+
(HS$19-$Z38+SUM($T$7*HS$13*$C38))*
(HS$19-$Z38+SUM($T$7*HS$13*$C38))
)))
```

HR38 = Just checks if the previous cell on the row has any value, if not, then the calculation stops. This is only to optimize the formulae and stop the worksheet from making unnecessary computations.

T7 = Earth years per slice
X38 = Xr Real coordinate of this star at Start Date
Y38 = Yr Real coordinate of this star at Start Date
Z38 = Zr Real coordinate of this star at Start Date
HS17 = X Coordinate at Slice Point
HS18 = Y Coordinate at Slice Point
HS19 = Z Coordinate at Slice Point
HS13 = Slice number
A38 = XAS Annual Shift of this star
B38 = YAS Annual Shift of this star
C38 = ZAS Annual Shift of this star

The closest approach value in HS38 cell pulls from the Slice mission data above which shows exactly where the Starship is in coordinate space for that slice. Starship coordinates are in HS17, HS18, HS19.

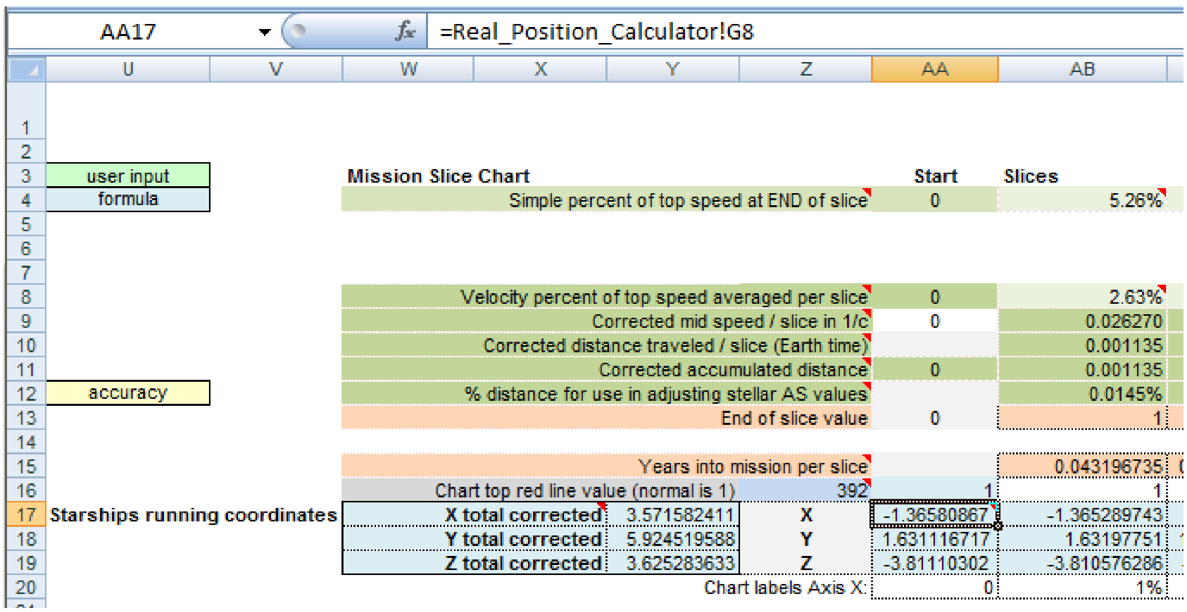
HS17 | =HS12*$Y17+$AA$17

	HQ	HR	HS	HT	HU
1					
2	100.00%	100.00%	100.00%	100.00%	Math for fly-by missions
3	10.52%	5.26%	0.00%	0.00%	Math for Rendezvous mission
4	10.52%	5.26%	0.00%	0.00%	Simple percent of top speed at END of slice
5					
6					
7					
8	13.15%	7.89%	2.63%	0.00%	Velocity percent of top speed averaged per slice
9	0.131349	0.078809	0.026270	0.000000	Corrected mid speed / slice in 1/c
10	0.005674	0.003404	0.001135		Corrected distance traveled / slice (Earth time)
11	7.805603	7.809007	7.810142		Corrected accumulated distance
12	99.9415%	99.9851%	99.9996%		% distance for use in adjusting stellar AS values And error due to Excel
13	198	199	200	201	End of slice value
14					
15	8.55295355	8.59615029	8.63934702		Years into mission per slice
16	1	1	1	1	
17	2.20368341	2.2052402	2.20575912	0.00001462	X total corrected (Errors < .1 due to Excel 15 decimal limitation)
18	7.55216888	7.55475126	7.55561206	0.00002425	Y total corrected
19	-0.1879411	-0.1863609	-0.1858342	0.00001484	Z total corrected
20	99%	100%	100%	100%	
21					

The Starship's X, Y and Z are found by pulling from:

HS12 = % Distance into the mission
Y17 = Total X coordinate shift from Start Position to Destination.
