

Missions To Outer planets

Transfers to Neptune and Pluto are included here

The transfers use purely impulsive manoeuvres.

Mission to Neptune

This example uses a sequence of gravity assist manoeuvres to reach Neptune, after fly-bys at Venus, Earth, Jupiter and Saturn.

The transfer duration is relatively long, although it could be accelerated with a DeltaV penalty.

The sequence is therefore as follows:

1. V-E-E-J-S, restricted arrival

The DeltaV calculations are based on initial and final target orbits.

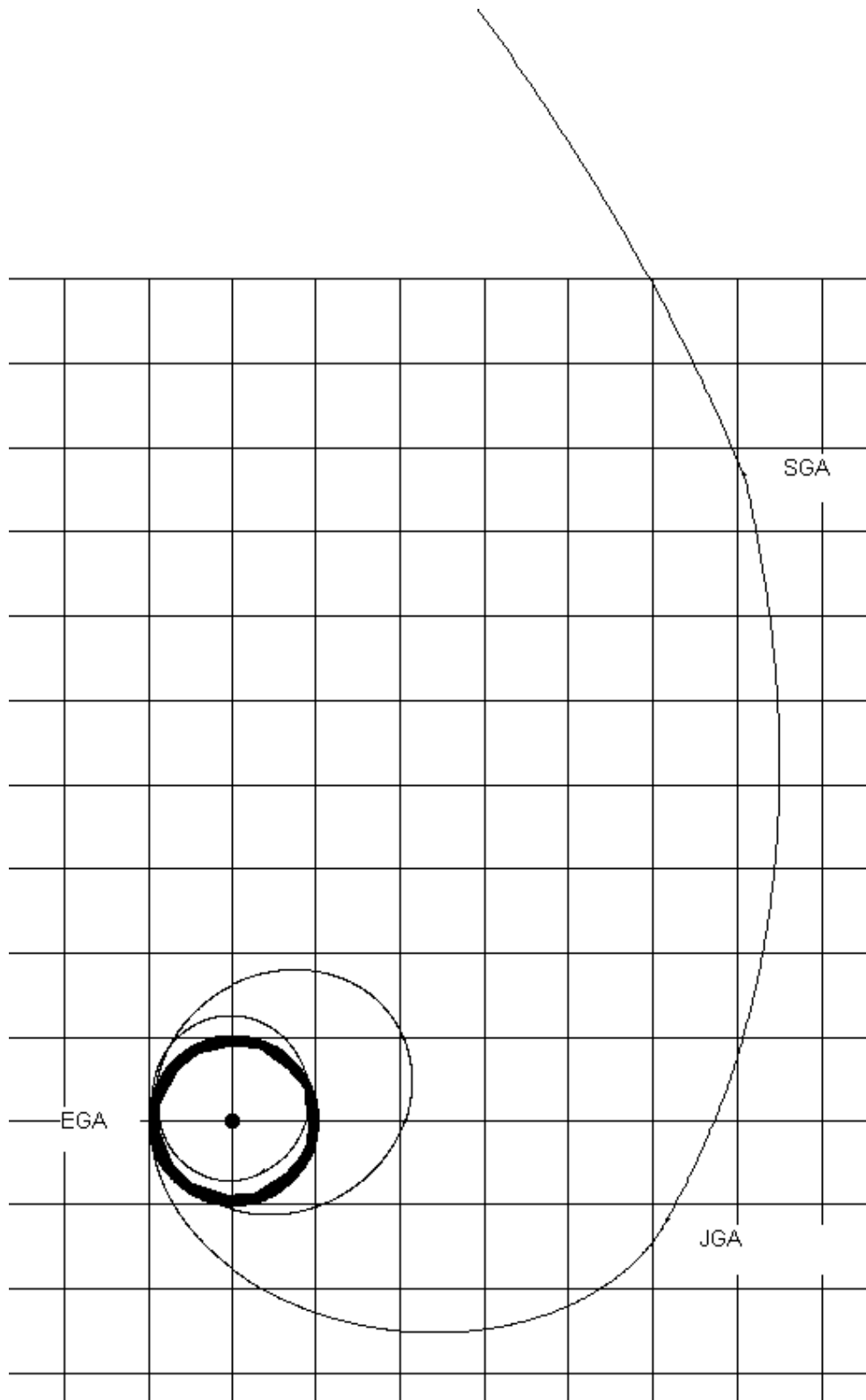
Initial orbit at Earth: Perigee radius 6578km	Apogee radius 42165 km
Final orbit at Neptune: Pericentre radius 25000km	Apocentre radius 1000000 km

Route V-E-E-J-S Arrival epoch fixed

Vinfinity (m/s)	DV (m/s)	Apo (AU)	Peri (AU)	Inclination (deg)	Epoch:	Event
4127.	1518	1.00	0.72	6.10	03-Oct-13	departure
5881.		1.27	0.70	3.41	15-Mar-14	VGA
8728.		2.28	0.90	0.00	08-Dec-14	EGA
	160	2.28	0.87	0.00	03-Dec-15	
9627.		5.39	0.97	3.78	01-Dec-16	EGA
6143.		23.53	4.74	1.63	17-May-19	JGA
7172.	1127	201.53	7.36	1.74	14-Aug-22	SGA
6323.		201.53	7.36	1.74	28-Jun-36	arrival

