

Missions To Saturn

A series of alternative transfers to Saturn can be compared. The starting point is to look at the possibilities for routes similar to the Cassini-Huygens transfer opportunity.

Transfers using purely impulsive manoeuvres are considered.

The spacecraft was launched in 1997, with a sequence of gravity assists at Venus, Venus, Earth and Jupiter, arriving in July 2004.

Alternatively, this transfer could be extended, such that the deep space manoeuvres are reduced and also the approach velocity at Saturn. The penalty is the longer duration of the transfer.

A different transfer strategy can be considered. This uses a single Venus gravity assist, followed by two gravity assists at Earth, then a Jupiter gravity assist. Once again, two options can be considered. These assume a fixed target arrival epoch, or alternatively, an optimised epoch. In the second case, the arrival speed is reduced and also the deep space manoeuvre requirement. In this second example, a later launch epoch is taken.

The following cases summarise these transfers:

1. V-V-E-J, restricted arrival
2. V-V-E-J, free arrival
3. V-E-E-J, restricted arrival
4. V-E-E-J, free 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 Saturn: Pericentre radius 1000000km

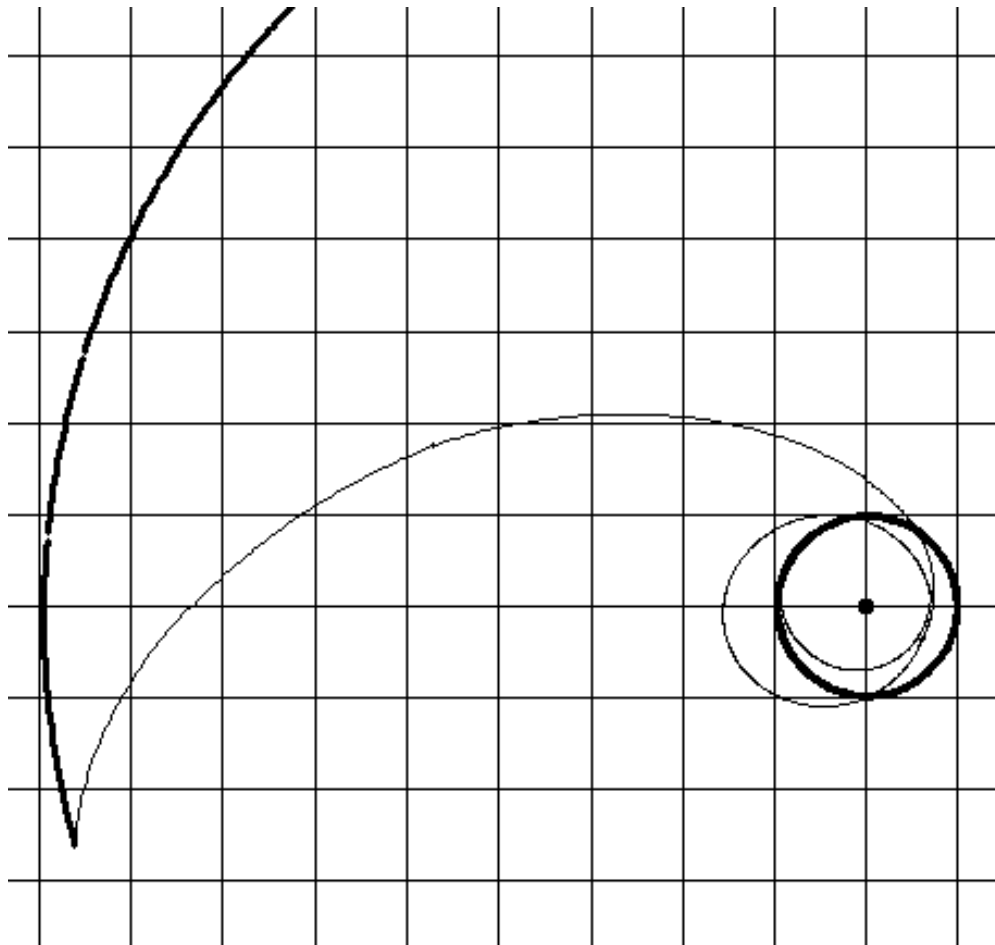
Apocentre radius 20000000 km

Case 1

Route V-V-E-J Arrival epoch fixed

Vinfinity	DV	Apo	Peri	Inclin	Epoch:	Event
4014	1479	1.01	0.67	1.48	19-Oct-97	departure
6049		1.58	0.73	3.40	29-Apr-98	VGA
	437	1.58	0.68	3.39	21-Nov-98	
9320		2.60	0.72	1.00	26-Jun-99	VGA
15940		7.37	0.87	0.69	18-Aug-99	EGA
10492		9.24	1.37	0.78	04-Jan-01	JGA
5356	1725	9.24	1.37	0.78	14-Jul-04	arrival

DV including insertion	3641	m/s
DV no insertion	1916	m/s
Transfer duration	6.73	years



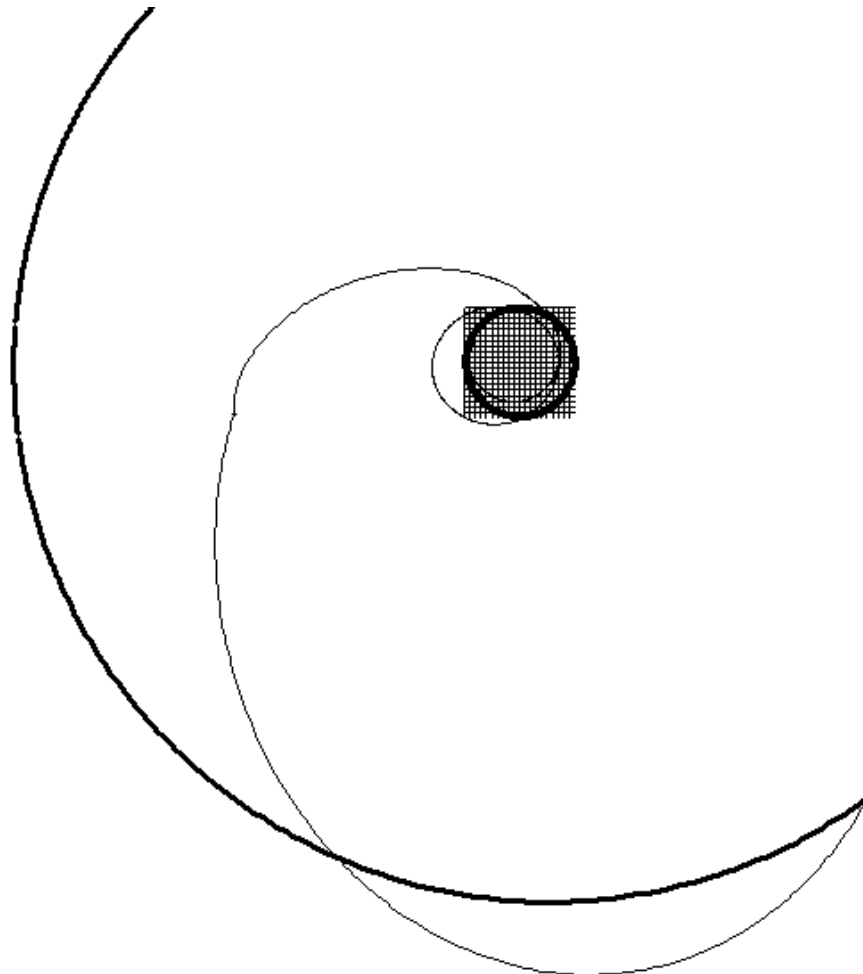
VVEJ transfer with constrained arrival. Orbits of Earth and Saturn shown. Grid size is 1AU squares

Case 2

Route V-V-E-J Arrival epoch optimal

Vinfinity	DV	Apo	Peri	Inclin	Epoch:	Event
3994	1472	1.01	0.67	1.46	19-Oct-97	departure
6023		1.57	0.73	3.39	29-Apr-98	VGA
	278	1.57	0.70	3.39	26-Nov-98	
8253		2.18	0.73	0.55	01-Jul-99	VGA
14558		5.19	0.88	0.00	24-Aug-99	EGA
6081		10.88	3.47	2.72	31-Dec-01	JGA
4130	1139	10.88	3.47	2.72	14-May-13	arrival