AA17 = Adjusted X coordinate real Start Position of Starship.

Cell AA17 – The real X coordinate of a star auto adjusted for distance and years back to Epoch 2000.



AA17 | =Real_Position_Calculator!G8

	U	V	W	X	Y	Z	AA	AB
1								
2								
3	user input		Mission Slice Chart				Start	Slices
4	formula					Simple percent of top speed at END of slice	0	5.26%
5								
6								
7								
8						Velocity percent of top speed averaged per slice	0	2.63%
9						Corrected mid speed / slice in 1/c	0	0.026270
10						Corrected distance traveled / slice (Earth time)		0.001135
11						Corrected accumulated distance	0	0.001135
12	accuracy					% distance for use in adjusting stellar AS values		0.0145%
13						End of slice value	0	1
14								
15						Years into mission per slice		0.043196735
16					Chart top red line value (normal is 1)	392	1	1
17	Starships running coordinates			X total corrected	3.571582411	X	-1.36580867	-1.365289743
18				Y total corrected	5.924519588	Y	1.631116717	1.63197751
19				Z total corrected	3.625283633	Z	-3.81110302	-3.810576286
20						Chart labels Axis X:	0	1%

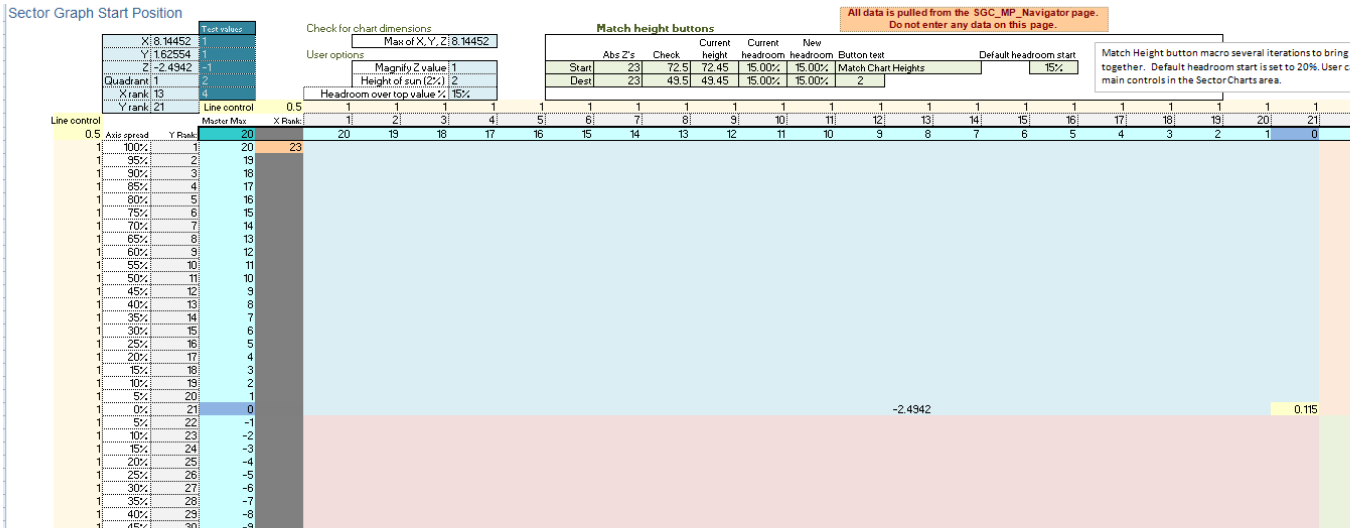
AA17 =Real_Position_Calculator!G8

The Real Position calculator finds the Real Coordinates of the Start position and auto adjusts for any Stellar Dbase start that has Proper Motion data. A star 10 light years distant with a mission start date in mid 2014 would get auto adjusted along its galactic orbit by 10 years plus 14.5 years (time back to January 1, 2000 – Epoch 2000).

Fly-By Worksheet Examples Summary:

The above examples are only to show the type of complexity that is needed to resolve some Navigation problems. Each Worksheet has many more functions that all work together.

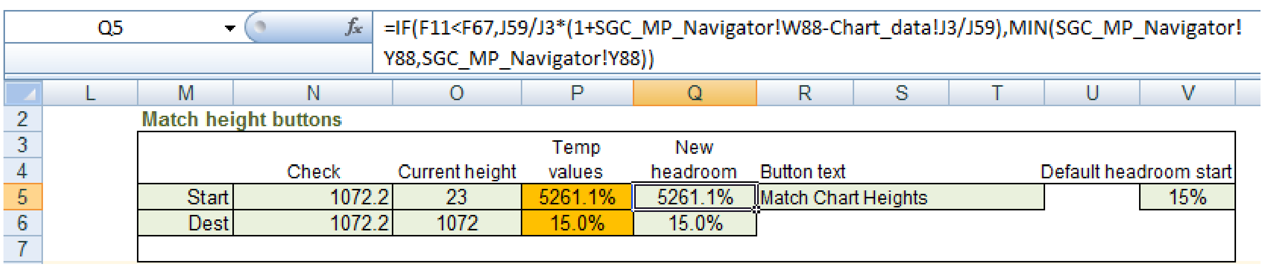
Chart Data



This is where the 3D sector chart data automatically updates. Getting the chart to auto update, no matter what distance the star is from Earth is very tricky. The axis have to automatically grow and keep a headroom value that you give from the Main Control MP Navigator page, 3D Sector Charts area.