DV including insertion	2805	m/s
DV no insertion	1678	m/s
Transfer duration	22.74	years

Fly-By:	Vinfinity (m/s)	Pericentre Radius (m)
1	5881.48	7923784.96
2	8728.517	10047215.3
3	9627.09	6878000.57
4	6143.928	1174556378
5	7172.947	2896883507



VEEJS transfer with constrained arrival. Orbit of Earth is shown. Grid size is 1AU squares

Mission to Pluto

Two examples of missions to Pluto are considered. These are both relatively fast transfers. The first corresponds to a locally optimal solution, taking approximately 14 years and the second a faster transfer taking less than 12 years. The first transfer assumes that all manoeuvres are performed in deep space. The second allows powered fly-bys.

The sequence is therefore as follows:

1. V-E-E-J, free arrival
2. V-E-E-J, fixed arrival

The DeltaV calculations are based on an initial orbit assumption. The arrival Vinfinity is high and these missions are more typical of Pluto fly-by missions rather than rendez-vous.

Initial orbit at Earth: Perigee radius 6578km Apogee radius 42165 km

Case 1:

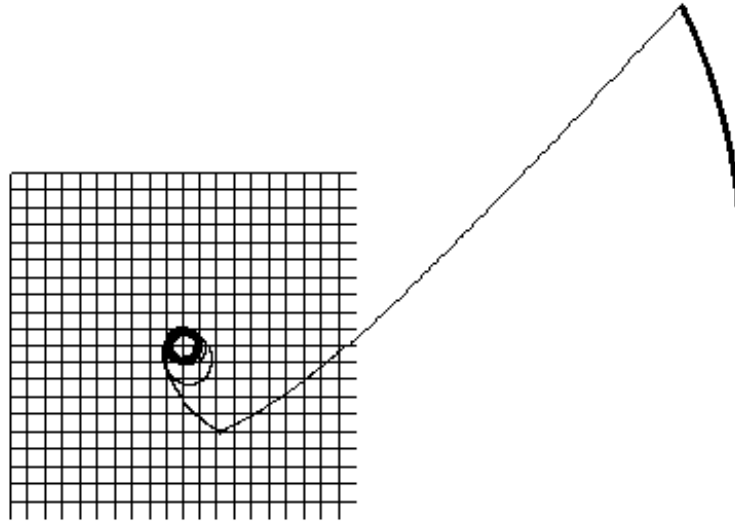
Route V-E-E-J Arrival epoch optimal

Vinfinity (m/s)	DV (m/s)	Apo (AU)	Peri (AU)	Inclination (deg)	Epoch:	Event
3338.91	1264.94	1.00	0.65	1.11	18-Apr-12	departure
6915.98		1.42	0.71	1.21	08-Oct-12	VGA
9773.13		2.40	0.90	0.00	23-Aug-13	EGA
	346.87	2.39	0.84	0.00	25-Sep-14	
11587.70		9.11	0.95	1.57	10-Dec-15	EGA
	292.40	9.11	0.95	1.57	10-Dec-15	
11284.05		-12.99	5.45	4.29	15-Jun-17	JGA
15405.56		-12.99	5.45	4.29	23-Oct-26	arrival

DV no insertion	1904	m/s
Transfer duration	14.51	years

Manoeuvres are deep space (except initial departure from Earth bound orbit at Earth perigee)

Fly-By:	Vinfinity (m/s)	Pericentre Radius (m)
1	6915.977	15211281.8
2	9773.132	11680610.6
3	11587.7	6678000.4
4	11284.05	172054562



VEEJ transfer with free arrival. Orbits of Earth and Pluto are shown. Grid size is 1AU squares

Case 2:

Route V-E-E-J Fixed arrival

Vinfinity (m/s)	DV (m/s)	Apo (AU)	Peri (AU)	Inclination (deg)	Epoch:	Event
3348.17	1267.63	1.00	0.65	1.13	18-Apr-12	departure
6939.67		1.42	0.71	1.25	08-Oct-12	VGA
9783.96		2.39	0.89	0.00	23-Aug-13	EGA
	308.85	2.39	0.84	0.00	27-Sep-14	
11406.69	308.20	9.11	0.95	1.57	09-Dec-15	EGA
11279.73	1522.95	-8.63	5.44	2.99	16-Jun-17	JGA
23079.25		-8.63	5.44	2.99	21-Dec-23	arrival

DV no insertion	3408	m/s
Transfer duration	11.68	years

Manoeuvres are deep space and at fly-by (except initial departure from Earth bound orbit at Earth perigee)

Powered fly-bys are used at Earth perigee (308 m/s) and at Jupiter pericentre (1523 m/s).

Fly-By:	Vinfinity (m/s)	Pericentre Radius (m)
1	6939.67	15150867.61
2	9783.96	11724545.20
3	11406.69	6678000.00
4	11279.73	84870330.52

The Pluto transfers show that mission acceleration is achievable with a certain DeltaV cost. Use of powered fly-bys is effective in achieving this mission acceleration.