ABORT SCENARIO FEASIBILITY FOR THE MANNED MARS MISSION

by

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ABSTRACT

The Synthesis Group has released its recommendations for the mission architectures to be used for the manned Mars mission.

This study investigates the abort capabilities of the mission types considered for the manned Mars mission and develops the costs in initial mass to low Earth orbit (IMLEO) of acquiring additional abort capability above that available for the nominal missions.

It was found that specifying that a rapid return to Earth capability be available throughout the entire mission results in the initial mass to low Earth orbit being vastly increased, but that aborts with 160-200 day trip times are available while outbound and at Mars using only the fuel carried by the nominal missions.

Reduction of the abort trip times from those available to the nominal mission was found to result in rapid increase in IMLEO well before the reduction in trip time became significant, so carrying contingency fuel to increase the abort capability available at mission points is not recommended.

The Synthesis Group specifies a split mission: an unmanned precursor mission carries the Mars exploration payloads and the return to Earth fuel to Mars on a minimum energy trajectory, and is followed by the piloted spacecraft on a high-energy rapid transfer trajectory. This architecture is found to be inferior to one in which all the fuel required for the entire mission is carried on the piloted mission - the total IMLEO increases only slightly, and the abort capability of the nominal mission is greatly increased.

The effect of dividing the Mars transfer vehicle into two transfer vehicles, only one of which need be carried on an abort trajectory, is investigated, and it is found that although splitting the transfer vehicle does not make carrying contingency fuel productive, it does provide substantial improvement in nominal mission abort capability for no change in IMLEO.

The 2015 Venus swingby mission, the non-minimum energy 2014/2015 mission with the lowest IMLEO, was found to offer better or comparable abort capability when compared to the other mission types considered for the first Mars launch, and is recommended as the mission to be used.

The abort capabilities of minimum-energy piloted missions were considered, and it was found that unless the mass of the transfer vehicle used for aborts is substantially less than the mass of the nominal transfer vehicle, requiring that aborts from Mars be available if rendezvous with the cargo mission fails will increase IMLEO to the same level as the IMLEO of the nominal high-energy missions, without also improving abort capability and nominal mission performance.

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1.0 INTRODUCTION

The Synthesis Group has released its report, America At The Threshold, containing a group of mission architectures for the manned Mars mission. The Synthesis Group emphasizes safety as the primary mission design driver, and specifies an abort mode as a requirement at all phases of the mission except the return to Earth leg.

However, they do not explore the performance requirements for this abort mode, or the burden which the existence of an abort capability places upon the mission architecture.

This thesis explores the amount of additional resources necessary to create a selection of abort scenarios addressing a range of failure situations, and, with these developments in hand, considers the issue of whether having an abort capability is worth the additional mission cost.

1.1 The Synthesis Group

The Synthesis Group is a group of civilian and military space experts which was convened by NASA to examine the submissions to the NASA and AIAA Outreach Programs and develop Space Exploration Initiative (SEI) mission architectures, utilizing any appropriate new concepts obtained from the submissions.

This thesis uses the Synthesis Group's recommendations as a baseline from which to develop the extra resources required to effect an abort capability.

1.2 Mission philosophy

From America At The Threshold:

> "The Space Exploration Initiative architectures are based on the priorities of safety, cost, performance and schedule. This

differs from the Apollo program priorities of safety, schedule, performance and cost."[1]

"The following principles were identified to ensure crew safety:

- Multiple levels of parallel redundancy with high reliability and low maintenance requirements.
- Capability for both the crew and built-in systems to monitor and control all critical functions during normal and contingency operations without support from Earth.
- Capability for the crew to manually control and override critical systems.
- System designs which allow crew maintenance and repair.
- System and consumable margins which reflect resupply rates."[2]

Although crew safety is taken as the highest priority, the presence of cost as the second priority emphasizes the fact that a minor increase in safety may not be worth a substantial increase in the cost of the mission. The primary avenue through which crew safety will be assured is reliability, redundancy and repairability.

The feasibility and cost of providing abort options must be determined to evaluate under what conditions this emotionally appealing concept actually makes an effective contribution to mission safety.

1.3 Mission architecture

The separate mission architectures specified by the Synthesis Group are developed to address different priorities for the SEI: Mars exploration; science emphasis for the Moon and Mars; the Moon to stay and Mars exploration; and space resource utilization.

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[1] Synthesis Group; America At The Threshold: Report of the Synthesis Group on America's SEI. p. 18.

[2] America At The Threshold. p. 18.

Although each architecture develops in a different way, all architectures specify the first manned Mars launch in 2014. Also common to all the architectures is the call for development of a new heavy-lift launch vehicle and the use of nuclear thermal propulsion for the Mars transits.

The Mars mission is specified as a "split" mission:

> "The mission would be performed using separate cargo and crew vehicles. Earth orbit operations will use automated rendezvous/docking of standard modules, minimizing on-orbit operations. Cargo missions for the Mars surface and orbit will be delivered in the most energy efficient way. The cargo for the surface includes the habitat, pressurized rover, unloader, power systems, exploration packages and in situ resource experiments. Mars orbit cargo includes the stages for returning to Earth and the descent/ascent vehicle. The piloted mission would be flown with minimum transit times to reduce crew exposure to high radiation and zero gravity."[3]

> "The piloted vehicles would include contingency fuel for return to Earth, but the Mars lander and additional fuel would be sent as part of the cargo vehicle."[4]

> "The piloted vehicle consists of the crew in the Earth-entry vehicle, along with their Mars transfer vehicle, the nuclear engine, inflight experiments and consumables."[5]

A cargo mission is sent to Mars on a minimum energy trajectory to arrive at Mars ahead of the piloted mission. The cargo mission carries everything except those mission elements necessary for Earth to Mars flight operations, and the payload includes the fuel for trans-Earth injection and Earth arrival maneuvers.

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[3] America At The Threshold. p. A-42.
[4] America At The Threshold. p. A-40.
[5] America At The Threshold. p. 33.

A manned mission follows on a high energy trajectory, carrying the crew in the Earth entry vehicle, their transfer vehicle, and inflight experiments.

After arrival at Mars, this piloted mission meets the cargo mission. The crew then descends to the Martian surface for exploration and experimentation. After the stay is complete, the crew ascends to Mars orbit, assembles the Earth return configuration, and heads home.

1.4 Specified abort capability

The Synthesis Group specifies an abort capability throughout the mission profile. The architectures in the report specify an abort capability from Mars orbit, and suggest an abort capability during the trip out to Mars, but an abort capability during the inbound leg is not specified.

> "The piloted vehicle carries contingency trans-Earth injection fuel to permit an abort from Mars orbit."[6]

> "Sufficient fuel would be carried in the crew transfer vehicle to ensure that a return trip with a minimum energy trajectory could be accomplished if rendezvous fails with the cargo flight carrying the return fuel."[7]

> "Sufficient fuel and supplies would be carried by the piloted vehicle to provide an abort mode for return to Earth."[8]

So, required by the base architecture is the ability to abort from Mars orbit throughout the stay at Mars (even if rendezvous with the cargo mission, carrying the majority of the return fuel, fails). The ability to abort home during the outbound (to Mars) leg is created by the presence of the contingency and Mars orbit insertion fuel while outbound.

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[6] America At The Threshold. p. 33.
[7] America At The Threshold. p. A-41.
[8] America At The Threshold. p. A-42.

The Synthesis Group report does not discuss this required abort capability beyond these points. Left unexamined is the crucial question of how fast an abort to Earth is required throughout the mission. This is a broad question since the same amount of contingency fuel supplies a different speed abort depending on where you are: for a 2015 Venus swingby mission, 20 km/sec worth of fuel allows a 150 day return from any point in the entire mission, but allows a 30 day return only until 50 days out from Earth or within 50 days of Earth inbound (see Figs. 2.15, 2.16).

1.5 Philosophy of abort capability

The Synthesis Group says:

> "The basis for all abort options is to reduce vulnerability to failure by system reliability and redundancy, and to provide flexibility to the mission commander to execute an abort mode if necessary.
>
> Essential functions must be tolerant to multiple failures and must be restorable. System design requires that the first failure results in no operational degradation; the second leaves the system operational , but possibly in a degraded mode; and the third leaves it in a safe and restorable configuration. Thus, the third failure is not catastrophic, and the time to restore the function, at least to a degraded operational mode, is less than the time leading to an irreversible catastrophic condition."[9]

The purpose of an abort capability is to provide a solution to an irreparable failure of a vital system, or to provide the mission commander with another option if the capability for or efficacy of repairs are dubious.

However, abort from a Mars mission is not like an abort from a Space Shuttle or lunar mission, where an abort capability means the ability to return to Earth in at most two or three days if something goes badly wrong. For a Mars mission, except in cases where the vehicle is already within two months'

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[9] America At The Threshold. p. 18.

travel of Earth, returning home in less than three months requires a prohibitively high delta-V (and even three months is often very expensive).

Therefore, the only failures for which an abort capability provides the mission commander with an option are those occurring very near Earth or those which threaten the crew's safety over the length of the nominal mission, but allow survival afterwards for three months or more (see 1.5.1).

This raises the issue of whether an abort capability is worth having at all. Although an abort capability is specified in the architectures proposed by the Synthesis Group, their discussion of the presence of the abort capability suggests that they have specified such a capability as a mandatory safety feature - 'manned missions must have an abort capability capable of returning the crew safely home after almost all possible vital system failures' - without having considered the narrow range of failures after which an abort would offer a survival option.

Because aborts for the manned Mars mission will not be able to ensure survival of all non-catastrophic failures, the cost of acquiring an abort capability must be compared not only to the cost of faster/slower and more/less robust abort capabilities, but also to the cost of other methods of increasing the level of crew safety.

Since the cost of space missions is driven by launch costs, the cost of any abort capability will be measured in the amount of extra mass it requires be placed in orbit from the Earth, particularly as a percentage of the mass to orbit required by the initial mission.

Although the cost of adding another layer of redundancy or increasing reliability of vital systems by another order of magnitude from an already high standard cannot be developed as accurately as the cost of carrying the extra fuel necessary to come home in a certain number of days from Mars throughout the stay there, these costs can be estimated as percentages of the initial dry mass, for comparison to the cost of an abort capability.

In the extreme case, it can be noted that carrying lots of spare parts and duplicates of critical items like landers, habitats and the Earth entry vehicle can be very accurately developed as a standard for comparison to very expensive aborts. This strategy has the large advantage over an equivalently

expensive abort capability of allowing completion of the mission after a failure.

1.5.1 Failure scenarios which allow abort

An abort will be necessary after any failure which threatens crew safety, or which eliminates the ability to complete any further mission objectives at Mars.

However, having an abort capability is not a solution to all such failures. Due to the long transit times required for Mars mission aborts occurring away from Earth's vicinity, aborts only provide salvation from failures which allow survival over an extended period of time after the failure occurs.

Types of failures which would allow such extended survival and yet still require an abort are discussed below.

Irreparable damage to a safety-critical system, reducing its capacity to a level which only allows survival over a reduced duration, or causing creeping degradation of performance, would allow an abort which returned the crew to Earth before the performance loss became critical. This type of failure can be prevented by increasing the robustness and reliability of system design and carrying spare parts.

Another failure allowing abort would be the contamination or loss of most consumables (fuel, air, water, food), leaving only enough for a faster than expected trip home. This can be anticipated by carrying extras of all consumables, in the piloted mission and the cargo mission, and scattering the consumables storage areas throughout the vehicles so that any event which violates enough storage areas to force an abort would also damage such a large portion of the vehicles that it would probably not be an event survivable over the length of an abort trajectory anyway.

Third, an unexplainable or untreatable loss of crew health due to disease or microgravity and radiation exposure would be cause for an abort option to be exercised. This "failure" mode cannot be countered by design, only by research into the effects of long-term spaceflight on the human body.

Finally, while not a life-threatening failure, if the piloted mission is unable to rendezvous with the cargo mission, or if the ascent/descent vehicle, surface hab modules or other Mars surface exploration necessities are

discovered upon inspection after cargo mission rendezvous to be damaged, these events could inspire an early exit from Mars, after all possible orbital science is completed.[10] This "failure" can also be prevented by reliable and robust design, and the presence of spare parts or equipment.

Thus, the carrying of extra fuel to create an abort capability will not be justified unless it costs less than the countermeasures described above. The countermeasures also have the advantage of preventing the threat from occurring at all, or allowing the mission to continue as planned after repairs are made.

Finally, the nominal mission does have some abort capability present at all times even without carrying extra fuel - at any given point, the fuel on hand can be used to perform an abort maneuver. However, the carrying of the trans-Earth injection fuel in the cargo mission reduces the utility of these aborts, since at no time is more fuel available to the crew than required for the next nominal mission maneuver - while outbound, the Mars orbit insertion fuel; while at Mars, the inbound mission fuel; and while inbound, none, unless a braking maneuver is required at Earth arrival.

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[10] For high-energy missions, the nominal mission would be completed, as they require a 40 day stay at Mars. However, for minimum energy missions, with 400 plus day stays at Mars, orbital facilities may not be able to support the crew for the nominal duration, and an early departure might be necessary.

2.0 ABORT TRAJECTORIES

The Space Exploration Initiative as envisioned by the Synthesis Group calls for Mars exploration to commence in 2014, with a follow-up flight in 2016.

The cargo mission will precede the first manned flight on a minimum-energy trajectory, so that its resources will be in place when the manned mission arrives at Mars.

"All Mars architectures are designed for a 30 to 100 day stay for the first mission and an approximate 600 day stay for subsequent missions. This leads to total mission durations of approximately 500 and 1,000 days respectively."[11]

The first manned mission is specified as a high-energy, rapid transfer "500-day class" mission by the Synthesis Group. This type of mission is specified due to lack of information about the effects of prolonged microgravity exposure on the human body. However, if sufficient information is gathered on microgravity and radiation exposure before the first manned launch, and a long Mars stay is approved for the first mission, a minimum energy trajectory may be used for the first piloted mission.

Follow-up missions will feature an extended stay at Mars. The transfer trajectories for these missions may be the high-energy transfers of the "500-day" missions, achieved by waiting on Mars through an Earth-Mars period until the next high-energy mission launch opportunity, but, if long-duration microgravity and radiation exposure is proved safe, minimum energy trajectories may be used for the manned mission as well as the cargo mission.

Therefore, this study examines aborts from both high-energy and minimum-energy trajectories, as well as aborts from Mars orbit. The specific trajectories studied are obtained from mission planning documents supplied by the Synthesis Group[12], and are discussed below.

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11 Synthesis Group; America At The Threshold: Report of the Synthesis Group on America's SEI. p. 16.

12 Lineberry, Drake, Joosten, Weaver; Orbital Mechanics Tutorial: Presentation to Synthesis Group; Sept. 4, 1990.

All of the trajectories considered below begin from a 407 km (Space Station) orbit at Earth, and use a propulsive maneuver to insert to a 500 km circular orbit at Mars arrival (Mars orbit insertion, MOI), where the spacecraft remains until it leaves Mars. The spacecraft uses direct entry at Earth return, and entry speed at Earth arrival is constrained to 14.5 km/sec or less, to limit aerodynamic forces and heat loads during entry.[13]

2.1 Minimum energy missions

Minimum energy missions consist of an burn to insert the vehicle into the Mars-bound trajectory, a Mars orbit insertion burn (MOI) upon arrival at Mars, and a final burn after the Mars stay is complete to enter the inbound trajectory.

Minimum energy missions take advantage of optimal Earth/Mars phasing at both trans-Mars insertion (TMI) and trans-Earth insertion (TEI), and therefore involve long Mars stay times to allow the phasing to cycle around.

Minimum energy trajectories will be used for the cargo missions and for follow-up manned missions.

2.2 High-energy missions

High-energy missions are designed to minimize transfer times and Mars stay times to reduce exposure to microgravity and radiation. The choice of where to stop minimizing trip time to keep the required mission delta-V below reasonable limits controls the trajectory design process.

The Synthesis Group and the NASA 90-day study have chosen 500 days, with a 40 day Mars stay, as a target figure for mission length. This study considers aborts from the "500-day" high-energy missions specified by the Synthesis Group.[14]

Four types of high-energy mission are considered: traditional "2-burn" trajectories (trajectory insertion and arrival burn only), with the outbound transfer either shorter or longer than the inbound; Venus swingby missions;

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[13] Orbital Mechanics Tutorial: Presentation to Synthesis Group

[14] Orbital Mechanics Tutorial: Presentation to Synthesis Group

and missions involving a deep space maneuver (DSM) during one or both of the transfers[15]. These categories shall be referred to as 2BSO[16], 2BLO, Venus swingby and DSM missions.

The Synthesis Group specifies that high-energy missions should be either Venus swingby or DSM missions[17], due to their lower mission total delta-V. The other classes of "500-day" mission specified in the mission planning documents are also considered to see whether one of them may allow the addition of abort capability at a lower cost.

High-energy transfers will be used for the initial manned mission, and may be used for follow-up manned missions if long-term exposure is discovered to be unsafe.

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15 These missions perform a propulsive maneuver at transfer perihelion, at which time Earth and Mars are in opposition (Mars, Earth and Sun colinear, with Earth between the Sun and Mars). In effect, this is a Sun-swingby maneuver.

16 These missions require a braking burn at Earth arrival to negate their large entry speed. See section 2.4.1 for details.