Match Height Button

Also on this page is the formulae for making both charts the same height. A code challenge that was amazingly complex to get right. It has to match the height of the Start Position Graph with the height of the Destination by auto adjusting the Headroom percent. You can give the preferred minimum headroom value and the Macro button makes the match.



Q5 =IF(F11<F67,J59/J3*(1+SGC_MP_Navigator!W88-Chart_data!J3/J59),MIN(SGC_MP_Navigator!Y88,SGC_MP_Navigator!Y88))

	L	M	N	O	P	Q	R	S	T	U	V
2		Match height buttons									
3					Temp	New					
4			Check	Current height	values	headroom	Button text				Default headroom start
5		Start	1072.2	23	5261.1%	5261.1%	Match Chart Heights				15%
6		Dest	1072.2	1072	15.0%	15.0%					
7											

The formulae in Q5, above and Q6 track the problem of the Z Axis height not matching. The current height is 23 vs. 1072 in column O. So Q5 and Q6 create a solution. Your preferred headroom from the 3D Sector charts, duplicated here in cell V5 is always to be the lower new headroom value. The other value is exactly what is needed to make the height match. See the check in column N.

The Macro first makes both values your preference, here it is 15%. Then it copies the values from Q5 and Q6 to number only into the orange P5 and P6. Then this value is taken to update the 3D sector values on the main MP Navigator page. This extra step is needed, because if you updated value Q5, then Q6 would change and the match wouldn't work. You need to find the correct values, copy them out to the orange temporary cells P5, and P6 and then copy those as the new values that will correctly match the chart heights.

Cell Q5

```
=IF(F11<F67,J59/J3*(1+SGC_MP_Navigator!W88-
Chart_data!J3/J59),MIN(SGC_MP_Navigator!Y88,SGC_MP_Navig
ator!Y88))
```

Cell Q6

```
=IF(F67<F11,J3/J59*(1+SGC_MP_Navigator!W88-
Chart_data!J59/J3),MIN(SGC_MP_Navigator!Y88,SGC_MP_Navig
ator!AC88))
```

Where:
Start Position Chart:
F11 = Top of chart with current headroom added
J3 = Absolute value Maximum of X, Y, Z but not less than 20

Destination Position Chart:
F67 = Top of chart with current headroom added
J59 = Absolute value Maximum of X, Y, Z but not less than 20

MP Navigator 3D Sector user entries:
SGC_MP_Navigator!W88 = Default headroom
SGC_MP_Navigator!Y88 = Headroom Start Position Chart
SGC_MP_Navigator!AC88 = Headroom Destination Chart

Course Headings

Course Heading Calculator: Converts change in X, Y, Z to RA 0 to <360 degrees, declination 0 North to 180 South

Course heading between start point and destination rendezvous after adjustments
XYZ difference data from Start to Destination 5th iteration

All data is pulled from the SGC_MP_
Do not enter any data on thi

Difference in X	-15.9429612557
Difference in Y	-4.1118720151
Difference in Z	-0.2401441618

Formulae to find RA, dec and distance
Finding the correct Right Ascension conversion to 360 degre

New RA 360 (decimal) Course heading	194.4620705377
declination astronomical standard (decimal)	-0.8356236508
Convert to (0 North -180 South degree) declination heading	90.8356236508
Distance ly	16.4664256682

Demo showing the conversion for RA - Change X and Y below to see it work

X	0				
Y	0	180.000			
	X Y entries	**0 0**	**0 -1**	**1 0**	**0 1**
	Old	Test for Z+ than) or Z- then 180	0	90	180
	Corrected		270	0	90

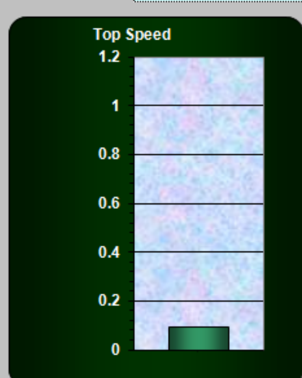
Formulae to find the Course Headings for any Start Position to any Destination.