DV including insertion	2889	m/s
DV no insertion	1750	m/s
Transfer duration	15.57	years



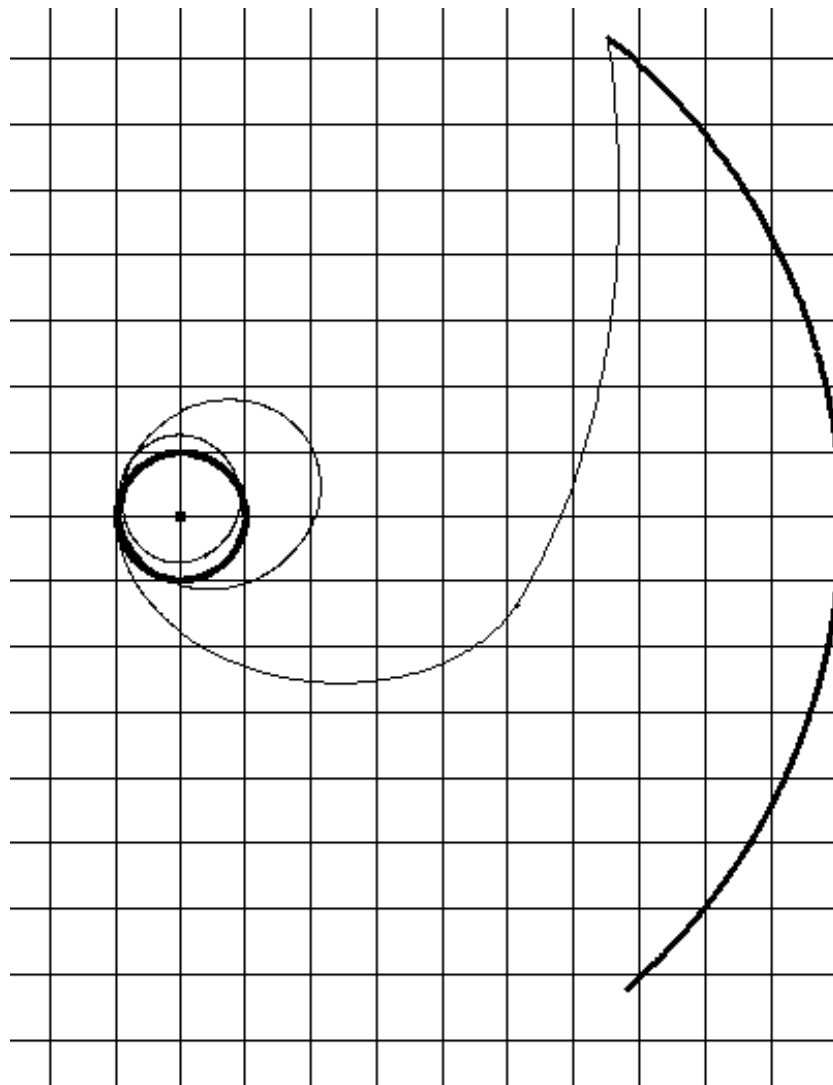
VVEJ transfer with free arrival. Orbits of Earth and Saturn shown. Grid size is 0.1AU squares

Case 3

Route V-E-E-J Arrival epoch fixed

Vinfinity	DV	Apo	Peri	Inclin	Epoch:	Event
4149	1526	1.00	0.72	6.19	03-Oct-13	departure
5942		1.27	0.70	-3.45	15-Mar-14	VGA
8742		2.28	0.90	0.52	08-Dec-14	EGA
	199	2.28	0.87	0.44	11-Dec-15	
9836		5.44	0.97	4.23	29-Nov-16	EGA
6335		35.73	4.86	1.55	19-Apr-19	JGA
8018	3338	35.73	4.86	1.55	30-Apr-22	arrival