17 America At The Threshold, p. 21

Table 2.1 Minimum energy missions[18]

Launch date-Earth	3-Apr-01	8-Jun-03	20-Aug-05	6-Oct-07	8-Nov-09	28-Nov-11	17-Jan-14	11-Mar-16	11-May-18	27-Jul-20
Outbound length, days	200	204	217	248	278	252	224	204	204	207
Arrival date - Mars	20-Oct-01	29-Dec-03	25-Mar-06	10-Jun-08	13-Aug-10	6-Aug-12	29-Aug-14	1-Oct-16	1-Dec-18	19-Feb-21
Stay length, days	545	547	492	437	374	418	458	529	553	517
Launch date-Mars	18-Apr-03	28-Jun-05	30-Jul-07	21-Aug-09	22-Aug-11	28-Sep-13	30-Nov-15	14-Mar-18	6-Jun-20	21-Jul-22
Inbound length, days	205	192	214	262	270	259	237	212	190	203
Arrival date- Earth	9-Nov-03	6-Jan-06	29-Feb-08	10-May-10	18-May-12	14-Jun-14	24-Jul-16	12-Oct-18	13-Dec-20	9-Feb-23
Total trip length	**950**	**943**	**923**	**947**	**922**	**929**	**919**	**945**	**947**	**927**
ΔV TMI, m/s	3639	3574	3963	4199	4035	3672	3832	3739	3530	3807
ΔV MOI, m/s	2532	2095	2038	2032	1988	2532	2794	2677	2230	2031
ΔV TEI, m/s	2108	2647	2703	2278	2064	1989	1941	1983	2466	2746
Total ΔV, m/s	**8279**	**8316**	**8704**	**8509**	**8087**	**8193**	**8567**	**8399**	**8226**	**8584**

Table 2.2 Deep space maneuver missions[19]

Launch date-Earth	15-Nov-13	28-Oct-15	5-Apr-17
Outbound length before DSM, days	246	272	172.8
Outbound length after DSM, days	0	0	184.2
Arrival date - Mars	19-Jul-14	26-Jul-16	28-Mar-18
Stay length, days	40	40	40
Launch date- Mars	28-Aug-14	4-Sep-16	7-May-18
Inbound length before DSM, days	162.4	152.9	197
Inbound length after DSM, days	97.6	213.1	0
Arrival date- Earth	15-May-15	5-Sep-17	20-Nov-18
Total trip length	**546**	**678**	**594**
ΔV TMI, m/s	3915	4861	3980
ΔV outbound DSM, m/s	0	0	4025
ΔV MOI, m/s	3467	3281	4171
ΔV TEI, m/s	4979	3996	2339
ΔV inbound DSM, m/s	1933	2705	0
Total ΔV, m/s	**14294**	**14843**	**14515**

[18] Orbital Mechanics Tutorial: Presentation to Synthesis Group

[19] Orbital Mechanics Tutorial: Presentation to Synthesis Group

Table 2.3 Venus swingby missions[20]

Launch date-Earth	1-Apr-01	22-Aug-02	9-Jun-04	27-Aug-07	17-Jan-09	28-Nov-10	21-Nov-13	26-Oct-15	6-Apr-17	9-Jun-20
Outbound length, days	201	302	344	188	330	330	281	279	359	190
Arrival date - Mars	19-Oct-01	20-Jun-03	19-May-05	2-Mar-08	13-Dec-09	24-Oct-11	29-Aug-14	31-Jul-16	31-Mar-18	16-Dec-20
Stay length, days	40	40	40	40	40	40	40	40	40	40
Launch date-Mars	28-Nov-01	30-Jul-03	28-Jun-05	11-Apr-08	22-Jan-10	3-Dec-11	8-Oct-14	9-Sep-16	10-May-18	25-Jan-21
Inbound length, days	345	261	271	340	367	303	311	261	245	364
Arrival date- Earth	8-Nov-02	16-Apr-04	26-Mar-06	17-Mar-09	24-Jan-11	1-Oct-12	15-Aug-15	28-May-17	10-Jan-19	24-Jan-22
Total trip length	**586**	**603**	**655**	**568**	**737**	**673**	**632**	**580**	**644**	**594**
ΔV TMI, m/s	3635	3820	4131	4600	4208	4426	3690	4874	4186	4164
ΔV MOI, m/s	2538	4744	4429	4341	3339	3502	2258	3131	3580	2707
ΔV TEI, m/s	4248	3134	2639	4030	3367	2494	4922	4811	2332	3961
Total ΔV, m/s	**10421**	**11698**	**11199**	**12971**	**10914**	**10422**	**10870**	**12816**	**10098**	**10832**
Venus swingby location	**in**	**out**	**out**	**in**	**in and out**	**out**	**in**	**in**	**out**	**in**

Table 2.4 2-burn, short leg outbound (2BSO) missions[21]

Launch date-Earth	13-Mar-01	11-Apr-03	9-May-05	19-Aug-07	16-Oct-09	13-Nov-11	1-Jan-14	25-Feb-16	7-Apr-18	30-Jul-19
Outbound length, days	174	170	184	184	205	245	214	181	165	174
Arrival date - Mars	3-Sep-01	28-Sep-03	9-Nov-05	19-Feb-08	9-May-10	15-Jul-12	3-Aug-14	24-Aug-16	19-Sep-18	20-Jan-20
Stay length, days	40	40	40	40	40	40	40	40	40	40
Launch date-Mars	13-Oct-01	7-Nov-03	19-Dec-05	30-Mar-08	18-Jun-10	24-Aug-12	12-Sep-14	3-Oct-16	29-Oct-18	29-Feb-20
Inbound length, days	236	250	256	236	215	205	216	229	245	256
Arrival date- Earth	6-Jun-02	14-Jul-04	1-Sep-06	21-Nov-08	19-Jan-11	17-Mar-13	16-Apr-15	20-May-17	1-Jul-19	11-Nov-20
Total trip length	**450**	**460**	**480**	**460**	**460**	**490**	**470**	**450**	**450**	**470**
Delta-V TMI, m/s	3577	4366	5822	4941	4008	3631	3608	3585	3809	5427
Delta-V MOI, m/s	3581	4024	4128	4804	4007	2882	3385	3550	3785	4371
Delta-V TEI, m/s	4796	4634	4741	5297	5748	6079	5419	4926	4696	4629
Delta-V braking, m/s	1446	971	2647	7871	9280	7671	4538	2025	1021	1464
Total Delta-V, m/s	**13400**	**13995**	**17338**	**22913**	**23043**	**20263**	**16950**	**14086**	**13311**	**15891**

[20] Orbital Mechanics Tutorial: Presentation to Synthesis Group

[21] Orbital Mechanics Tutorial: Presentation to Synthesis Group

Table 2.5 2-burn, long leg outbound (2BLO) missions[22]

Launch date-Earth	27-Aug-00	5-Oct-02	6-Nov-04	13-Dec-06	19-Jan-09	27-Mar-11	6-Jun-13	31-Jul-15	15-Sep-17	24-Oct-19
Outbound length, days	262	251	236	219	207	221	247	264	260	242
Arrival date - Mars	16-May-01	13-Jun-03	30-Jun-05	20-Jul-07	14-Aug-09	3-Nov-11	8-Feb-14	20-Apr-16	2-Jun-18	22-Jun-20
Stay length, days	40	40	40	40	40	40	40	40	40	40
Launch date-Mars	25-Jun-01	23-Jul-03	9-Aug-05	29-Aug-07	23-Sep-09	13-Dec-11	20-Mar-14	30-May-16	12-Jul-18	1-Aug-20
Inbound length, days	168	169	174	201	233	209	183	176	170	168
Arrival date- Earth	10-Dec-01	8-Jan-04	30-Jan-06	17-Mar-08	14-May-10	9-Jul-12	19-Sep-14	22-Nov-16	29-Dec-18	16-Jan-21
Total trip length	**470**	**460**	**450**	**460**	**480**	**470**	**470**	**480**	**470**	**450**
Delta-V TMI, m/s	7692	7276	7889	9421	11790	13053	11142	8844	7488	7576
Delta-V MOI, m/s	4437	4595	4899	5352	5795	5217	4757	4467	4454	4781
Delta-V TEI, m/s	5401	4209	3404	3133	2972	4812	6244	5085	4556	3585
Total Delta-V, m/s	**17530**	**16080**	**16192**	**17906**	**20557**	**23082**	**22143**	**18396**	**16498**	**15942**

[22] Orbital Mechanics Tutorial: Presentation to Synthesis Group

High energy missions with long stay times may be achieved by mixing the missions as presented above. For example, if an extended stay is desired for a mission beginning as the 2015 Venus swingby mission, the launch date from Mars can be delayed from Sept. 9, 2016 to May 10, 2018, providing a 608 (rather than 40) day stay, and lowering the size of the TEI burn and duration of the inbound transfer as well. Or, the inbound trajectory from the 2018 2BSO mission could be used, giving a 780 day stay and lowering the TEI delta-V even more.

Of course, many more such combinations are possible. To examine aborts for such a mixed mission, simply piece together the abort data for each of the separate legs as obtained for their original missions.

The 2014/2015 mission within each class is examined, because the target year for first manned launch is 2014.

2.3 Abort trajectory generation

Abort trajectories were generated for aborts from points throughout all three phases of each mission: outbound to Mars, from Mars orbit, and inbound to Earth.

For each mission point abort trajectories of varying return to Earth (RTE) lengths were considered, taking from 10 to 250 days. For points during the inbound leg where less than 250 days remained until Earth arrival if no abort was performed, the maximum abort trip length was limited to the remaining nominal trip time.

The abort trajectory data generated consists of the delta-Vs necessary for injection into the abort trajectories and the hyperbolic excess velocities at Earth arrival, which are used to compute the braking burns required at Earth arrival.

2.3.1 Earth arrival braking burn

The missions described in the mission planning documents from the Synthesis Group limit entry velocity at Earth arrival to 14.5 km/sec or less,[23]

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[23] Orbital Mechanics Tutorial: Presentation to Synthesis Group

to keep heat and deceleration loads within acceptable limits. This figure is also used to constrain entry speeds for abort trajectories, to keep the results consistent with those of the Synthesis Group.

The hyperbolic excess velocity is defined as the component of a body's velocity which is perpendicular to local planetary escape velocity. The Earth entry speed can be found from the hyperbolic excess velocity at Earth arrival in the following manner:

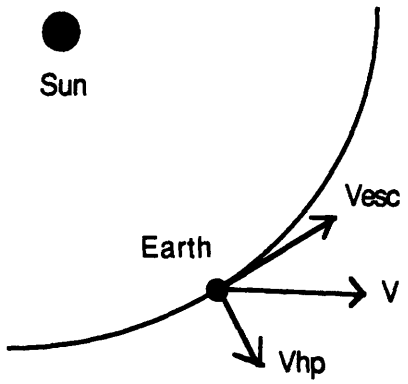

Figure 2.1: Definition of hyperbolic excess velocity

$$V_{entry} = \sqrt{V_{hyp}^2 + V_{esc}^2}$$

$$V_{esc} = \sqrt{\frac{2\mu}{R}}$$

$$\mu_{Earth} = G\,M_{Earth} = 3.989 \times 10^{14}\ m/s^2$$

$$r_{Earth} = 6378\ km$$

"At an altitude somewhere below 150 km, atmospheric forces become appreciable," [24] so escape velocity at 150 km is used as V_{esc} in the entry speed calculation. Inserting this figure, and restricting entry speed to 14.5 km/sec, we find that the hyperbolic excess velocity at Earth must be less than or equal to 9.383 km/sec.

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[24] Regan, Frank J. Re-Entry Vehicle Dynamics; AIAA Education Series, 1984. p. 97

To make the size of the braking burns a conservative calculation, 9.3 km/sec was used as the constraint on hyperbolic excess velocity at arrival.

Most abort trajectories developed in this study have arrival speeds greater than 9.3 km/sec, and so most abort scenarios require a braking burn at Earth arrival as well as the burn to insert the vehicle into the abort trajectory.

This arrival burn is also required for the "500-day" 2BSO trajectories, which have an arrival speed greater than 9.3 km/sec (see Table 2.4) Using 9.3 km/sec as the hyperbolic excess velocity constraint results in slightly higher braking burns for 2BSO trajectories than those specified by the mission planning documents, but the discrepancies are under 50 m/s, so the hyperbolic excess velocity limit is accepted as conservative.

2.3.2 MULIMP

The delta-Vs necessary to enter the abort trajectories were generated using the MULIMP trajectory analysis program from SAIC. MULIMP is "designed to compute a multi-targeted trajectory as a sequence of 'two-body' subarcs in a central gravitational field using Kepler and Lambert analytical solution algorithms."[25]

Given the dates at which you wish to be at each planet, and the parameters of the spacecraft orbit at each planet, MULIMP supplies the delta-Vs necessary for each maneuver, velocity and position vectors for times at set intervals throughout the trip, and the hyperbolic excess velocity at each impulse point (used to find entry velocity at Earth).

The program's accuracy was tested by supplying it with the parameters of the missions supplied by the Synthesis Group. MULIMP supplied the same delta-Vs as specified in the tutorial.

The delta-Vs necessary for abort from Mars orbit were generated using the same method as for nominal missions, by simply varying the date Mars is left and the date of Earth arrival.

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[25] MULIMP manual, SAIC Corporation.

The delta-Vs necessary for aborts during the inbound and outbound transfers were generated using MULIMP's capacity for deep-space maneuvers (DSM). Given a set of XYZ coordinates and a date for a DSM, the date the original planet was left and the date of arrival at the target planet, MULIMP supplies the delta-V from the original planet, the delta-V for the DSM and the hyperbolic excess velocity at arrival, which sets the braking burn delta-V. This supplies the abort delta-Vs, and allows a check on the result, by comparing the injection delta-V specified with that of the nominal mission.

Although these delta-Vs did not always match, they were always within 100 m/s of each other, and almost always within 25 m/s of each other. These errors can be considered insignificant to the results when compared to the original delta-Vs of several kilometers per second, and are due to the fact that MULIMP output supplies only 4 digits when dispensing XYZ coordinates.

Another set of accuracy checks was performed during these calculations. For inbound aborts, if the length of the trip to Earth after the abort burn was set to the length of time remaining in the nominal trip, the resulting abort injection delta-V should be 0, since no delta-V is necessary to put the vehicle in the trajectory it's already travelling. Also, the resulting hyperbolic excess velocity at Earth arrival should match that of the nominal mission. The abort delta-Vs generated by this check remained consistently under 100 m/s, and this error is also caused by the inaccuracy of the XYZ coordinates, which leave the spacecraft slightly off the nominal mission trajectory at the DSM point under consideration.

2.4 Selected mission abort trajectories

The following section is divided into subsections, one for each mission studied. Each section contains a series of graphs which present the total delta-Vs required for aborts from that mission. The raw data for the abort trajectories is contained in Appendix A.

The graphs present total delta-V required to perform aborts versus the number of days from Earth when the abort occurs, with the number of days from Earth when planetary departures and arrivals occur noted under the time axis. Each curve represents a set of aborts with the same return to Earth (RTE) trip length. The data are divided into multiple graphs for clarity - when

one curve's range is from 0 to 1000 km/sec and another's is from 0 to 25 km/sec, all resolution for the smaller is lost if they're put on the same plot.

Another graph for each mission plots the time history of the insertion and braking burns for selected RTE lengths, to illustrate how the total delta-V is divided between the two burns.

The curves each end on a different date because inbound aborts with a given RTE are no longer considered after the point where the nominal mission returns to Earth in that many days.

These graphs can be used to find the delta-V required to return to Earth in a certain number of days from a certain point. They can also be used to discover, for a certain delta-V, how fast a return to Earth can be accomplished if that much delta-V is available throughout the mission. For example, in the 2014 minimum energy mission, if 60 km/sec are available throughout the mission, this allows 110 day RTE across the whole mission (see Fig. 2.4), 70 day RTE from points 0 to 200 or 700 to 919 days from Earth (Fig. 2.3), and 10 day RTE from points 0 to 100 or 850 to 919 days from Earth (Fig. 2.2).

On some of these plots, there appear sudden spikes in the total delta-V required for certain aborts. These spikes in total delta-V represent aborts which encounter an unfavorable configuration of planets and the Sun, and raise the total delta-V only for a very brief period of time. When actually planning an abort capability, the need to carry enough fuel to acquire these "spike" delta-Vs can be avoided by noting that in most cases the delta-V required for an abort from the same mission point with the next fastest RTE is lower than the "spike" delta-V, and then replacing the "spike" delta-V with this lower delta-V. In cases where the next fastest abort from the same point is not less expensive, the total delta-V required for an abort with the next fastest RTE from the point after the next time step was, and the "spike" delta-V was replaced with this delta-V. Since the time steps are always shorter than the 20 days between RTE speeds, the time to Earth since the decision to abort is made remains less than the original RTE speed.

The final graph for each mission details the total delta-V required to return to Earth with any RTE length up to 250 days for trips leaving Mars on the date the nominal mission would leave Mars. This graph is used to examine

the change in the nominal mission's return to Earth trip length when extra fuel has been brought to Mars to create abort capability, allowing an increase in the delta-V available to the nominal mission configuration as well, and thus a decrease in the nominal mission return to Earth trip length.