Speedometer

Data used to make the Speedometer chart

C3 OK - Checked for logic

		Number spacing	Speedo Numbers	
Speed	0.098000			
		10	0	
Area before needle	98	10	5	
Needle size	20	10	10	
Area after needle	912	10	15	
		10	20	
		10	25	
		10	30	
		10	35	
		10	40	
		10	45	
		10	50	Warning in formula E14 at mid point to show only when speed exceeds limit
		10	55	
		10	60	
		10	65	
		10	70	
		10	75	
		10	80	
		10	85	
		10	90	
		10	95	
		10	c	
Bottom non-movable buffer areas	515	-105		Optional text in formula E25 below chart enter to remove all text or number
Total to define bottom speedo area in dark green	1030	66.85		Totals to auto define pushing the last speedometer value to the right of center



Converting FTL light speeds to fictional Star Trek Warp Factors:

Star Trek Warp data	c multiple	Warp factor	fraction	difference to next warp factor
2	10	0.098		29
3	39			63
4	102			112
5	214			178
6	392			264
7	656			368
8	1024			492
9	1516			133
9.2	1649			260
9.6	1909			6003
9.9	3053			196463
9.99	7912			191604
9.9999	199516			86484
10	286000			28886000
14	29172000			
	Totals	0.098000		

In the Speedometer worksheet this table finds the exact Warp factor percentage according to the Star Trek online statistics. TL Star Trek Warp Speeds are shown next to the speedometer for FTL type missions.

16. SGC X, Y, Z coordinates:

This spreadsheet is based on Right Ascension and Earth Polar rather than galactic polar. It is more convenient NOT to change all Right Ascension and declination to a galactic polar. The original abbreviation, SGC stands for Shuster Galactic Coordinates.

This system's XYZ coordinates are:

```
X+ = RA 6h declination 0
Y+ = RA 12h declination 0
X- = RA 18h declination 0
Y- = RA 0h declination 0
Z+ = RA 12h declination 90
Z- = RA 0h declination -90
```

Unfortunately this does not divide the Galaxy very well:

Approximate galactic center about 26,250 light years away becomes:

```
X = −23451 Y = 1469 Z = 13299
```

I'd rather have this coordinate be:

```
Galactic Center: X = 0, Y = −26250, Z = 0
```

It makes more sense to stick with RA values determining the axis, for now. Converting everything to galactic coordinates is an extra step. It adds an extra step to calculations and has no discernible benefit for this project.

The Stellar Dbase has many galactic way-points in the Stellar Dbase already. Galactic locations such as the edges of our local bubble of stars in the Orion Spur the galactic Z positive border, Z negative border, Rimward edge and Coreward edge of the Origin Spur. Click the Stellar Dbase sort on Galactic to find these waypoints. Going back and forth between these major galactic meeting points will take a lot of time. If you choose a fast enough ship, time dilation will help shorten the ride.

Galactic Locations in the Stellar Dbase

Here are locations you can find by sorting Galactic and scrolling downward.