DV including insertion	5063	m/s
DV no insertion	1724	m/s
Transfer duration	8.57	years



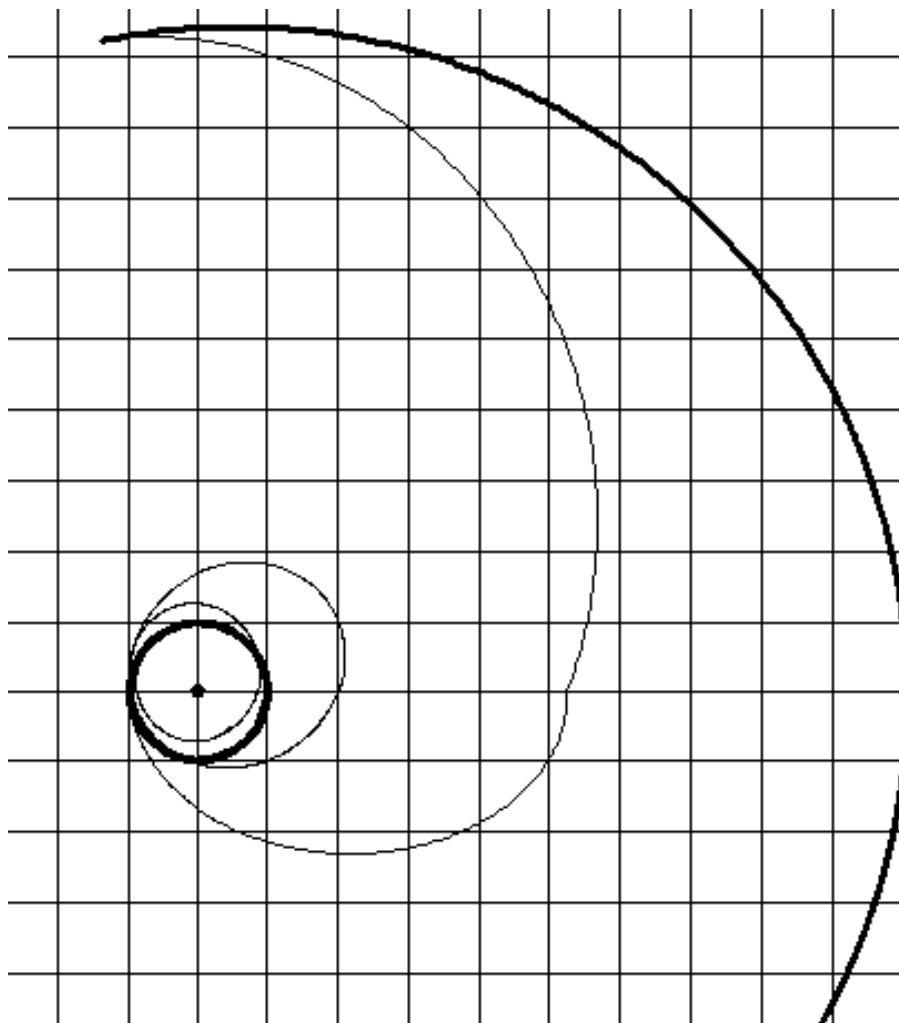
VEEJ transfer with constrained arrival. Orbits of Earth and Saturn shown. Grid size is 1AU squares

Case 4

Route V-E-E-J Arrival epoch free

Vinfinity	DV	Apo	Peri	Inclin	Epoch:	Event
3972	1465	1.00	0.72	5.90	10-Oct-13	departure
5971		1.28	0.70	-3.01	18-Mar-14	VGA
8835		2.26	0.91	5.49	14-Dec-14	EGA
8866		5.26	0.98	1.85	14-Dec-16	EGA
5657		9.45	4.00	2.40	21-Oct-19	JGA
2340	519	9.45	4.00	2.40	22-Jul-26	arrival

DV including insertion	1983	m/s
DV no insertion	1465	m/s
Transfer duration	12.78	years



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

These transfers show that the Cassini VVEJ route is efficient in achieving a fast transfer to Saturn. If lower DV transfers are required, then using a VEEJ route offers some interesting possibilities