2.4.1 2014 minimum energy mission aborts

Figure 2.2: 2014 minimum energy abort total ΔVs

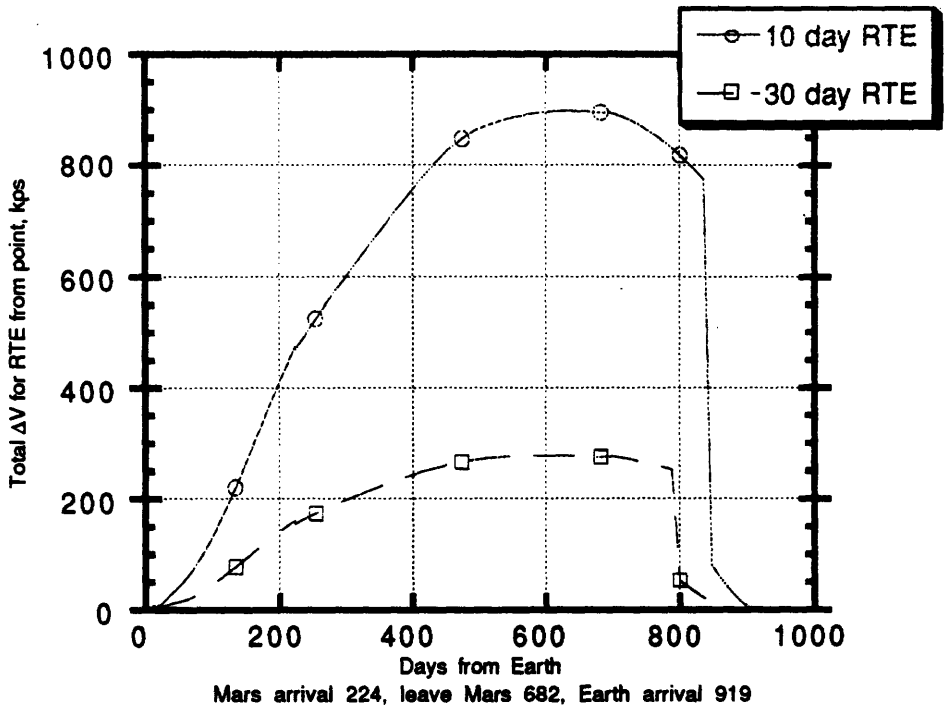


Figure 2.3 2014 minimum energy abort total ΔVs

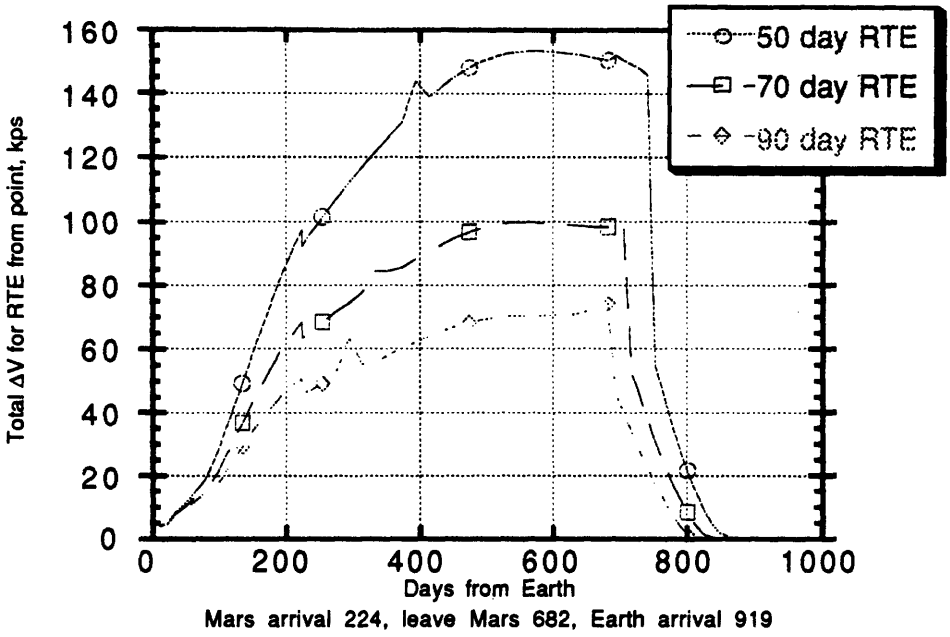


Figure 2.4: 2014 minimum energy abort total ΔVs

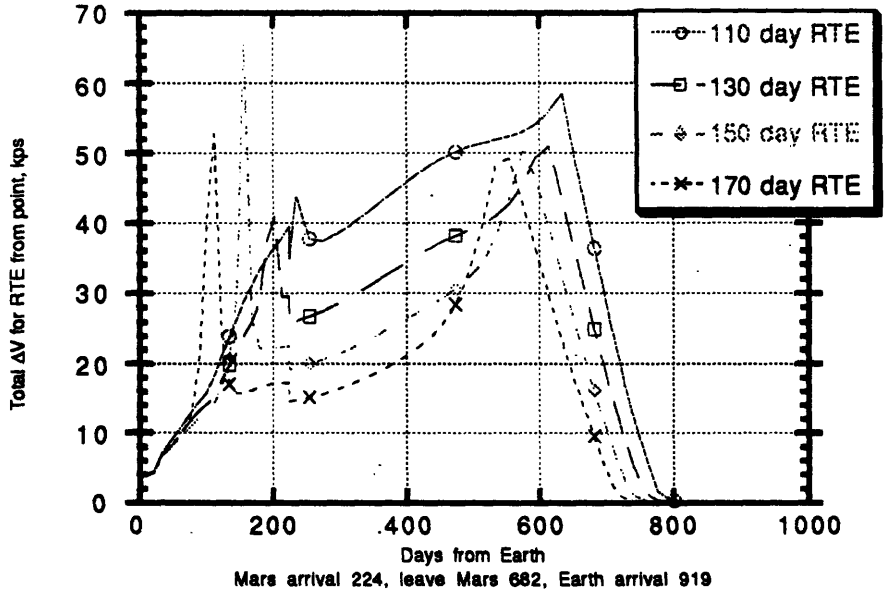


Figure 2.5: 2014 minimum energy abort total ΔVs

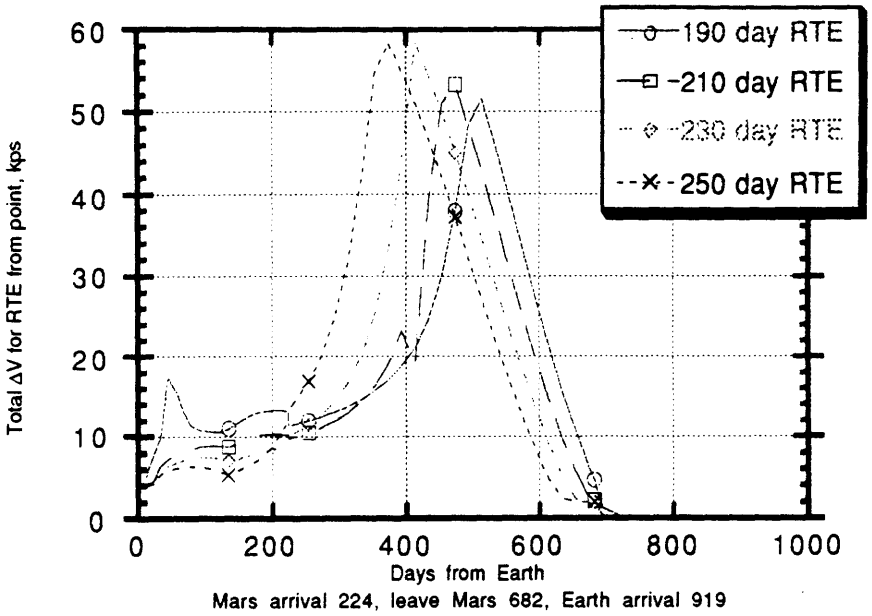


Figure 2.6: ΔV split for 2014 minimum energy mission aborts

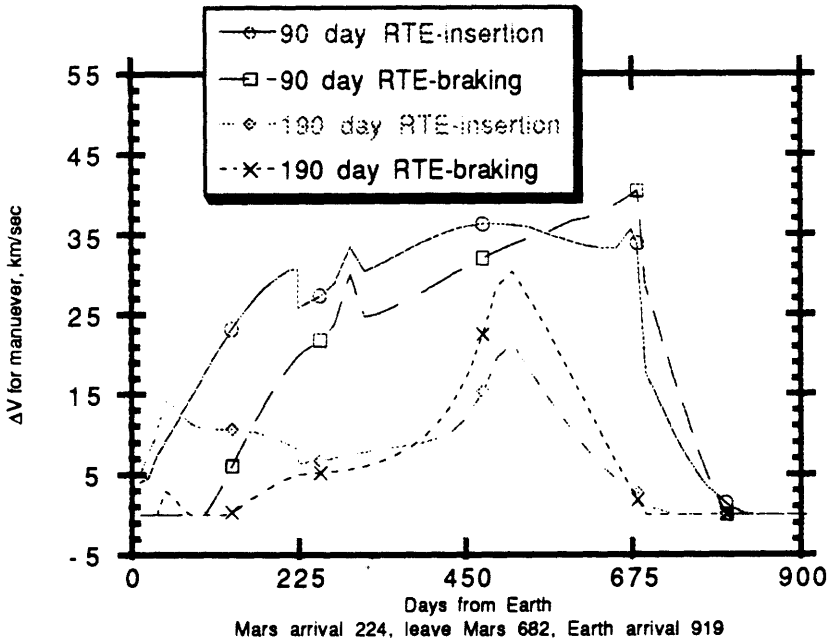
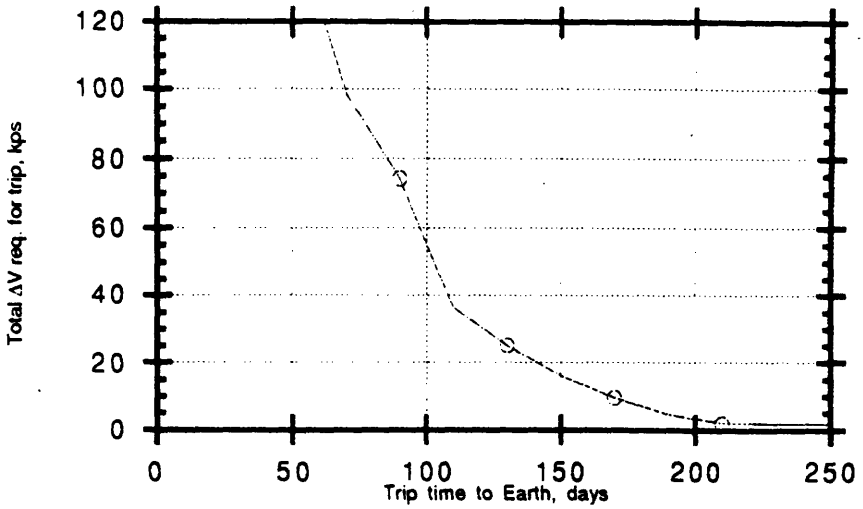


Figure 2.7: Mars-Earth trips leaving Mars on the nominal 2014 minimum energy mission TEI date



2.4.2 2015 deep space maneuver mission aborts

Figure 2.8: 2015 deep space maneuver mission abort total ΔVs

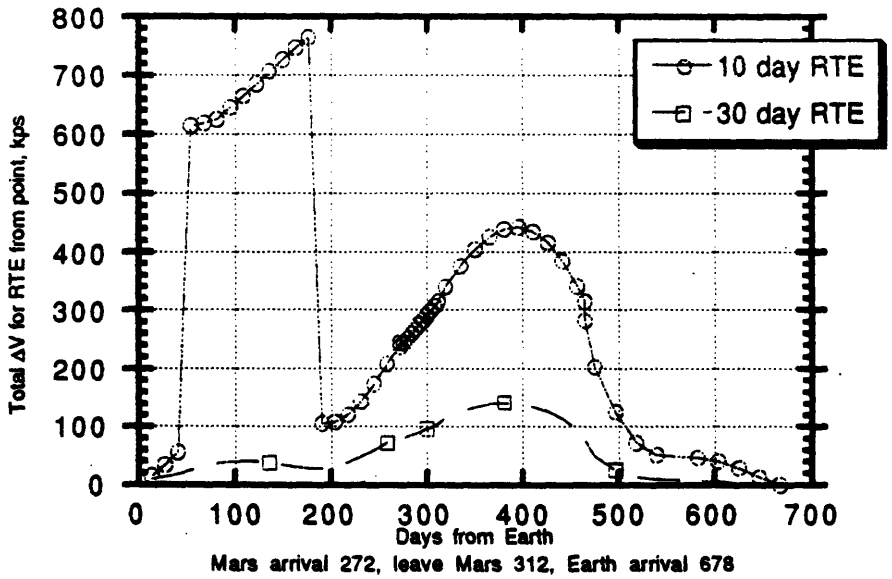


Figure 2.9: 2015 deep space maneuver mission abort total ΔVs

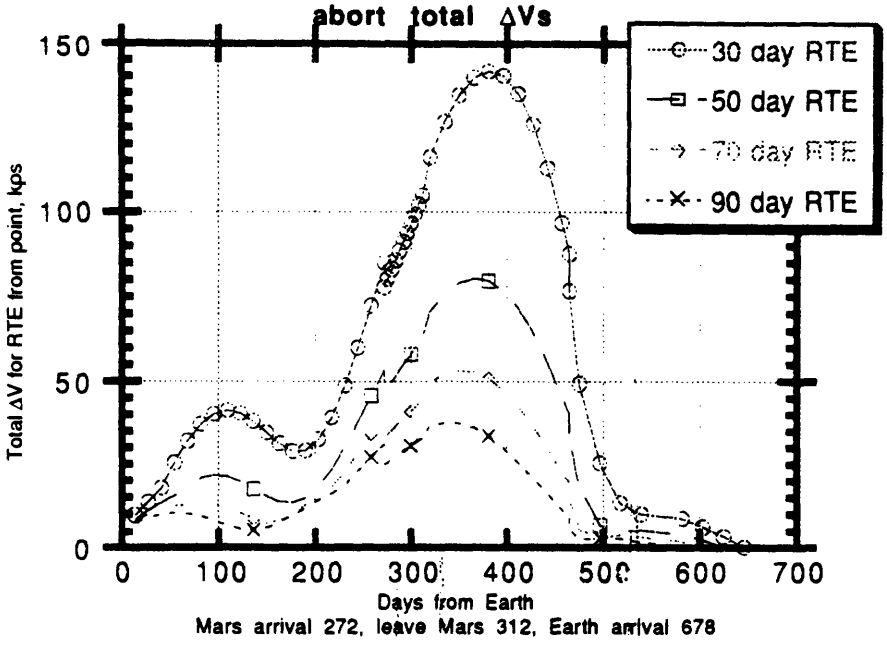


Figure 2.10: 2015 deep space maneuver mission abort total ΔVs

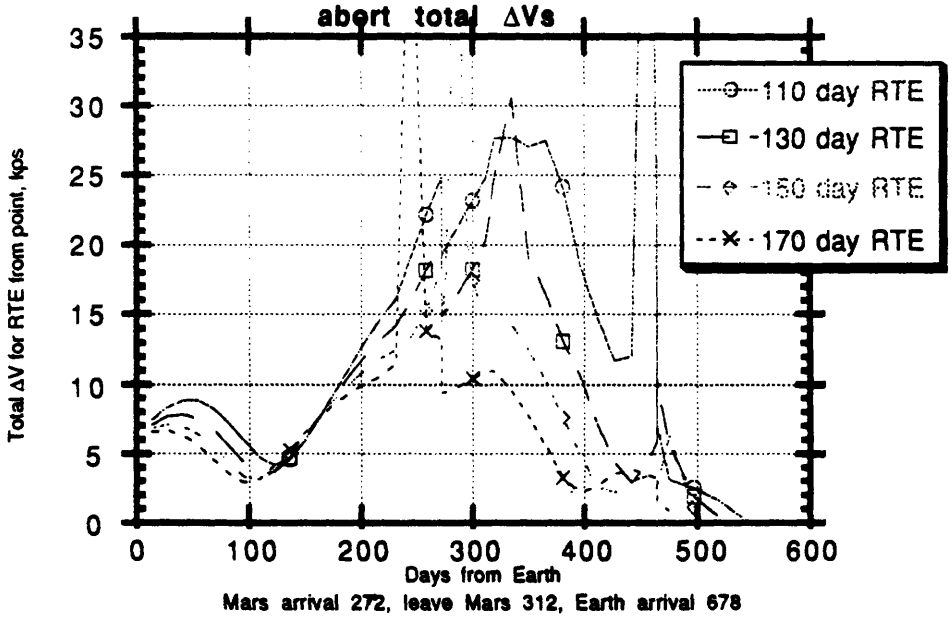


Figure 2.11: 2015 deep space maneuver mission abort total ΔVs

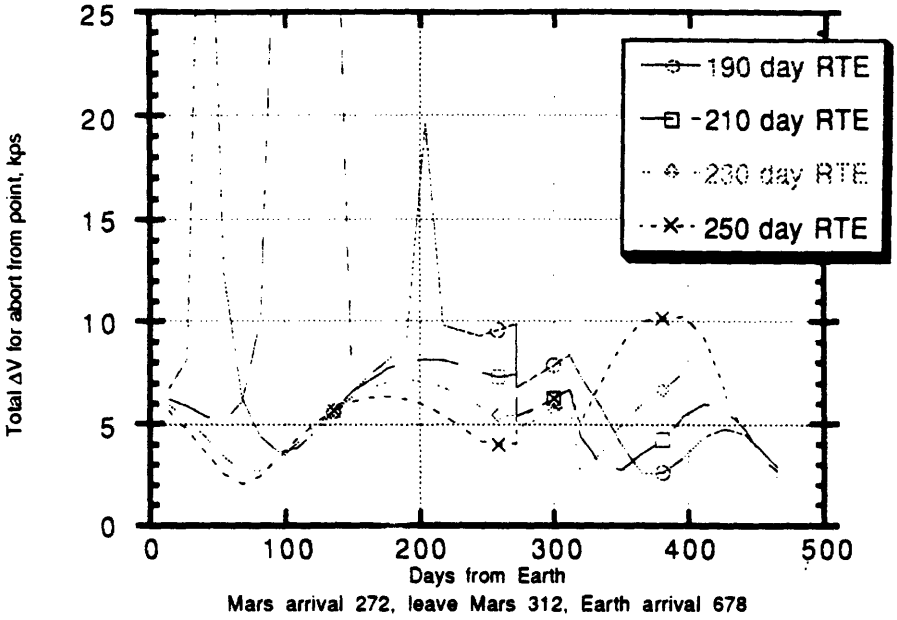


Figure 2.12: ΔV splits for 2015 deep space manuever mission aborts

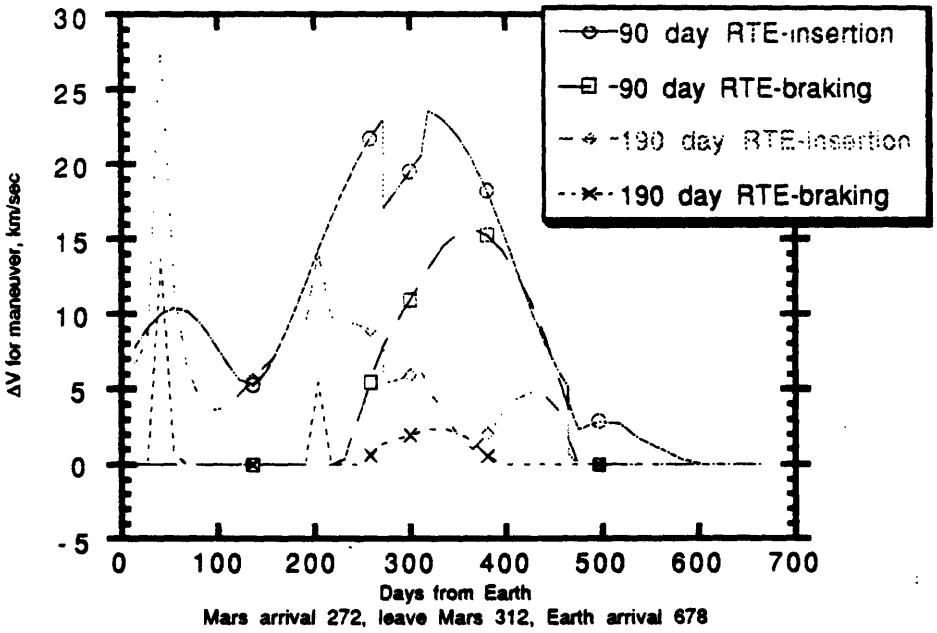
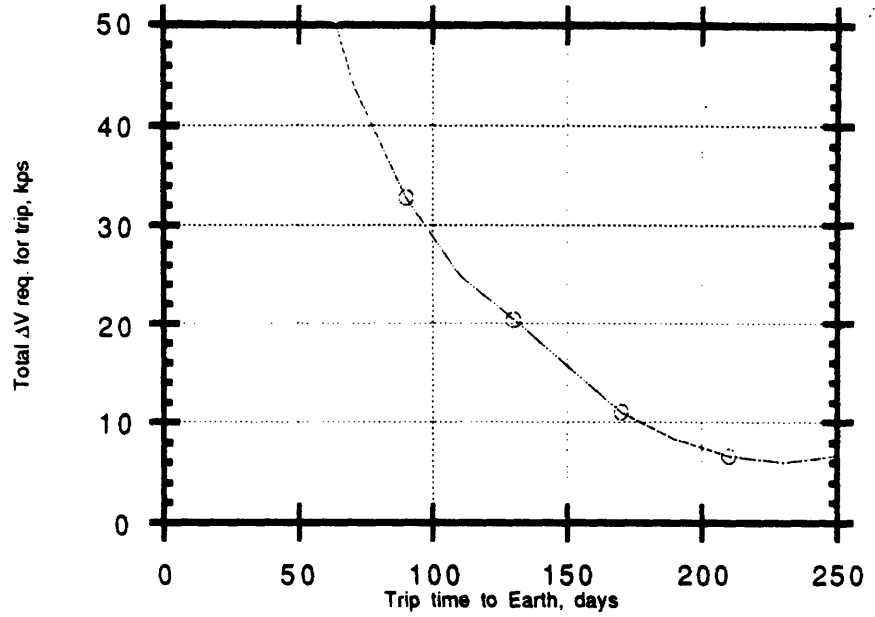