Galactic Sort Rank	Galactic Waypoint		Sector	Light years
5	M25 Sagittarius Arm	Galactic Arm	Omega +	2,750
6	M52 NGC 7654		Omega +	3,000
7	Milky Way Orion Spur Edge G-North	Straight Galactic North to edge of Galaxy	Omega +	5,000
8	Sagittarri OGLE-TR-10	has a transiting planet b	Alpha +	5,000
9	Milky Way Far Sag Arm Edge	Far Edge of Sagittarius Arm Coreward	Gamma +	5,000
10	M1 - Crab Nebula	supernova remnant	Alpha +	6,500
11	M16 NGC 6611 Eagle Nebula	Eagle Nebula Pillars of Creation	Tau +	7,000
12	NGC 6397	50 l/y wide globular	Omega +	7,200
13	Milky Way Perseus Arm Far Border	Far edge of Perseus Arm Rimward	Omega +	12,000
14	Ophiuchi RS Oph	recurrent 6/30/1898	Alpha +	12,000
15	Milky Way Near Norma Arm Edge	Close Edge of Norma Arm Coreward	Omega +	13,800
16	Milky Way Galactic Bar Edge	Center galactic Bar Edge	Omega +	15,500
17	NGC 2158		Omega +	16,000
18	Milky Way Near 3kpc Arm Edge	Center galactic Near 3kpc arm	Omega +	17,000
19	Milky Way Long Bar Edge	Center galactic Long Bar	Omega +	17,500
20	Milky Way Edge of Outer Arm Inner	Near Edge Outer Arm Rimward	Alpha +	18,000
21	Milky Way Far 3kpc Arm Edge	Center galactic Far 3kpc arm	Omega +	23,000
22	Milky Way Edge of Outer Arm Outer	Far Edge of Galaxy Rimward	Alpha +	24,000
23	M19 NGC 6273		Beta +	25,000
24	Milky Way Center	Edge of Rotating Black orbit	Omega +	26,250
25	Milky Way Far Long Bar End	Past Galactic Center	Tau +	37,000
26	Milky Way View from above Zenith	Same distance Sol to galactic Center to above view of Galaxy	Gamma +	37,123
27	Milky Way Far Sag Arm End	Past Galactic Center	Omega +	38,000
28	Milky Way Far Norma Arm Mid	Middle of Far Norma Arm Past Galactic Center	Tau +	42,000
29	Milky Way Far Perseus Arm End	Past Galactic Center	Tau +	42,000
30	Milky Way Far Norma Scutum-Cent Gap	Middle of Gap in far Norma & Scuti Centaurus Arms - opposite side Galactic	Tau +	43,000

Galactic Sort Rank	Galactic Waypoint		Sector	Light years
31	Milky Way obscured view opposite side	In Sol galactic orbit behind the center	Tau +	53,000
32	Milky Way Far Edge Scutum-Centaurus arm	Opposite Side Galactic	Omega +	53,000
33	M72 NGC 6981		Tau +	60,000
34	M14 NGC 6402		Tau +	74,000
35	Magellanic Cloud Large	irregular galaxy	Omega +	162,980
36	Magellanic Cloud Small	irregular galaxy	Sigma +	197,000

Sectors

Using the 3 axis, there are 8 definable sectors, and border zones. We might as well name them. The names were arbitrary and just sounded nice. Standing on the Earth and looking up, These sectors progress counter-clockwise pointing up, around the North Pole and clockwise around the Southern cross, follows a Right Ascension standard, looking upward from anywhere on Earth.

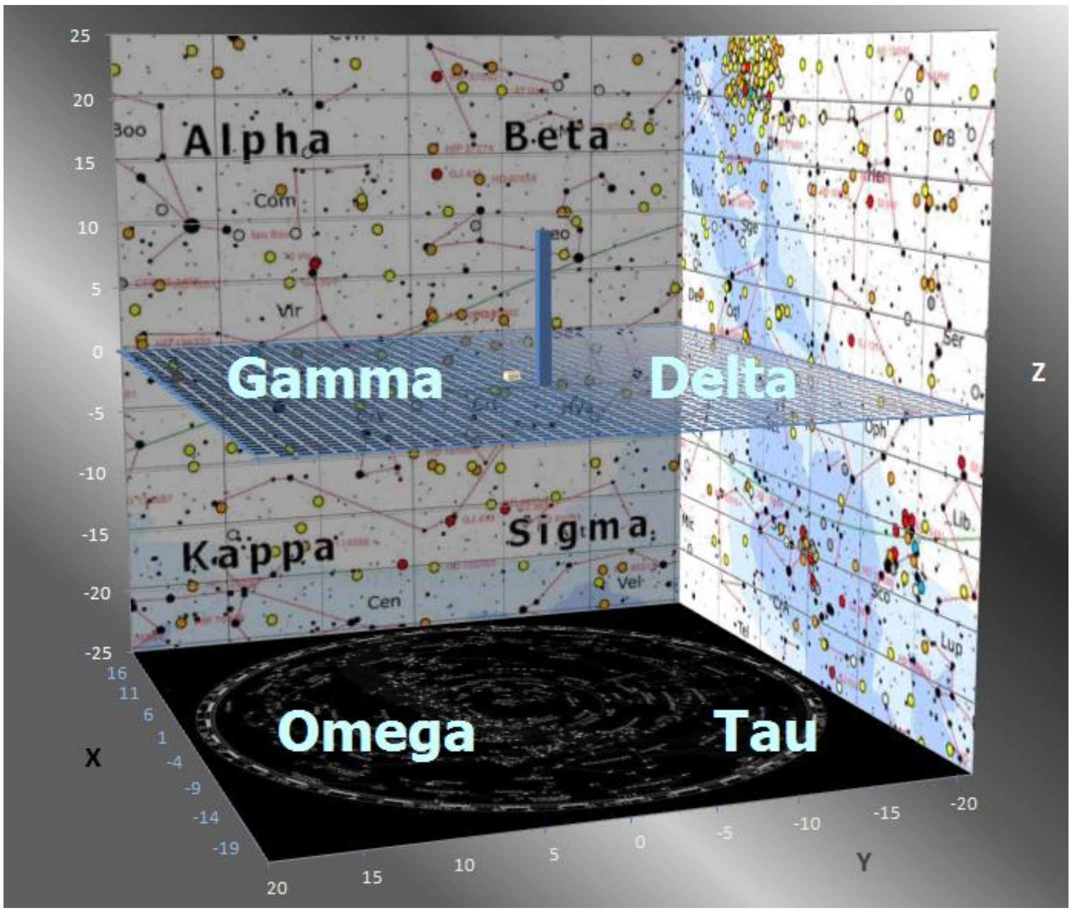
If you imagine yourself from high above in space towards Polaris, looking down, both sector names are clockwise from left to right. This can more easily be seen in the 3D sector charts.