Figure 2.13: Mars-Earth trips leaving on the nominal 2015 deep space manuver mission TEI date



2.4.3 2015 Venus swingby mission aborts

Figure 2.14: 2015 Venus swingby mission abort total ΔVs

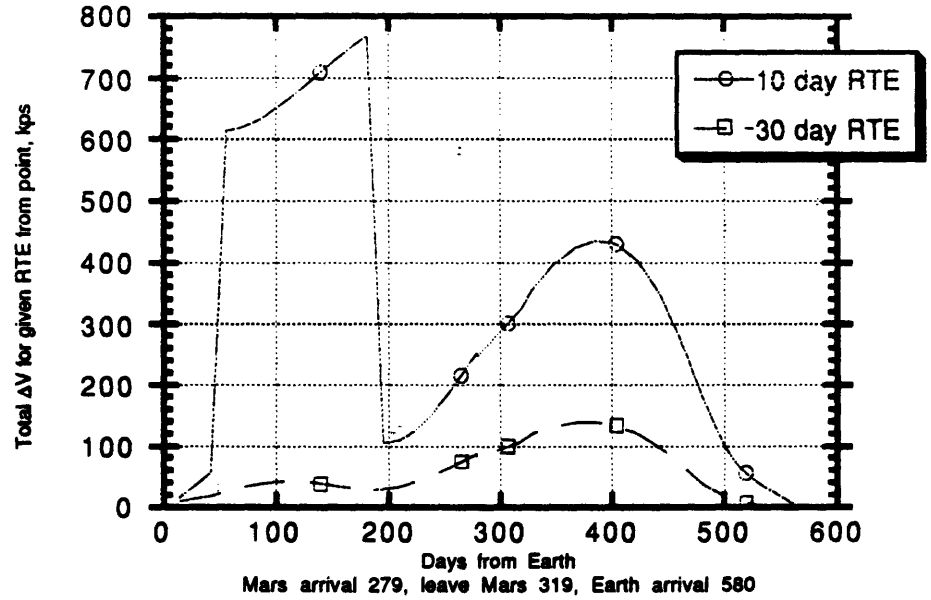


Figure 2.15: 2015 Venus swingby mission abort total ΔVs

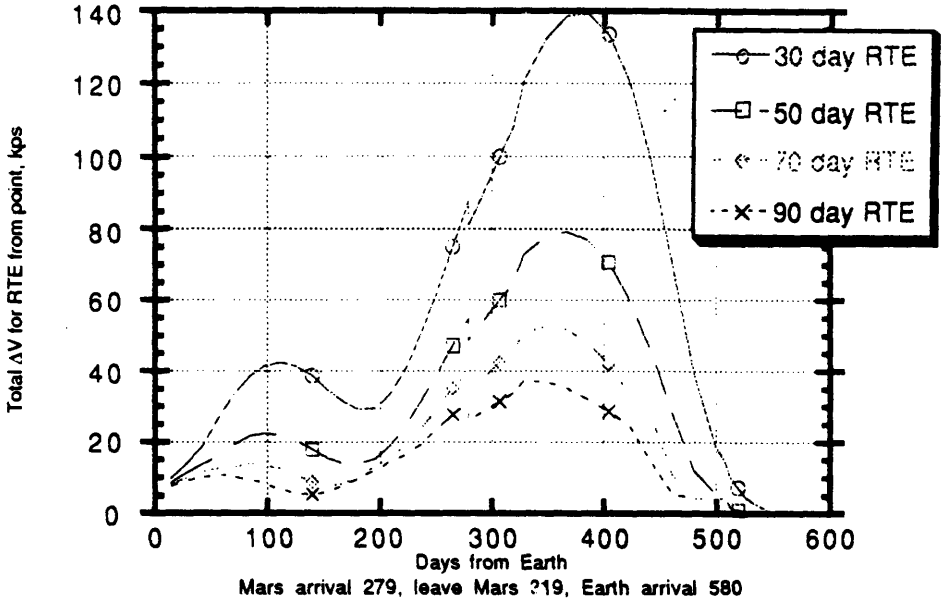


Figure 2.16: 2015 Venus swingby mission abort total ΔVs

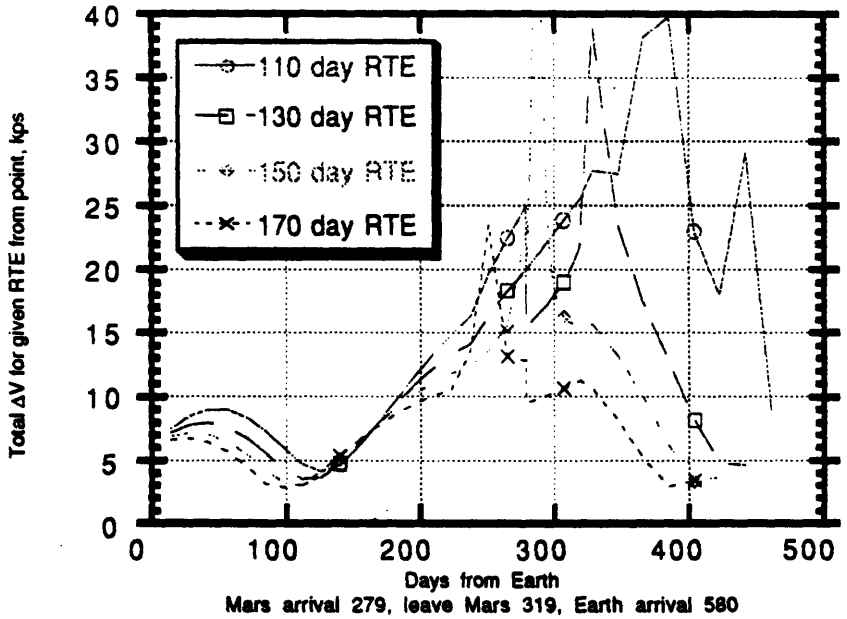


Figure 2.17: 2015 Venus swingby mission abort total ΔVs

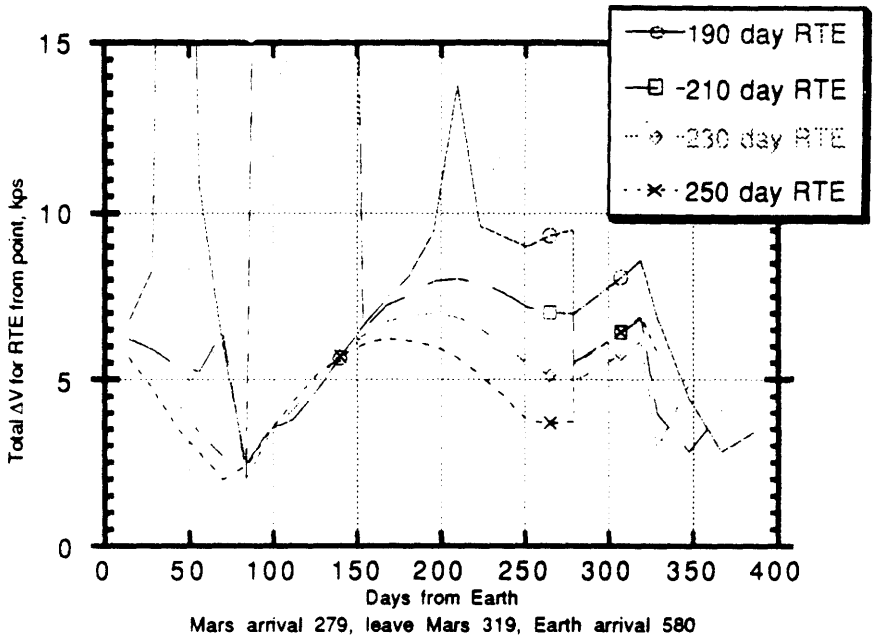


Figure 2.18: ΔV split for 2015 Venus swingby mission aborts

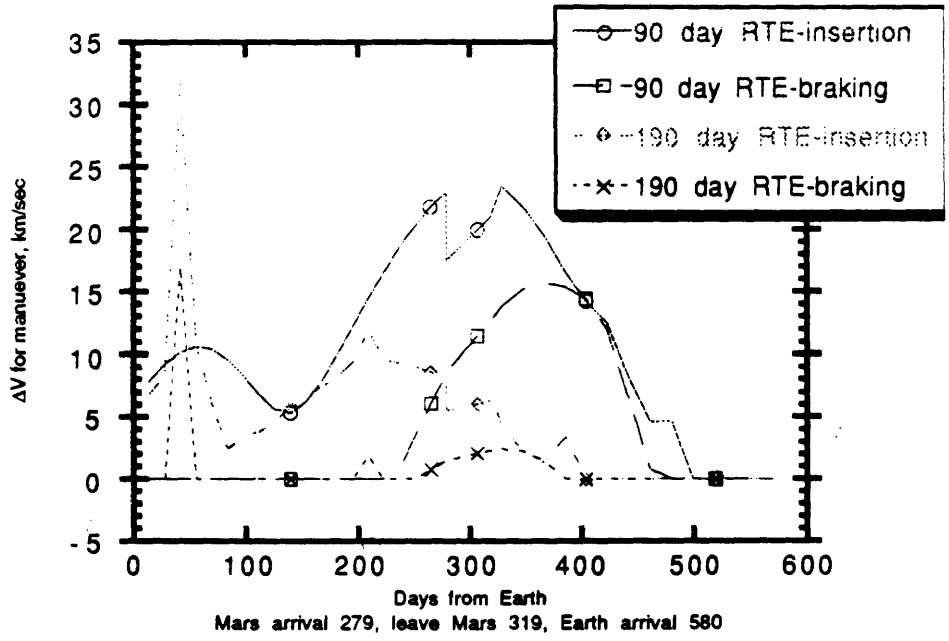
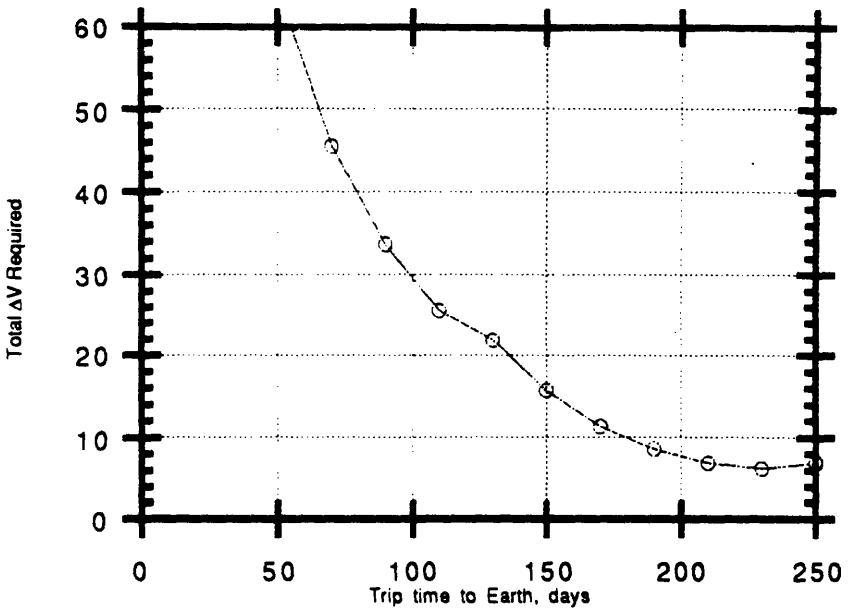


Figure 2.19: Mars-Earth trips leaving Mars on the nominal 2015 Venus swingby mission TEI date



2.4.4 2014 2-burn short leg outbound (2BSO) mission aborts

Figure 2.20: 2014 2BSO mission abort total ΔVs

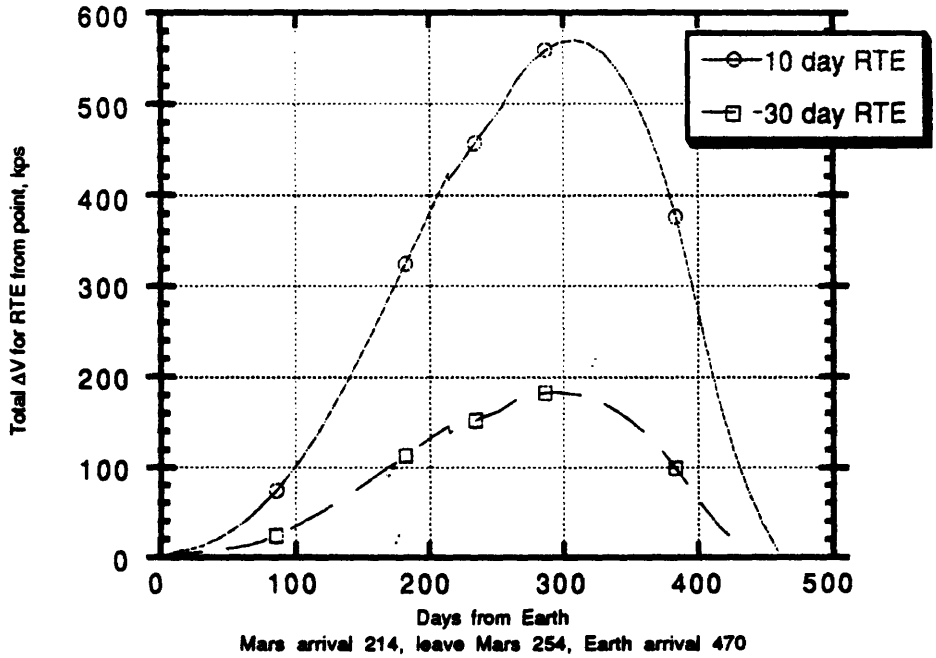


Figure 2.21: 2014 2BSO mission abort total ΔVs

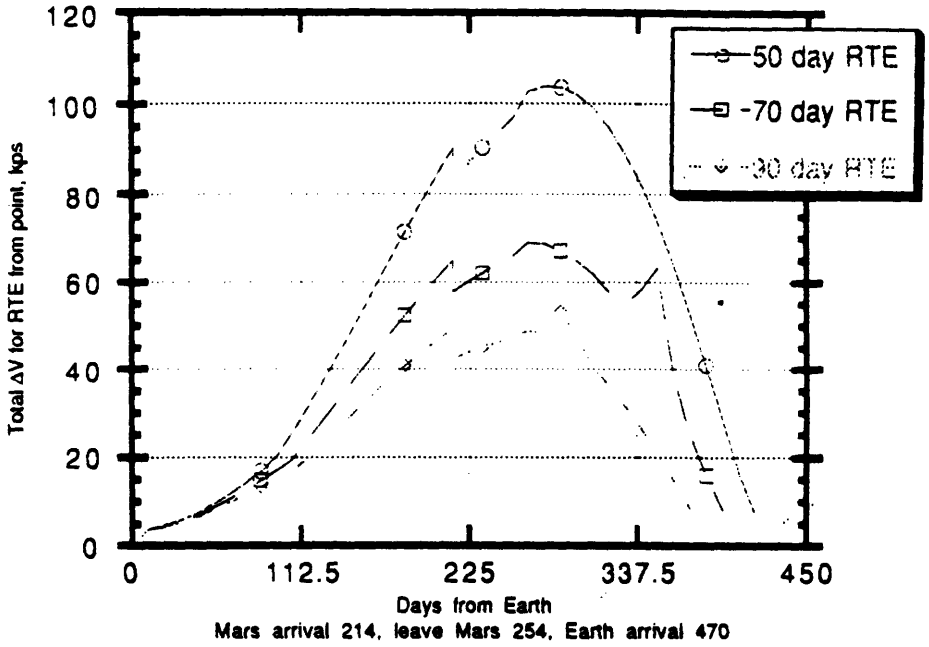


Figure 2.22: 2014 2BSO mission abort total ΔVs

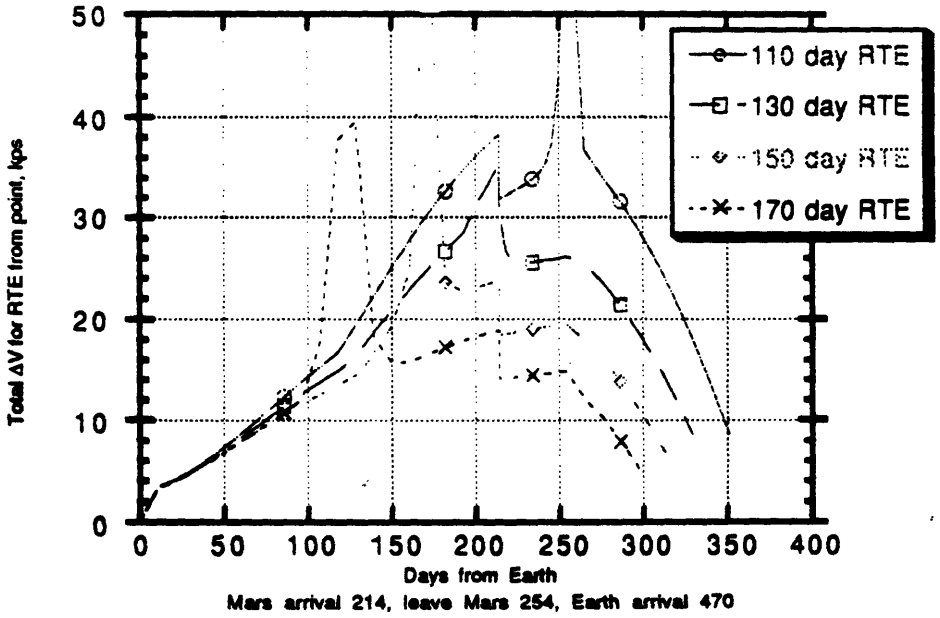


Figure 2.23: 2014 2BSO mission abort total ΔVs

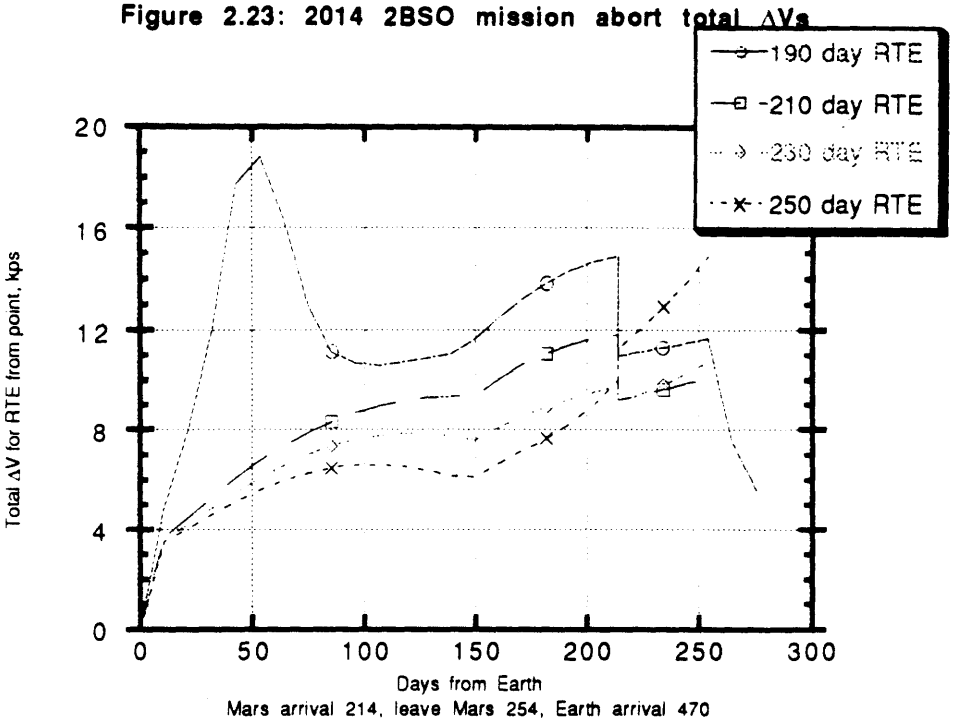


Figure 2.24: ΔV split for 2014 2BSO mission aborts

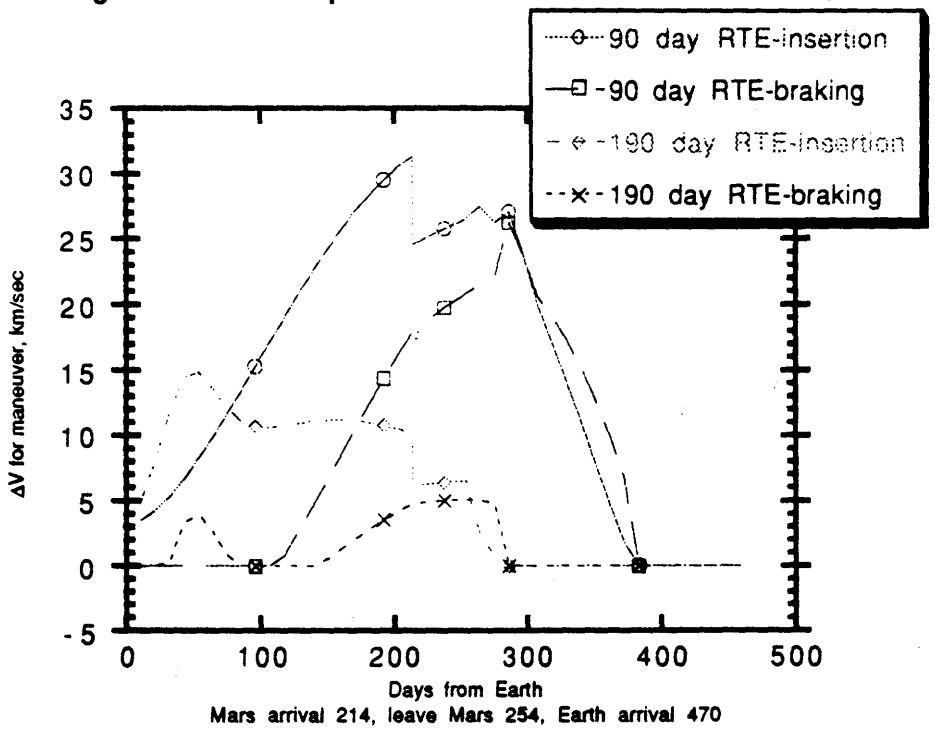
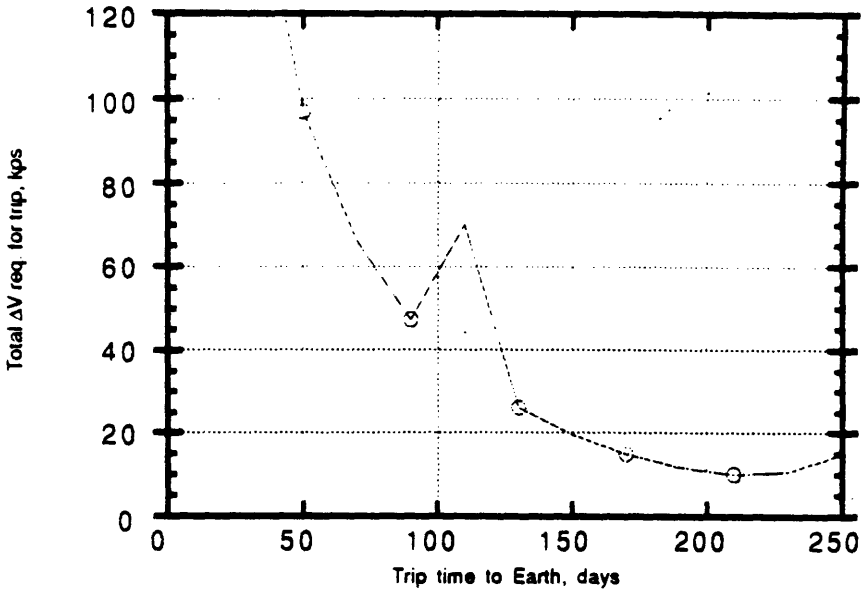


Figure 2.25: Mars-Earth trips leaving Mars on the 2014 2BSO nominal mission TEI date



2.4.5 2015 2-burn long leg outbound (2BLO) mission aborts

Figure 2.26: 2015 2BLO mission abort total ΔVs

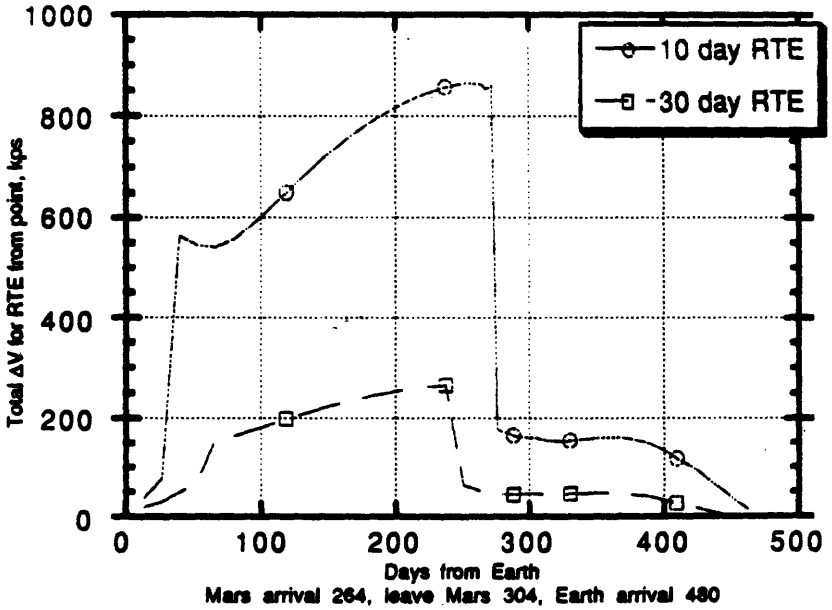


Figure 2.27: 2015 2BLO mission abort total ΔVs

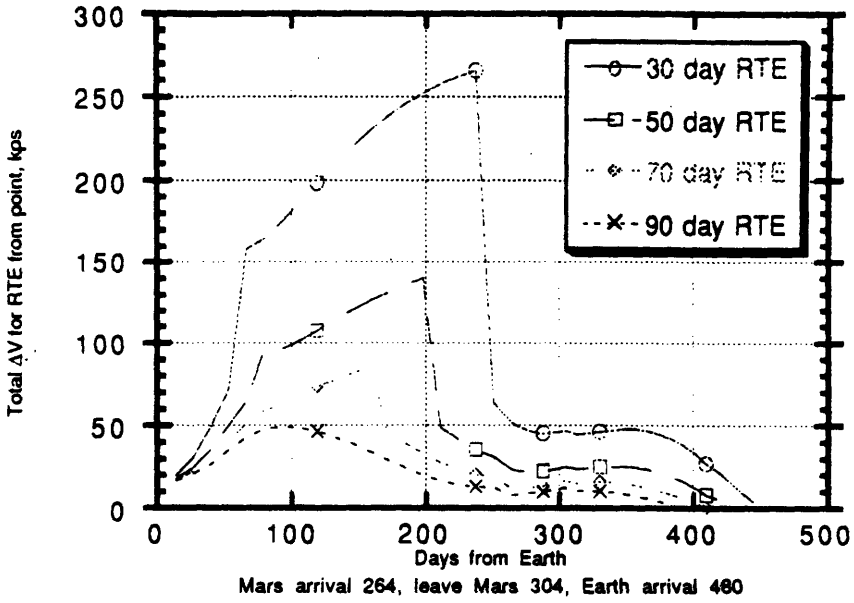


Figure 2.28: 2015 2BLO mission abort total ΔVs

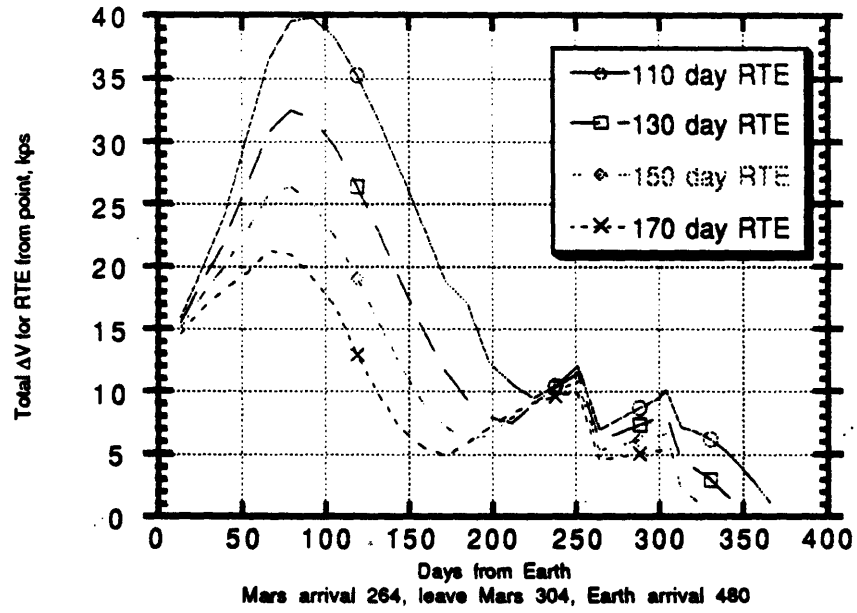


Figure 2.29: 2015 2BLO missio abort total ΔVs

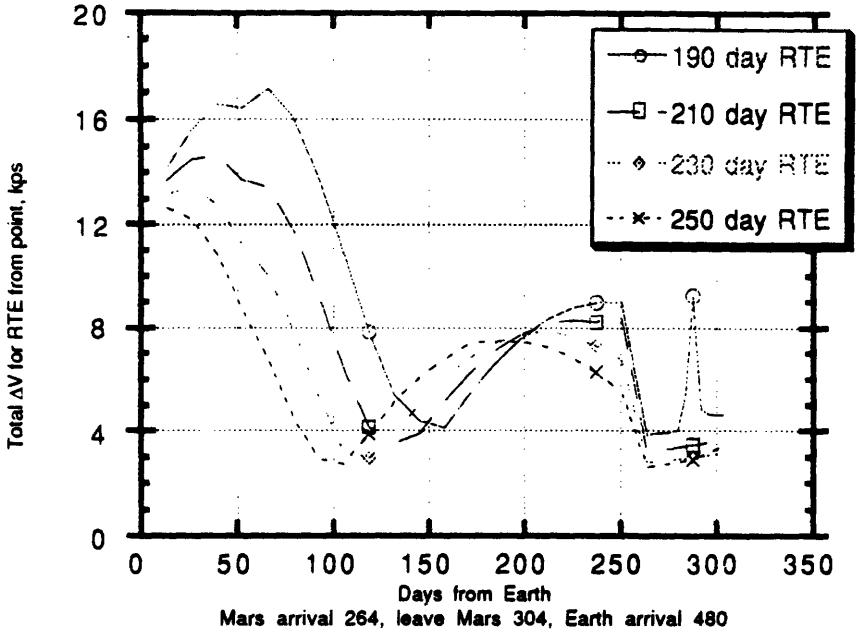


Figure 2.30: ΔV split for 2015 2BLO mission aborts

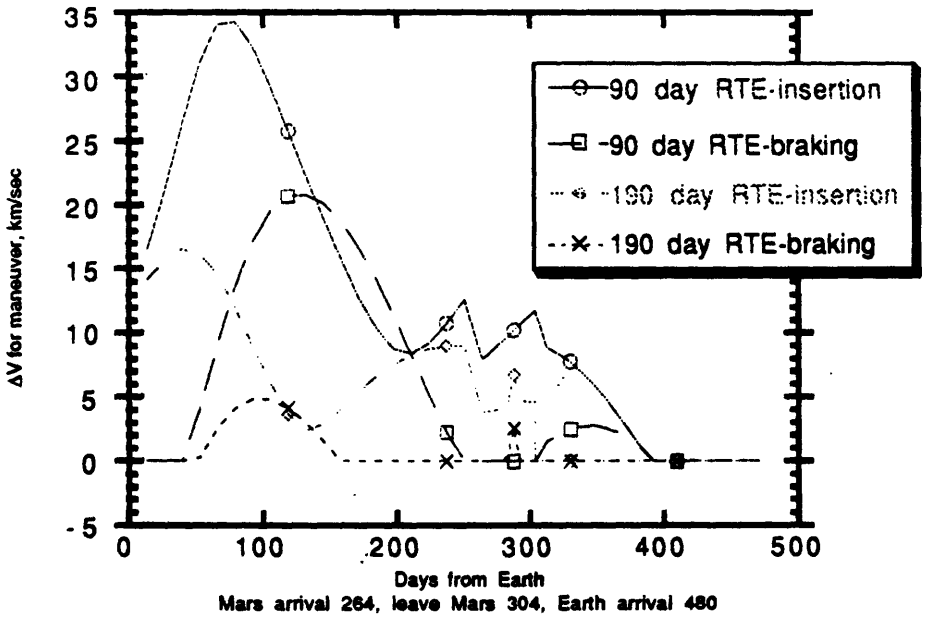
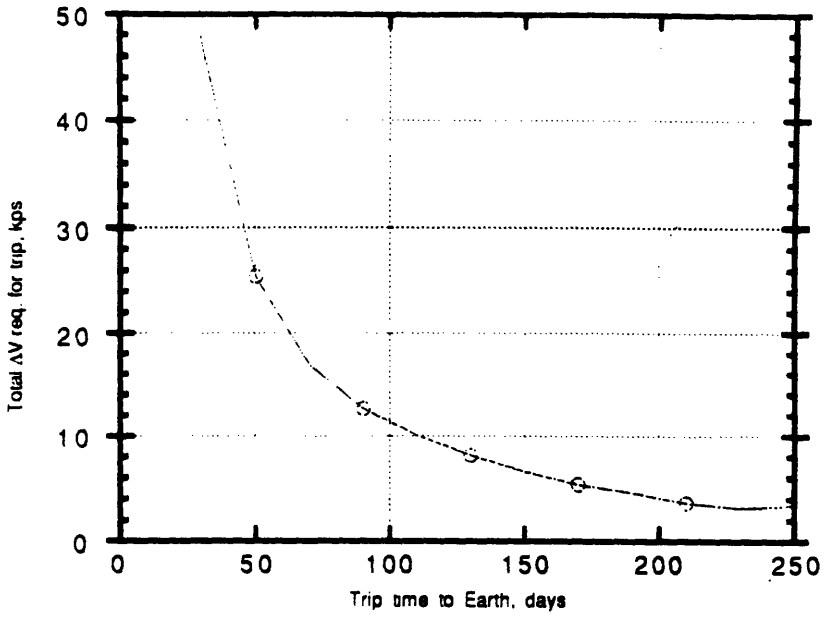


Figure 2.31: Mars-Earth trips leaving Mars on the 2015 2BLO nominal mission TEI date



2.5 Abort types

2.5.1 Outbound Aborts

Outbound aborts have lower braking burns than insertion burns, and often may not require a braking burn at all (see Figures 2.2-2.30, and appendices A.1-A.5). This is because while near Earth, the outbound trajectory is still roughly parallel to Earth's orbit, and the insertion burn does not have to cancel the vehicle's outbound velocity and then impose a new velocity towards Earth. A near-Earth outbound abort therefore only has to nudge the velocity vector back in towards Earth, and accelerate the spacecraft to allow it to catch up to Earth (outbound transfer has a slower angular rate than Earth's). For such a case, the spacecraft velocity will nearly match that of the Earth, and no braking burn will be required.