Standing on Earth, pointing up, Counter clockwise around Polaris

Alpha ....X+ Y- Z+

Beta X+ Y+ Z+
Delta X- Y+ Z+
Gamma X- Y- Z+

Pointing down, Clockwise Southern Cross starting at RA 0h
Kappa X+ Y- Z-
Sigma X+ Y+ Z-
Tau X- Y+ Z-
Omega X- Y- Z-



17. Glossary

Acceleration Leg

The first part of a mission where the ship accelerates to top coasting speed. You have the option to adjust this by changing the amount of days in the "Time to Top Speed" cell in the Input Area.

Dashboard cockpit girl next door - Marilyn Monroe on Santa Monica Beach by Andre DeDiens (1945) Image Credit

Annual Shift Calculator

This worksheet handles conversion from Stellar Proper Motion into the values of change in X, Y and Z coordinates. 1 = light year. You can automatically use this worksheet by entering choosing Use RA and entering the Proper Motion data in the Input Area.

Annual Shifts

These are derived from stellar Proper Motion into an annual coordinate shift for X, Y and Z The shifts are abbreviated XAS, YAS, and ZAS. Due to oscillations caused by gravitational interactions of stellar groups and arcs of the galactic orbit of stars, these Annual Shifts will drift over time. In our stellar neighborhood, 11,000 is about 1 second of our galactic orbit. This type of shifts is less than our current resolution of distance. A warning of inaccuracy based on galactic orbits will come up if the mission exceeds 11,000 years.

Apparent Distance

Distance to visible position of star as viewed from the Starting Position. This will vary very slightly from the catalog position depending on how much closer or further away the observer is from the star. The further away the observer, the further back in time the star will appear and therefore the further back along the Annual Shifts the star will be. Moving the observer around will change these values, while the values for the Real positions of the star remains the same.

Apparent Stellar Position

(ASP) as viewed from the Starting Position is the Right Ascension, declination and distance of a star. X, Y and Z coordinates for the ASP can be derived with the galactic Calculator worksheet. It is automatically done when a RA position is entered into the Mission Profile Navigator.

Border Zones

These are areas between the named sectors where a ship is within 0.2 light years of another sector. Border Zone listing may appear in the Sector names for Start Position and Destination MP Navigator Output area.

Coasting Leg

This is the leg after acceleration where the Starship coasts at top speed.

Course headings

Automatically adjusted from any Start Position to the Destination Real Stellar Position (RSP) at rendezvous. This can vary depending on the Start Position. A star high in the Z Axis will need to aim downward at a star lower in the Z Axis. This is quite the opposite if the Start Position was Earth.

The Real Stellar Position (RSP) is the position of the star taking the Annual Shifts forward the amount of light years the star is distant.

Course headings to Real coordinates

A Starship heads to the destination star's real coordinates at rendezvous. This differs from Apparent coordinates of where the star appears to be from a distance. 10 light years away will make the star appear to be where it was 10 years ago.

Current Earth Time

Derived from the computer clock running this worksheet.

Custom Start Date

The Input area of the MP Navigator allows for start dates in the past and future. If Auto Adjust is turned on, the Start position star will auto adjust to its real position for that date. There is no adjustment if the Solar System is chosen as a Start Position. However Destination star that has Proper Motion will also be shifted to its correct position for the Custom Start Date. This means that a mission between two stars beginning in 1900 will be different slightly from the same mission beginning at another Start Date, due to Auto Adjustment based on the mission dates.

Dbase Sorting

You can sort the Stellar Dbase from the Navigator page by Name, Stellar Type, Sector and Distance.

Dbase Position Locked

Lock on for Destination of any two Stellar Dbase entries for stars, nebulae or galaxies

Dbase Spectral Type

Spectral Type of primary and secondary stars are listed in the Stellar Dbase.

Dbase Absolute Magnitude

Absolute Magnitude of the star or galaxy is listed in the Stellar Dbase.

Deceleration Leg

The deceleration leg always matches the acceleration leg inverted. There is no provision to create a different deceleration profile. This occurs in Rendezvous missions after a coasting leg, if there is a coasting leg. In some missions where you set a long time to top speed, there may be an immediate reversal from acceleration to deceleration at mission mid-point. There is no deceleration leg in the Fly-By type mission.

Declination

Standard declination is 90 degrees = North and -90 degrees = South. Arbitrarily the declination for Course Headings has been changed to 0 degrees = Earth Polar North and 180 degrees = South.