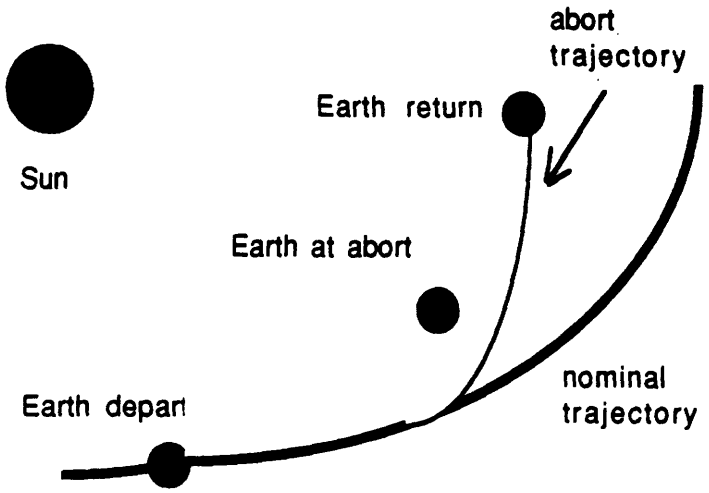


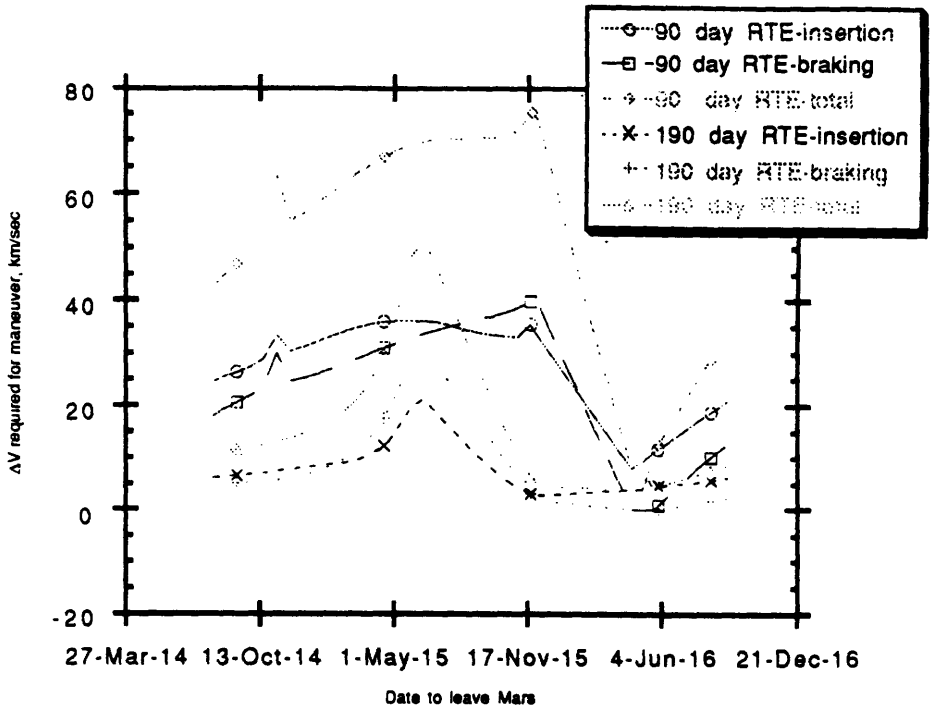
Figure 2.32: near-Earth outbound aborts

This is also why the total delta-Vs for near-Earth outbound aborts remain comparatively low, even for the very fast aborts. The sudden jump in injection delta-V from 50 km/sec or less to more than 300 km/sec some missions' 10-day RTE trajectories experience (see Figures 2.8, 2.14, 2.26) is due to the swing of the velocity vector to a direction such that it must be negated. This is also the point where the hyperbolic excess velocity at arrival begins to grow commensurately with the insertion burn, keeping the braking burn roughly 9 km/sec below the insertion burn (see Figs. 2.6, 2.12, 2.218, 2.264, 2.30).

2.5.2 Abort from Mars orbit

The delta-Vs required for an abort from Mars orbit are functions of the mission type only in that the mission types set the dates of the Mars stay. An abort from Mars orbit is simply a Mars-Earth transfer of a certain length leaving on a certain day. The delta-Vs required for aborts from Mars orbit are shown by date of launch from Mars below, and are also included in the overall abort profiles for each mission type in section 2.4.

Figure 2.33: Mars-Earth trip ΔVs vs. launch date



The total delta-V (insertion plus braking) required for a given RTE grows throughout the Mars stay for all the high-energy missions.[26] For the minimum energy mission the total delta-V remains roughly constant over the Mars stay for fast RTEs, but grows steeply to a peak and the falls off rapidly for the slower RTE aborts (see Figs. 2.4, 2.5).

For abort from Mars orbit the growth of the braking burn continues to follow the growth of the insertion burn, until the hyperbolic excess velocity matches the insertion delta-V and the braking burn levels out at 9 km/sec less than the insertion burn.

The curve of total delta-V necessary for a given length of abort has a visible transition across the line between outbound aborts and aborts from Mars orbit. In most cases this drop is slight compared to the total delta-V and the transition can be considered smooth, but for 10-day RTE aborts and some other cases the drop is substantial (see Figs. 2.8, 2.14, 2.26, 2.28, 2.29).

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[26] This is why high energy missions have such short stay times. The Earth-Mars phasing is worsening over the length of the Mars stay, a result of the phasing that makes the short trip times possible for relatively low delta-V.

This drop represents the fact that after Mars orbit insertion (MOI), it is no longer necessary to kill outbound velocity to head back towards Earth. That the transition in abort delta-V from before MOI to after MOI is not larger is because the delta-V necessary to escape Mars orbit after MOI restores some of the lost delta-V requirement. The larger the outbound velocity was before MOI, the larger the drop at transition.

2.5.3 Inbound aborts

For high-energy missions, the slope of the curve of total delta-V versus time for each abort RTE length increases after the trans-Earth injection (see Figs. 2.8, 2.9, 2.10, 2.14, 2.15, 2.24). The curve peaks, and then descends to 0 as the time from Earth goes to the total trip time minus the RTE length.

All curves drop suddenly towards 0 at the end, because the last data point for each RTE time is an abort performed when the nominal inbound trajectory had only a few more days than the RTE time remaining, resulting in a trivial delta-V requirement to enter the abort trajectory.

For inbound aborts, the braking burn continues to grow even after the insertion burn begins to decline. In some cases, the braking burn becomes larger than the insertion burn before it too starts to decline. For near-Earth aborts the braking burn returns to 0 as the insertion burn heads to 0 as well.

2.5.4 Free return missions

A free return trajectory is one which is designed with a period which is a multiple of Earth's so that if Mars orbit insertion is not made, the vehicle still returns to Earth. These trajectories are not considered. The only system failures to which a free return is an appropriate response are those which prevent MOI, such as loss of all fuel or total failure of the entire engine system, including all the reactors.

Any other system failure making an abort necessary will do so because the crew could not survive the rest of the nominal mission or are unable to complete any mission objectives due to the failure. Free return trajectories require at least a year after Mars flyby to return to Earth; if the crew could not survive the rest of the nominal mission, it is unlikely they will last that

year (only minimum energy missions last substantially more than a year after MOI, and minimum energy free return missions take even longer).

Furthermore, free return trajectories only provide the option for an abort until Mars orbit insertion; after this maneuver the vehicle is no longer on the free return trajectory. An abort configuration which allows relatively swift return to Earth from Mars orbit over the entire stay at Mars will require enough fuel to also allow an abort option during the outbound (to Mars) leg with much faster RTE than the free return.

So, free returns are not considered a viable abort strategy. However, while having a free return option normally raises mission total delta-V substantially, in cases where the base mission's Earth to Mars transfer is nearly a free return trajectory, the free return trajectory is not much more expensive than the nominal one. In such a case, a free return option can be had for minimal cost, and should be used.

As can be seen by comparing the Table 2.6 to Table 2.1, some minimum energy trajectories are of this type. Note also that the inbound transfers are the same whether the outbound trajectory is free return or not. For a mission like the 2003, 2005 or 2007 minimum energy missions where the free return option increases total delta-V only marginally, the free return option should be utilized.

Table 2.6: Minimum energy missions with free return[27]

Launch date-Earth	25-Mar-01	15-Jun-03	21-Aug-05	6-Oct-07	27-Nov-09	23-Nov-11	31-Dec-13	25-Feb-16	16-May-18	27-Jul-20
Outbound length, days	135	218	217	250	300	215	182	148	125	207
Arrival date - Mars	7-Aug-01	19-Jan-04	26-Mar-06	12-Jun-08	23-Sep-10	25-Jun-12	1-Jul-14	22-Jul-16	18-Sep-18	19-Feb-21
Stay length, days	619	526	491	435	333	460	517	600	627	517
Launch date-Mars	18-Apr-03	28-Jun-05	30-Jul-07	21-Aug-09	22-Aug-11	28-Sep-13	30-Nov-15	14-Mar-18	6-Jun-20	21-Jul-22
Inbound length, days	205	192	214	262	270	259	237	212	190	203
Arrival date- Earth	9-Nov-03	6-Jan-06	29-Feb-08	10-May-10	18-May-12	14-Jun-14	24-Jul-16	12-Oct-18	13-Dec-20	9-Feb-23
Total trip length	**959**	**936**	**922**	**947**	**903**	**934**	**936**	**960**	**942**	**927**
ΔV TMI, m/s	3740	3600	3970	4211	4470	3690	3670	3710	3770	3807
ΔV MOI, m/s	5500	2150	2031	2020	2450	3640	5040	5700	4310	2031
ΔV TEI, m/s	2108	2647	2703	2278	2064	1989	1941	1983	2466	2746
Total ΔV, m/s	**11348**	**8397**	**8704**	**8509**	**8984**	**9319**	**10651**	**11393**	**10546**	**8584**

[27] Orbital Mechanics Tutorial: Presentation to Synthesis Group

2.6 Comparison of missions for aborts

The high delta-Vs required for "fast" aborts requiring 70 days or less to return to Earth are prohibitively expensive. Except for aborts from mission points already within a month's travel of Earth, these aborts require total delta-Vs of more than 50 km/sec, more than double the mission total delta-V of even the most energetic mission considered.

However, slow aborts with RTEs of 190 or more days can be had for under 10 km/sec for all or nearly all the duration of each of the missions considered except the 2014 minimum energy mission. Making this amount of delta-V available may be possible at a reasonable cost, particularly during mission phases where fuel is already present for nominal maneuvers.

The minimum energy mission requires the most total delta-V for inbound and outbound aborts because it is more difficult to accelerate a spacecraft into a high-energy abort trajectory from a minimum energy initial trajectory than from a high-energy initial trajectory. The minimum energy mission also has the highest delta-V requirements for aborts from Mars because it waits at Mars through the worst period of Earth-Mars relative phasing, waiting for the minimum energy alignment to come return, before returning to Earth.

3.0 IMPACT OF ABORT CAPABILITY ON IMLEO

This chapter considers the initial mass to low Earth orbit (IMLEO) required for various mission configurations and architectures, and the impact on these IMLEOs of requiring various abort capabilities of the missions.

3.1 Architectures

3.1.1 Baseline architecture: split fuel mission

> "The payload mass would be split among several vehicles, with the return vehicle from Mars made as light as possible. Most of the mass would be carried on the cargo flights, with return fuel being the largest single item of cargo. Sufficient fuel would be carried in the crew transfer vehicle to ensure that a return trip with a minimum energy trajectory could be accomplished if rendezvous fails with the cargo flight carrying the return fuel."[28]

> "The piloted vehicle consists of the crew in the Earth-entry vehicle, along with their Mars transfer vehicle, the nuclear engine, inflight experiments and consumables ..... The piloted vehicle carries contingency trans-Earth injection fuel to permit an abort from Mars orbit."[29]

> "The cargo for the surface includes the habitat, pressurized rover, unloader, power systems, exploration packages and in situ resource experiments. Mars orbit cargo includes the stages for returning to Earth and the descent/ascent vehicle. The piloted mission would be flown with minimum transit times to reduce crew exposure to high radiation and zero gravity. Sufficient fuel

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[28] America At The Threshold, p. A-41.
[29] America At The Threshold, p. 33.

and supplies would be carried by the piloted vehicle to provide an abort mode for return to Earth."[30]

The baseline mission as specified by the Synthesis Group is a "split" mission: two spacecraft are sent to Mars. The first is an unmanned cargo mission, carrying everything not needed for the outbound transfer, including not only all Mars surface supplies and the lander, but also the fuel for the trans-Earth injection (and the fuel for the Earth braking burn, if one is necessary). This spacecraft is sent ahead on a minimum energy trajectory.

The next spacecraft is the manned flight, carrying the crew in their transfer vehicle and Earth-entry vehicle, and inflight experiments and consumables.

The Synthesis Group also specifies that the piloted vehicle carry enough fuel to allow a minimum energy return to Earth if rendezvous with the cargo mission fails. However, due to the two year wait between high-energy mission Mars arrival dates and minimum energy mission Mars departure dates, and the year and a half gap between minimum energy mission arrival and departure dates, specifying a minimum energy abort capability from Mars was not accepted as a baseline.

Instead, the IMLEO impact of requiring aborts from Mars orbit which will be available from the date of Mars arrival until the date of nominal Mars departure was considered.

This architecture shall be referred to as the "split fuel" (SF) architecture, for the division of the fuel between the two missions.

3.1.2 Alternate architecture: all fuel piloted mission

The baseline architecture as specified by the Synthesis Group has a weakness from the perspective of abort development in that most of the fuel is carried as cargo to Mars, and is unavailable for use in performing abort burns until after rendezvous with the cargo mission.

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[30] America At The Threshold, p. A-42.

This weakness is overcome in the alternate architecture, to be referred to as the "all fuel piloted" (AFP) architecture. In this architecture, all fuel and consumables required over the entire duration of the mission are carried by the piloted vehicle. The cargo mission in this architecture carries only the Mars surface supplies and the ascent/descent vehicle.

This architecture has two obvious advantages over the baseline (split fuel) architecture. The first is having all fuel with the piloted vehicle at all times, allowing faster aborts at all times than those available to the baseline. The second is having enough consumables with the piloted vehicle to allow completion of the entire duration of the nominal mission even if rendezvous with the cargo mission fails, allowing the crew to stay and engage in orbital observation and science at Mars even if landing is impossible.

The total fuel and consumables masses available after Mars arrival and cargo mission rendezvous are the same as in the split fuel mission. The difference is that they were carried on the piloted mission rather than the cargo mission.

The only reason this architecture is not chosen over the baseline out of hand is that the exchange of fuel mass from the minimum energy cargo mission to a higher energy mission may create an unacceptable increase in the IMLEO.

For minimum energy piloted missions, the choice of the architecture is obvious. With both the cargo and piloted missions flying minimum energy trajectories, the exchange of fuel will simply exchange the cargo mission and piloted mission IMLEOs, leaving the total IMLEO unaltered, but increasing the delta-V available during the outbound leg, and allowing an abort from Mars orbit before cargo mission rendezvous.

3.2 Mission configurations

A further variation in the architecture is considered by varying the mission configuration. The nominal piloted mission configuration consists of the engines (and associated tanks, shielding and pumps), the Earth entry vehicle and a Mars transfer vehicle.

Only the crew and the Earth-entry vehicle actually need to reach Earth in an abort scenario, but the Earth entry vehicle is specified as a small vehicle, along the lines of the Apollo command module, which will not have

sufficient capability to support the crew for the 100 plus days many abort scenarios require for Earth return. Therefore, the Mars transfer vehicle is left attached for the abort journey, to provide living space and life support.

This is the baseline mission - the nominal transfer vehicle is the abort scenario transfer vehicle.

The transfer vehicle for the nominal mission will be a fairly comfortable facility, to support the crew for 2-3 years away from Earth. It will contain lab space and computer areas for inflight experiments, space for large amounts of consumables storage, private areas for each crewmember, exercise facilities to prevent deconditioning, entertainment facilities, arrays of high-data-rate communications equipment, an airlock and space suits, and perhaps probes and sensors for orbital observation and cargo mission checkout.

Most of these facilities are unnecessary in an abort scenario. In principle, in order to reduce mass as much as possible to allow maximum performance for abort burns, much of this equipment could be jettisoned. In practice, much of it could not actually be removed.

An alternate configuration is considered where the transfer vehicle is split into two transfer vehicles, the main transfer vehicle and the abort transfer vehicle. The abort transfer vehicle contains only those facilities absolutely necessary for survival which are not present in the Earth entry vehicle. This vehicle would carry only enough consumables for the maximum length abort considered, air and waste processing equipment, minimal medical equipment and other bare necessities. The other facilities necessary for the nominal mission would be housed in the main transfer vehicle. The abort transfer vehicle would be situated between the Earth entry vehicle and the main transfer vehicle, allowing the main transfer vehicle to be separated from the spacecraft assembly to reduce mass before an abort burn.