Destination Position

The Destination may be picked from the Stellar Dbase and locked in place. It may also be entered manually using either X, Y, Z coordinates or Use RA to enter in the RA, declination and Distance. If the Proper Motion is known, that may be entered and a movement in X, Y, Z space Annual Shifts will automatically be resolved. These values XAS, YAS, ZAS will show up and will be used to solve the hit a moving target problem by using 5 mission iteration of mission profiles.

Destination Annual Shifts

If Proper Motion of a star is known, the star will have an annual movement in X, Y, and Z space. This can be found using Trig from the knowing the distance, angle of Proper Motion, degree of Annual shifts and receding / approaching velocity of the star.

Earth time

The time a Mission Profile takes in Earth years. This will differ from Ship Years by the factor of time dilation formula and is most noticeable with speeds approaching light speed.

Epoch 2000

1/1/2000, 0:00 UCT or GMT. The Epoch is set to compensate for the difference between the date of the catalog star position reading and today's date (automatically adjusted to the computer clock). This assumes that the computer is set to the correct time and date of Earth UCT or GMT time. If the computer is in another time zone, this is not adjusted by this worksheet. Any star will travel along its cataloged Annual Shifts, XAS, YAS, and ZAS. These adjustments also apply to time after the catalog date.

FTL Missions – Star Trek Warps

Due to pressure from friends, I've added the values that are considered authentic for Star Trek Warp speeds as macro button options. The speedometer does list this speeds as imaginary missions.

Galactic Locations

When you sort the Stellar Dbase on Galactic, it brings all the galactic locations to the top of the list. This includes directly upward, or downward from the galactic plane to the galactic edge. Coreward or Rimward to the edges of the galactic arm where the Solar system is located, the Orion Spur, to midpoints between galactic arms, other arms and galactic bars. Also destinations to the galactic center and the far unseen edge of the galaxy are listed.

Other directions used in describing galactic directions are Spinward and Anti-Spinward. Spinward would refer to the direction of the Earth galactic orbit, towards the Cygnus constellation. Anti-Spinward would be the trailing galactic orbit direction, towards the Vela constellation in the Southern Hemisphere. MP Navigator uses Earth Polar, so there is not an exact alignment with galactic directions of Coreward, Rimward or Spinward.

Mission iterations

When a destination star has known Proper motion movement, it can be tracked over time. Making a rendezvous with such a star becomes the problem of "Hitting a moving target". To resolve this problem, the MP Navigator does five mission iterations. Find the mission duration based on ship speed and distance. Track the destination star to its new location for the first iteration arrival date. Run the mission parameter math again and find a new mission duration. Track the destination star to its second new location for the second iteration arrival date and so on. Five iteration to most missions within 1000 light year allows accuracy to less than 0.001%.

Moving Target Problem

As explained in the Mission iterations section above, "Hitting a moving target" star destination is resolved by making five mission profile iterations to bring the accuracy for most mission to under 0.001%.

Nearby Stars

Local stars within our local bubble and surrounding Loops I toward the Galactic Center, Loop II the direction of our galactic orbit and Loop III Rimward and the area trailing our local bubble, backwards along our galactic orbit inside the Orion Spur within 500 light years. This area includes about 90% of the stars listed in the Stellar Dbase. The Stellar Dbase probably misses many thousands of undiscovered mostly M type or dwarf stars within this area.

Orion Spur

The area where the Solar System is located. It is about 8000 light years long, 1800 light years deep and 2400 light years wide. It is often referred to as the Orion Arm.

Payload

Payload, fuel weights and any other ship design that would affect top speed and "Time to top speed" is not handled at all with the MP Navigator. It is assumed you pick a preset ship type or enters in their own parameters that match a ship type of their own design for sufficient fuel, to reach a speed and reverse thrust to decelerate to a rendezvous.

Real Coordinates

All stars including our Sun shine light on us from the past. The amount of time it takes for the light to reach us times the speed the star is moving along a galactic orbit, is the method to find the Real coordinates of a star as opposed to its Apparent coordinates. Even the speediest star, local to us, Barnard's Star will only move the width of one little finger held at arm's length over 40 years, or half the angular diameter of the full Moon in 75 years. For long interstellar missions, it is important to calculate the Real Coordinates of a stars to make a rendezvous possible and to be more accurately aware of any stars that may intersect your path along the way.

Real Postiions

Course headings to Apparent Stellar Position (ASP). These are the Course Headings from the Start Position to the Destination star. If the observer is on Earth (Solar System). the Course Headings will be the same as the catalog headings of that star. As the observer moves through space, the Course Headings that point at the Destination star will shift, as the Destination star moves. In addition, the apparent position of the star will change because it will become closer or further away from the observer in space compared to the observer on Earth. These course settings are automatically compensated for these shifts.

Real Stellar Distance

Derived by simply finding the square root of the hypotenuse using the shifts of the real Xr, Yr, and Zr coordinates and the coordinates of the observer. The Real Stellar Position can designate stars that are quite distant and may appear to point to empty space.