In this configuration the nominal transfer vehicle is the combination of the main and abort transfer vehicles, and the nominal transfer vehicle mass is the sum of their masses.

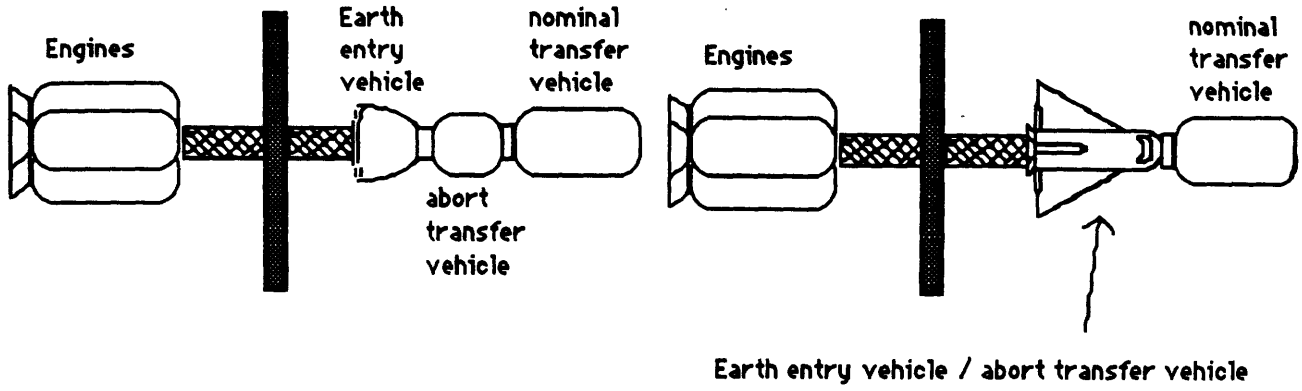

Figure 3.1: abort transfer vehicle configurations

Mass drives the cost of any maneuver. So, to optimize performance for abort maneuvers, in the split transfer vehicle configuration the abort transfer vehicle will be made as light as possible. Although the nominal transfer vehicle will be also made as light as possible, the crew will spend over a year in it, and its design will be sensitive to the comfort of the crew, containing personal and public areas, and it will have storage areas for samples and space for inflight experiments.

In the split transfer vehicle configuration, not only will all equipment not directly necessary for life support or abort maneuver control be housed in the main transfer vehicle, but the internal space of the abort transfer vehicle will be as cramped as is considered survivable, to reduce structural mass. Basically, the crew will spend the entire abort trip, up to 200 days, living in their couches, in a volume comparable to the interior of a bomber. Although this will not be a pleasant experience, it's better than not coming home after a threatening failure.

It is not relevant to this study what form the abort transfer vehicle takes. Whether the Earth entry vehicle and abort transfer vehicle are the same vehicle or separate, attached modules does not affect the cost in IMLEO of the mission if the total masses of the two cases are the same.

What is important is the difference between the mass of the nominal mission spacecraft assembly and the mass of the abort scenario spacecraft assembly. If this difference is small compared to the nominal mission

a significant increase in performance in exchange for the sacrifice of crew comfort and the samples obtained at Mars.

3.3 Mass studies

Mass studies were conducted in which the parameters of a mission, including masses of configuration elements and nominal and abort mission trajectories were varied and IMLEOs and delta-Vs available throughout the mission were obtained.

All categories of mission discussed in Chapter 2 were studied as nominal missions (no added abort capability, only enough fuel for nominal mission), examining IMLEOs and abort delta-Vs available at all phases during the nominal missions.

The Synthesis Group specifies the trajectories to be used for the first manned Mars mission as the 2015 Venus swingby mission, the 2015 deep space maneuver mission or the 2014 minimum energy mission. For these missions the impact on IMLEO of specifying abort capabilities was examined.

The impact of adding abort capability to the 2014 2BSO and 2015 2BLO missions was not examined, as their nominal mission profiles revealed that they were substantially more expensive than even the other high-energy missions, and the increase in nominal mission abort capability they offer over deep space maneuver and Venus swingby missions (the next best for nominal mission abort capability) was not sufficient to make up for this, as shown in chapter 4. The only clear advantage was the presence of an inbound abort capability all the way in for the 2BSO mission, but this was discovered to be insufficient to overcome the higher IMLEO.

The actual architectures studied involved not only the trajectories for the piloted mission mentioned above, but also included the closest minimum energy mission which arrives at Mars before the piloted mission trajectory, for the cargo mission.

3.3.1 Mass study parameters

The following parameters were used as inputs to the mass study calculations: engine Isp; crew size; mass of crewmembers; consumables per person-day; tank fraction for fuel; entry vehicle mass; transfer vehicle mass; abort transfer vehicle mass; mass of samples to be returned from Mars; and the mass of the cargo mission including payload and vehicle but excluding consumables and fuel carried as cargo.

The delta-Vs and trip times for the nominal mission, the cargo mission and any abort capabilities specified were also control variables for the mass calculations.

The mass study outputs were the piloted and cargo IMLEOs and the delta-Vs available using all fuel at hand at each phase of the mission.

3.3.1.1 Fixed parameters

The fixed parameters' values were extracted from mass waypoint analysis documents provided by the Synthesis Group. The crew size was set at 6, with body mass and personal effects set at 200 kg per crewmember. The consumables consumption rate was 4 kg per person per day, including air, food, water and sanitary water.[31]

The tank fraction, for computing the mass of tanks and attached structure for fuel stores, was set at 7%.

The mass of the Earth entry vehicle was set at 4.5 metric tons, as specified by the Synthesis Group. Again, this figure has no merit in and of itself, it is the total mass of the Earth entry vehicle plus the abort transfer

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[31] From Manned Spacecraft: Engineering Design and Operation; ed. Purser, Faget, Smith; Fairchild Publications; New York; 1964; p. 108:

Water Balance (per day) - in: 2550 g food and drink, 350 g water of oxidation; out: 1300 g insensible perspiration and lung loss, 1500 g urine, 100 g feces; total 2900 g in & out each day (assumes comfortable environment, no sweat loss).

Mass Balance (per day) - in: 850 g oxygen, 600 g dry food, 2550 g water; out: 1000 g carbon dioxide, 150 g feces, 1550 g urine, 1300 g insensible perspiration and lung loss. Total: 4 kg in & out each day.

Agrees with Synthesis Group consumables rate figures if water and air loops are partially closed.

vehicle that drives the IMLEO variation, not how the mass is divided between the two.

The length of the aborts the output section computes the delta-Vs for is set at 110 days. This is needed to specify the mass of the consumables required for the abort, which is a factor in abort performance.

3.3.1.2 Variable parameters

The following parameters were varied in the mass studies to examine their effect on the IMLEOs required for various abort capabilities to be available

The engine Isp was varied from the nominal 925 sec down to 800 and 875 sec. This was varied only for the nominal missions; having an abort capability proves nearly prohibitively expensive even for the best case. For abort mission analysis, the design target of 925 seconds specified by the Synthesis Group was used.

The manned and cargo mission delta-Vs and trip times were varied to examine the different classes of mission discussed in Chapter 2.

The nominal transfer vehicle's mass[32] was set to the minimum and maximum of the values contained in the Synthesis Group mass analyses: 50 and 75 metric tons.

The mass of the abort scenario transfer vehicle[33] was set as equal to the either the nominal transfer vehicle's mass (for nominal transfer vehicle aborts) or at 20 metric tons (for the split transfer vehicle configuration).

Also varied is the mass of samples to be returned to Earth from Mars in the nominal scenario. This is varied from 0 to 25 to 50 metric tons. It is unlikely the mass of actual samples returned from Mars will leave the lower end of this range, but variation of this mass can also be used to consider the return of Mars surface equipment, if this is desired.

The cargo mission dry mass to Mars, including engines, cargo lander, crew ascent/descent vehicle and surface payload was varied from the

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32 This mass includes the NTR reactors, pumps and shielding. The engine mass is not called out separately.

33 Again, this includes the engine mass.

minimum to the maximum of the cases presented in the Synthesis Group's waypoint analyses, from 100 to 300 metric tons, with 200 mT also considered.

As discussed above, sub-elements like engines and separate cargo payload items were not specified separately because their individual masses have no effect on the total IMLEO except as part of the total masses. Whether the cargo mission is 30 tons of engine, 30 tons of lander and 40 tons of surface payload or whether it is 15 tons of engine, 20 tons of lander and 65 tons of surface payload makes no difference to the mission IMLEO.

3.3.1.3 Output parameters

The cargo and piloted IMLEOs are output.

Also output are the delta-Vs available at each mission phase if all fuel at hand at that phase is consumed. The delta-Vs presented are those available for single burn aborts occurring while outbound both before and after any outbound deep space maneuver, from Mars orbit before and after rendezvous with the cargo mission, and while inbound before and after any inbound deep space maneuver. These delta-Vs are computed for an abort vehicle configuration carrying enough consumables for a set abort length, which is common across all phases. The amount of fuel, and thus of delta-V, available will be constant throughout each of these mission phases.

Also computed is the delta-V available to the nominal mission return-to-Earth configuration[34] while at Mars, for cases where an abort requirement has resulted in more fuel than required by the nominal mission being brought to Mars. These delta-Vs may be compared to the plots of return to Earth time versus delta-V available (in chapter 2) to find the new length available to the nominal inbound leg.

These available delta-Vs, for aborts and the nominal mission return to Earth, are for single-burn maneuvers. As explained in section 3.3.2, any insertion delta-V and braking delta-V combination adding to this total can be performed for the same amount of fuel, as can some combinations adding to a slightly higher total.

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34 Crew, inbound consumables, Earth entry vehicle, nominal transfer vehicle and samples.

3.3.1.4 Abort parameters

Three types of abort may be specified for each architecture, whether split fuel or all fuel piloted.

Inbound aborts may be specified for both architectures. Inbound aborts are specified as an insertion delta-V and a braking delta-V, which are to be available at all times during the inbound leg, both before and after any DSM. Also specified is the maximum length of the abort, which sets the amount of consumables to be carried in the abort configuration. For inbound aborts, the abort consumables are not excess consumables above and beyond the nominal consumables, as the nominal consumables are enough for the nominal inbound trip, and any abort will only shorten that trip.

Aborts from Mars for the all fuel piloted mission are also defined by insertion delta-V, braking delta-V and maximum length.

For split fuel missions, aborts from Mars before and after the cargo mission rendezvous may be specified. An abort from Mars after cargo mission rendezvous is specified as an abort to be available for the length of the Mars stay, and is defined in the same way as an abort from Mars for the all fuel piloted mission.

Aborts from Mars orbit before cargo mission rendezvous (referred to as "piloted abort" in the data sections) are to be used if the attempt to rendezvous with the cargo mission fails. Definition of this abort also requires insertion burn, braking burn, and trip length, but added is a term for stay length before the burn is made, to allow the option of waiting for favorable phasing or performing orbital science and observation for a while if the abort is to be made due to failure of rendezvous rather than because of a dangerous failure. This abort capability is meant to allow abort from the time of Earth departure until cargo mission rendezvous, and so includes the outbound abort capability for split fuel missions.

Outbound aborts for the all fuel piloted mission may be specified by insertion and braking delta-Vs and trip length, to be available before and after any outbound DSM.

During the mass studies, total abort delta-Vs were varied from 5 km/sec to 20 km/sec. For each total, both the case of all the delta-V being insertion burn and the case of half the delta-V being insertion and half being braking

delta-V were considered. The limit was set at 20 km/sec because by this point the maximum IMLEO required to obtain the delta-V for all phases had increased by at least half, in some cases doubling.

All abort lengths were set to 110 days, the same as for the aborts used to find available delta-Vs at mission points.

3.3.2 Behavior of total delta-V versus delta-V splits

Otherwise identical missions with the same total delta-V but with different insertion burn/braking burn splits do not have the same IMLEO. There are two reasons for this. The first is the tanks that contain the fuel. The way the calculations in this mass study were performed, no assumptions are made about the capacity of the tanks used to hold the fuel, and it is assumed none of the tanks used to hold the fuel for a burn are detached until the burn is over. This method gives the maximum amount of fuel necessary to produce a certain delta-V.

As a result of this, the same total delta-V performed as two separate burns will require less fuel, since the tanks to hold the fuel required for the first burn have been detached before the second burn, reducing the mass accelerated by the remaining fuel, and increasing the delta-V produced by the use of that fuel.

If there are to be two burns (insertion and braking) the optimum split is to divide the total delta-V in half. The more of the delta-V that is shifted from insertion burn to braking burn from a case where the total delta-V is all insertion delta-V, the lower the IMLEO becomes. However, once the point of even division is past, the IMLEO begins to rise again - splitting the a 10 km/sec burn into 2 km/sec insertion delta-V and 8 km/sec braking delta-V requires the same IMLEO as splitting it into 8 km/sec insertion and 2 km/sec braking.

So, for each total delta-V and phase, both the 2x/0 and x/x cases are examined, giving both the maximum and minimum IMLEOs required for that total delta-V to be available in the phase.. The reason that both cases must be examined is that the division between insertion and braking delta-Vs for abort burns goes from all insertion to even division and back to all insertion as the mission goes from outbound to Mars to inbound phases (see 2.6, 2.12, 2.18, 2.24, 2.30).

The need for consumables during the inbound abort also plays a role in lowering the IMLEO when the total delta-V is not all insertion burn. When the insertion burn is made, there is a certain mass of consumables on board, which are gone when the insertion burn is made, lightening the vehicle even further than the loss of the tanks from the first burn. This factor lowers the IMLEO steadily as portions of the total delta-V are shifted from insertion to braking burn, even continuing past the point of even division.

The minimum IMLEO is for the even insertion/braking split of total delta-V, with IMLEO rising as either insertion or braking burn goes to 0, and the cases with the braking burn greater than the insertion burn have lower IMLEO than cases with the same division of delta-Vs, but with the insertion burn greater.

By the same arguments, the available delta-Vs expressed in the output section represent the maximum single burn which could be made with the amount of fuel available at that point. Any combination of insertion and braking burn which add to that total delta-V can be made, as can some combinations which total more. Therefore, the RTE times corresponding to the delta-Vs produced by the mass studies are the slowest RTEs which the fuel available at that point can produce.

For example, in the 2015 Venus swingby all fuel piloted mission, with an abort from Mars orbit capability of 7500 m/sec insertion delta-V and 7500 m/sec braking delta-V specified, the single burn abort delta-V available from Mars for a mission of 50 ton nominal transfer vehicle and 50 ton abort transfer vehicle is 13831 m/sec; the same amount of fuel required for one 13831 m/sec delta-V will allow the specified two 7500 m/sec delta-Vs.

3.3.3 Mass study methods

The following equations form the heart of the calculations in the mass impact studies.

To find the IMLEO for any given mission, the fuel amounts needed to give the various specified delta-Vs to the set masses are required:

m_F = mass after burn

m_f = delivered spacecraft mass

F = fuel mass for burn

T = tank fraction

m_0 = mass before burn

$$m_0 = m_f + (1 + T) F$$

$$m_F = m_f + TF$$

$$\text{let } X = e^{-\frac{\Delta V}{g_0 Isp}}$$

$$X [m_f + (1 + T) F] = m_f + TF$$

$$X m_f - m_f = TF - X (1+T)F$$

$$m_f (1-X) = [X(1+T) - T] F$$

$$F = m_f \frac{1-X}{X(1+T) - T}$$

The mass of the tanks containing the fuel is equal to TF.

To find the delta-Vs available during the mission stages, the delta-V a certain amount of fuel can supply to a given mass is what is needed:

$$\frac{m_f}{m_0} = e^{-\frac{\Delta V}{g_0 Isp}}$$

$$-\frac{\Delta V}{g_0 Isp} = \ln \left(\frac{m_f}{m_0} \right)$$

$$\Delta V = - g_0 Isp \ln \left(\frac{m_f}{m_0}\right) = - g_0 Isp \ln \left(\frac{m_f + TF}{m_f + (1+T)F}\right)$$

3.3.4 Split fuel mission mass study

The split fuel mission mass study begins by examining the piloted abort capability, if one has been specified. The abort mass arriving at Earth: crew, Earth entry vehicle and abort transfer vehicle, is calculated. This mass and the braking delta-V for "piloted" abort are used to find the fuel and tank mass required for this burn.

The braking burn fuel and tanks are added to the arrival mass, and consumables for the length of the abort are added to find the mass after the abort insertion burn. This mass and the piloted abort insertion delta-V are used to find the fuel and tank mass for the insertion burn.

The abort insertion and braking burn fuel and tank masses are added to find the fuel mass to Mars as cargo for the piloted mission. This fuel mass is added to the abort trip consumables, consumables for the stay at Mars before the abort burn (if any), the nominal transfer vehicle, the Earth entry vehicle and the crew masses to find the piloted mission mass to Mars orbit.

This mass and the MOI, TMI and outbound DSM delta-Vs and trip times are used to find the fuel masses for these burns and the outbound consumables masses, in the same way as described above. These masses are added to the Mars orbit arrival mass to find the piloted IMLEO.

To compute the cargo mission IMLEO two scenarios are considered: the specified abort from Mars after rendezvous and the nominal mission with the specified inbound abort capability.

For the abort from Mars orbit after cargo rendezvous, the consumables and fuel required are computed in the same way as described for piloted aborts above.

Next, the fuel required for the specified inbound abort is computed.

Then, the nominal mission is considered. At Earth arrival, the fuel for an inbound abort, if any, will still be present. The amount of fuel required for the braking burn at Earth arrival is computed, and compared to the amount of inbound abort fuel present. Whichever of the two is larger is added to the crew, nominal transfer vehicle, Earth entry vehicle and samples masses to find the Earth arrival mass.

This mass and the inbound DSM and TEI delta-Vs and trip times are used to find the fuel and consumables necessary in Mars orbit for the inbound trip.

The amount of fuel required for the nominal inbound mission and inbound abort are compared to the fuel quantity required for the abort from Mars after rendezvous. The same is done for consumables. The larger amounts are compared to the amount of excess fuel and consumables carried as cargo to Mars orbit by the piloted mission, and, if more than carried by the piloted mission is required, these masses are added to the cargo payload to obtain the total cargo mission mass to Mars orbit.