Relativistic Time

Einstein's General Relativity allows for time shifts with high relative velocities. These changes are tracked as Ship Time compared to Earth Time.

Rendezvous

A mission that allows acceleration and deceleration with a possible coasting leg to rendezvous with a destination star or second Starship B.

Retro burn deceleration begins (In Earth years)

When the retro burn needs to begin in order to decelerate into the Destination. This happens only in Rendezvous mission types.

Sectors

Lists the arbitrary 8 named sectors divided by X, Y and Z axis. A plus sign means distances greater than 50 light years. Often the Galaxy is divided into Quadrants defined by Right Ascension values. Currently the MP Navigator uses Earth Polar to avoid conversion to Galactic Coordinates and to allow using Right Ascension and declination to still work for standard stellar data input. For details see: 3D Sector Chart

Sensor Range

You may set any distance as a Sensor Range in the MP Navigator Input area. The sensor range is used to plot Fly-by report of nearby stars that are passed during a mission.

Ship time

The traveler onboard the ship will experience time dilation, increasing in effect as one approaches the speed of light. This will cause the acceleration leg, the coasting leg, the retro burn and the deceleration leg to all be different values than the Earth years.

Time has slowed to this percentage, overall, for the entire mission (100%=no slowing): The overall percentage of slowing includes the accumulated dilation as one accelerates and decelerates.

Time to top speed in days (Earth time): A typical mission profile will have an acceleration leg and an equivalent deceleration leg. If this time is set too short, so that the G-Force exceeds 1G, a warning note displays.

Slice Points

Every mission is divided into 200 slice points of equal duration based on Earth Time. The exact location of the Starship and nearby stars are found for each slice point. This information is used to plot precise values for distance and mission times.

Specific Impulse

A particular engine types Specific Impulse and any other ship design that would affect top speed and “Time to top speed” is not handled at all with the MP Navigator. It is assumed you pick a preset ship type or enters in their own parameters that match a ship type of their own design for sufficient fuel, to reach a speed and reverse thrust to decelerate to a rendezvous.

Start position

This is the SGC position of any observer within the coordinate system. These values may be set to another star or to an observer in route between stars.

Start Position Locked

The Stellar Dbase allows you to scroll through different stars and choose a Start Position or Destination to Commit or Lock in place by using the Commit or Lock buttons. There are two buttons each for Start Position and Destination. They both do they exactly same thing for each location.

Stellar Distances at a Slice Points

Every mission is divided into 200 slices of equal duration in Earth Time. Stars within sensor range have their distances to the Starship calculated on all 200 slice points. This information is used to plot precise values for distance and mission times.

Stellar Dbase Browse

Look through stars, nebulae, galaxies in the Stellar Dbase

Time Dilation

This relativistic adjustment is automated and very accurate. Acceleration and deceleration legs are divided into several hundred segments and each segment’s time shift is summed to find an accurate dilation. Top cruising speed is much easier to resolve for time dilation. The entire mission sum is used to find to find Ship time end of mission dates.

The Fly-by sensor data that shoes when various stars pass closest and at what mission time they enter Sensor Range uses a mission average time dilation, which will cause the exact times during top speed coasting to be a little late.

Time spent coasting

Derived from the entire time to Destination - acceleration and deceleration legs

Top speed

(in fraction of the speed of light c=1): 0.5 would be 1/2 the speed of light. This entry can go up to 0.99999 for use within our physical universe. The spreadsheet will accept values of 1 and greater for imaginary missions of FTL. When such a top speed equal to light speed or faster is chosen, the ship time section becomes invalid.

Time to Top Speed

User sets “Time to top speed” in Days or chooses a Ship Type preset with the “Time to top speed” preset. You can always adjust this in the Input Area. A Julian year is used by the MP Navigator which equals 365.25 days.

Use RA

Input Right Ascension, declination and distance to a star and use this to calculate the mission.

Use XYZ

Input X, Y, Z and distance to the star and use this to calculate the mission.

X, Y, Z

Arbitrary coordinates based on Earth Polar = Z+, RA 6 hours = X+, RA 12 hours = Y+

Xr, Yr, Zr

Real positions for a star for current Earth time. This always differs from the Apparent position of the star. However it can have value if there is Proper Motion data for the star.

Author's Notes:

Many of the worksheets start to have a lot of "Excel if" functions to solve all possible scenarios of missions. This adds a lot to the complexity and leaves open, possible problems with unusual mission types. A better approach may be to be less automated and ask you to define exact mission parameters, as they go.

One may expect that an actual operating navigation planner may take the form of a tax questionnaire software package, where all options are examined and you have to input choices in order to get an accurate result.

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