This total is used with the cargo mission MOI and TMI delta-Vs to find the cargo IMLEO.

The available abort delta-Vs are computed by using the total fuel amounts available at each phase, the specified trip length, and the abort assembly (crew, Earth entry vehicle, abort transfer vehicle and consumables) mass in the algorithm above to find the delta-V available.

Before the outbound deep space maneuver, the outbound DSM fuel, the MOI fuel and the fuel for piloted abort are available. After the outbound DSM, the MOI and piloted abort fuel are available. After Mars arrival and before rendezvous, only the piloted abort fuel is available.

At Mars after cargo mission rendezvous, the amount of fuel available is determined by whichever is greater: the piloted abort fuel; the abort from Mars after cargo mission rendezvous fuel; or the inbound abort fuel plus the TEI, inbound DSM and braking burn fuel. Whichever of these is larger is the amount of fuel available at Mars after cargo mission rendezvous.

During the inbound leg the Earth braking burn fuel is always available, as is the fuel for any specified inbound abort. If there is an inbound deep space maneuver there is also the fuel for that burn, until the maneuver is performed.

3.3.5 All Fuel Piloted mass study method

The all fuel piloted mission mass study begins by examining the inbound abort capability, if one has been specified. The abort mass arriving at Earth: crew, Earth entry vehicle and abort transfer vehicle, is calculated. This mass and the braking delta-V for the inbound abort are used to find the fuel and tank mass required for this burn.

The braking burn fuel and tank masses are added to the arrival mass, and consumables for the length of the abort are added to find the mass after the abort insertion burn. This mass and the inbound abort insertion delta-V are used to find the fuel and tank mass for the insertion burn. These are added to the braking burn fuel and tank masses to find the total mass of fuel and tanks which must be carried as cargo while inbound.

Next, the nominal mission is considered. At Earth arrival, the fuel for an inbound abort, if any, will still be present. The amount of fuel required for

the nominal braking burn at Earth arrival is computed, and compared to the amount of inbound abort fuel present. Whichever of the two is larger is added to the crew, nominal transfer vehicle, Earth entry vehicle and samples masses to find the Earth arrival mass.

This mass and the inbound DSM and TEI delta-Vs and trip times are used to find the fuel and consumables masses necessary for the inbound trip.

Then, the abort scenario mass arriving at Earth and the abort from Mars insertion and braking delta-Vs and trip time are used to find the fuel and tank masses necessary for the specified abort from Mars.

The amount of fuel required for the nominal inbound mission and inbound abort are compared to the fuel quantity required for the abort from Mars. The same is done for consumables. The larger of each mass is added to the crew, nominal transfer vehicle and Earth entry vehicle masses to find the total mass delivered to Mars orbit by the piloted mission.

This mass and the MOI, outbound DSM and TMI delta-Vs and trip times are used to find the fuel masses for these burns and the outbound consumables masses, in the same way as described above. These masses are added to the Mars orbit arrival mass to find the piloted IMLEO.

The abort mass to Earth and the outbound abort delta-Vs and trip time are used to find the amount of fuel required for any specified outbound abort.

If the fuel carried to Mars as cargo developed above, plus the fuel for the MOI burn, is sufficient for the outbound abort, the calculation is complete. If not, the fuel required for outbound abort is added to the crew, nominal transfer vehicle and Earth entry vehicle masses to find a new mass immediately before MOI.

This mass is used with the outbound DSM and TMI delta-Vs to find new fuel amount for those burns. The consumables mass for the outbound trip is unchanged. The new outbound fuel masses and the outbound consumables mass are added to the pre-MOI mass to find the real piloted IMLEO.

Then, the new pre-MOI mass is multiplied by X (see 3.3.3) for that burn to find the mass after the burn. The mass of the tanks for the fuel used in the burn, the inbound and stay consumables masses, and the crew, nominal transfer vehicle and Earth entry vehicle masses are subtracted to find the fuel and tank masses present in Mars orbit.

The cargo IMLEO is computed using the cargo payload mass and cargo mission TMI and MOI delta-Vs.

The available abort delta-Vs are computed by using the total fuel amounts available at each phase, the specified trip length, and the abort assembly mass (crew, Earth entry vehicle, abort transfer vehicle and consumables) to find the delta-V available.

During the inbound leg the Earth braking burn fuel is always available, as is the fuel for any specified inbound abort. If there is an inbound DSM there is also the fuel for that burn, until after the maneuver is performed.

At Mars, the amount of fuel available is determined by whichever is greater: the outbound abort fuel minus the MOI fuel; the abort from Mars orbit fuel; or the inbound abort fuel plus the TEI, inbound DSM and braking burn fuel. Whichever of these is larger is the amount of fuel available in Mars orbit.

The same comparison governs the amount of fuel available while outbound. Available is the greater of: the outbound abort fuel; the Mars abort fuel plus the MOI fuel; or the inbound abort fuel, extra braking burn fuel (if any), inbound DSM fuel, TEI fuel and MOI fuel.

3.4 Mass study results

In the split fuel mission with no outbound abort specified, the piloted IMLEO is insensitive to variations in cargo payload or samples mass. In the all fuel piloted mission, the cargo mission IMLEO is sensitive only to Isp, cargo payload, and cargo mission delta-Vs; and the piloted mission IMLEO is insensitive to variations in cargo payload mass.

The delta-Vs available at the various mission phases are insensitive to cargo payload mass variations - any extra fuel required for a change in cargo mass goes to propelling the cargo, and is not available for aborts. After cargo mission rendezvous, the delta-Vs available are the same for all fuel piloted and split fuel missions, since the same amount of fuel is required to send the nominal mission home regardless of how it got to Mars.

For cases where outbound aborts or aborts from Mars orbit are specified, once the amount of fuel carried to Mars orbit is determined by the abort

requirements rather than the nominal mission requirements, the IMLEOs lose their sensitivity to variations in samples mass.

The rest of this section consists of a subsection for each mission studied.

Each subsection consists of three tables. Each table details the piloted mission, cargo mission and total IMLEOs; available abort delta-Vs for each phase; and the delta-V available to the nominal configuration at Mars.

The tables are for the nominal missions (split fuel and all fuel piloted), the split fuel missions with aborts and the all fuel piloted missions with aborts.

The nominal mission table is indexed by Isp, nominal transfer vehicle mass, abort transfer vehicle mass, cargo payload mass, and samples mass to be returned. The abort scenario tables are indexed by type of abort, abort insertion delta-V, abort braking delta-V, nominal transfer vehicle mass, abort transfer vehicle mass, cargo payload mass and samples mass to be returned. Entries in the abort table where the piloted IMLEO is listed as "NOM" indicate that the nominal mission is capable of this abort. This is done rather than simply re-listing the parameters of the nominal mission to emphasize that these cases have capabilities beyond those of their neighbors, while having a smaller IMLEO.

The full tables for abort mass studies varying all the parameters are extremely long, and available in Appendix B. Tables 3.1-3.11 offer the full tables for only the nominal mission variations, but contain selected cases from the abort mass studies. The cases shown are for cargo payload of 200 metric tons, and samples mass to be returned to Earth of 25 mT. The reasons for choosing these parameters to be fixed, and for choosing these values to fix them at, are discussed in section 4.2.

All values on the tables are in units of metric tons and meters/sec.

Table 3.1: 2014 2BSO nominal missions

Split fuel nominal missions
masses in mT, ΔVs in kps

Isp	Transfer vehicle masses Nominal	Abort	Cargo Payload	Samples Returned	Cargo	IMLEOs Piloted	Total	ΔV available for aborts at mission phase Outbound	From Mars after rendezvous	Inbound
800	50	50	100	0	671.57	155.77	827.34	3266	9534	4446
				25	853.98	155.77	1009.75	3266	11204	5740
				50	1036.38	155.77	1192.15	3266	12420	6804
			200	0	908.14	155.77	1063.91	3266	9534	4446
				25	1090.55	155.77	1246.32	3266	11204	5740
				50	1272.96	155.77	1428.73	3266	12420	6804
			300	0	1144.72	155.77	1300.49	3266	9534	4446
				25	1327.12	155.77	1482.89	3266	11204	5740
				50	1509.53	155.77	1665.3	3266	12420	6804
	75	75	100	0	853.98	221.88	1075.86	3303	9551	4491
				25	1036.39	221.88	1258.27	3303	10776	5419
				50	1218.8	221.88	1440.68	3303	11743	6223
			200	0	1090.55	221.88	1312.43	3303	9551	4491
				25	1272.96	221.88	1494.84	3303	10776	5419
				50	1455.88	221.88	1677.76	3303	11743	6223
			300	0	1327.12	221.88	1549	3303	9551	4491
				25	1509.53	221.88	1731.41	3303	10776	5419
				50	1691.94	221.88	1913.82	3303	11743	6223
875	50	50	100	0	562.88	143.41	706.29	3264	9593	4441
				25	705.84	143.41	849.25	3264	11403	5782
				50	848.8	143.41	992.21	3264	12743	6896
			200	0	782.33	143.41	925.74	3264	9593	4441
				25	925.29	143.41	1068.7	3264	11403	5782
				50	1068.25	143.41	1211.66	3264	12743	6896
			300	0	1001.79	143.41	1145.2	3264	9593	4441
				25	1144.75	143.41	1288.16	3264	11403	5782
				50	1287.7	143.41	1431.11	3264	12743	6896
	75	75	100	0	705.84	204.13	909.97	3301	9610	4488
				25	848.8	204.13	1052.93	3301	10934	5448
				50	991.75	204.13	1195.88	3301	11994	6287
			200	0	925.29	204.13	1129.42	3301	9610	4488
				25	1068.25	204.13	1272.38	3301	10934	5448
				50	1211.21	204.13	1415.34	3301	11994	6287
			300	0	1144.75	204.13	1348.88	3301	9610	4488
				25	1287.7	204.13	1491.83	3301	10934	5448
				50	1430.66	204.13	1634.79	3301	11994	6287
925	50	50	100	0	509.16	136.75	645.91	3262	9625	4439
				25	633.02	136.75	769.77	3262	11520	5806
				50	756.87	136.75	893.62	3262	12937	6952
			200	0	719.34	136.75	856.09	3262	9625	4439
				25	843.2	136.75	979.95	3262	11520	5806
				50	967.05	136.75	1103.8	3262	12937	6952
			300	0	929.52	136.75	1066.27	3262	9625	4439
				25	1053.38	136.75	1190.13	3262	11520	5806
				50	1177.23	136.75	1313.98	3262	12937	6952
	50	20	100	0	509.16	136.75	645.91	5645	13462	7320
				25	633.02	136.75	769.77	5645	15346	9112
				50	756.87	136.75	893.62	5645	16655	10507
			200	0	719.34	136.75	856.09	5645	13462	7320
				25	843.2	136.75	979.95	5645	15346	9112
				50	967.05	136.75	1103.8	5645	16655	10507
			300	0	959.52	136.75	1096.27	5645	13462	7320
				25	1053.38	136.75	1190.13	5645	15346	9112
				50	1177.23	136.75	1313.98	5645	16655	10507
	75	75	100	0	633.02	194.58	827.6	3300	9641	4486
				25	756.87	194.58	951.45	3300	11026	5464
				50	880.73	194.58	1075.31	3300	12142	6324
			200	0	843.2	194.58	1037.78	3300	9641	4486
				25	967.05	194.58	1161.63	3300	11026	5464
				50	1090.91	194.58	1285.49	3300	12142	6324
			300	0	1053.38	194.58	1247.96	3300	9641	4486
				25	1177.23	194.58	1371.81	3300	11026	5464
				50	1301.09	194.58	1495.67	3300	12142	6324
	75	20	100	0	633.02	194.58	827.6	7224	15346	9112
				25	756.87	194.58	951.45	7224	16655	10507
				50	880.73	194.58	1075.31	7224	17268	11636
			200	0	843.2	194.58	1037.78	7224	15346	9112
				25	967.05	194.58	1161.63	7224	16655	10507
				50	1090.91	194.58	1285.49	7224	17268	11636
			300	0	1053.38	194.58	1247.96	7224	15346	9112
				25	1177.23	194.58	1371.81	7224	16655	10507
				50	1301.09	194.58	1495.67	7224	17268	11636

Table 3.1: 2014 2BSO nominal missions

All fuel piloted nominal missions
masses in mT, ΔVs in kps

Isp	Transfer vehicle masses Nominal	Abort	Cargo Payload	Samples Returned	Cargo	IMLEOs Piloted	Total	ΔV available for aborts at mission phase Outbound	From Mars	Inbound
800	50	50	100	0	236.57	641.98	878.55	12277	9534	4446
				25	236.57	845.87	1082.44	13723	11204	5740
				50	236.57	1049.76	1286.33	14749	12420	6804
			200	0	473.15	641.98	1115.13	12277	9534	4446
				25	473.15	845.87	1319.02	13723	11204	5740
				50	473.15	1049.76	1522.91	14749	12420	6804
			300	0	709.72	641.98	1351.7	12277	9534	4446
				25	709.72	845.87	1555.59	13723	11204	5740
				50	709.72	1049.76	1759.48	14749	12420	6804
	75	75	100	0	236.57	911.98	1148.55	12283	9551	4491
				25	236.57	1115.87	1352.44	13349	10776	5419
				50	236.57	1319.75	1556.32	14175	11743	6223
			200	0	473.15	911.98	1385.13	12283	9551	4491
				25	473.15	1115.87	1589.02	13349	10776	5419
				50	473.15	1319.75	1792.9	14175	11743	6223
			300	0	709.72	911.98	1621.7	12283	9551	4491
				25	709.72	1115.87	1825.59	13349	10776	5419
				50	709.72	1319.75	2029.47	14175	11743	6223
875	50	50	100	0	219.45	523.5	742.95	12437	9593	4441
				25	219.45	681.72	901.17	14043	11403	5782
				50	219.45	839.94	1059.39	15208	12743	6896
			200	0	438.91	523.5	962.41	12437	9593	4441
				25	438.91	681.72	1120.63	14043	11403	5782
				50	438.91	839.94	1278.85	15208	12743	6896
			300	0	658.36	523.5	1181.86	12437	9593	4441
				25	658.36	681.72	1340.08	14043	11403	5782
				50	658.36	839.94	1498.3	15208	12743	6896
	75	75	100	0	219.45	742.44	961.89	12441	9610	4488
				25	219.45	900.66	1120.11	13621	10934	5448
				50	219.45	1058.88	1278.33	14552	11993	6287
			200	0	438.91	742.44	1181.35	12441	9610	4488
				25	438.91	900.66	1339.57	13621	10934	5448
				50	438.91	1058.88	1497.79	14552	11993	6287
			300	0	658.36	742.44	1400.8	12441	9610	4488
				25	658.36	900.66	1559.02	13621	10934	5448
				50	658.36	1058.88	1717.24	14552	11993	6287
925	50	50	100	0	210.18	465.79	675.97	12525	9625	4439
				25	210.18	602.1	812.28	14227	11520	5806
				50	210.18	738.4	948.58	15478	12937	6952
			200	0	420.36	465.79	886.15	12525	9625	4439
				25	420.36	602.1	1022.46	14227	11520	5806
				50	420.36	738.4	1158.76	15478	12937	6952
			300	0	630.54	465.79	1096.33	12525	9625	4439
				25	630.54	602.1	1232.64	14227	11520	5806
				50	630.54	738.4	1368.94	15478	12937	6952
	50	20	100	0	210.18	465.79	675.97	16283	13462	7320
				25	210.18	602.1	812.28	17779	15346	9112
				50	210.18	738.4	948.58	18809	16655	10507
			200	0	420.36	465.79	886.15	16283	13462	7320
				25	420.36	602.1	1022.46	17779	15346	9112
				50	420.36	738.4	1158.76	18809	16655	10507
			300	0	630.54	465.79	1096.33	16283	13462	7320
				25	630.54	602.1	1232.64	17779	15346	9112
				50	630.54	738.4	1368.94	18809	16655	10507
	75	75	100	0	210.18	659.92	870.1	12527	9641	4486
				25	210.18	796.23	1006.41	13776	11026	5464
				50	210.18	932.54	1142.72	14771	12142	6324
			200	0	420.36	659.92	1080.28	12527	9641	4486
				25	420.36	796.23	1216.59	13776	11026	5464
				50	420.36	932.54	1352.9	14771	12142	6324
			300	0	630.54	659.92	1290.46	12527	9641	4486
				25	630.54	796.23	1426.77	13776	11026	5464
				50	630.54	932.54	1563.08	14771	12142	6324
	75	20	100	0	210.18	659.92	870.1	17947	15346	9112
				25	210.18	796.23	1006.41	18930	16655	10507
				50	210.18	932.54	1142.72	19568	17628	11636
			200	0	420.36	659.92	1080.28	17947	15346	9112
				25	420.36	796.23	1216.59	18930	16655	10507
				50	420.36	932.54	1352.9	19568	17628	11636
			300	0	630.54	659.92	1290.46	17947	15346	9112
				25	630.54	796.23	1426.77	18930	16655	10507
				50	630.54	932.54	1563.08	19568	17628	11636

Table 3.2: 2014 2BLO nominal missions

Split fuel nominal missions
masses in mT, ΔVs in kps

Isp	Transfer vehicle masses Nominal	Abort	Cargo Payload	Samples Returned	Cargo	IMLEOs Piloted	Total	ΔV available for aborts at mission phase Outbound	From Mars after rendezvous	Inbound
800	50	50	100	0	425.38	393.34	818.72	4299	5274	0
				25	492.65	393.34	885.99	4299	6608	0
				50	559.93	393.34	953.27	4299	7960	0
			200	0	676.49	393.34	1069.83	4299	5274	0
				25	743.76	393.34	1137.1	4299	6608	0
				50	811.03	393.34	1204.37	4299	7960	0
			300	0	927.59	393.34	1320.93	4299	5274	0
				25	994.87	393.34	1388.21	4299	6608	0
				50	1062.14	393.34	1455.48	4299	7960	0
	75	75	100	0	492.65	559.73	1052.38	4343	5246	0
				25	559.93	559.73	1119.66	4343	6214	0
				50	627.2	559.73	1186.93	4343	7045	0
			200	0	743.76	559.73	1303.49	4343	5246	0
				25	811.03	559.73	1370.76	4343	6214	0
				50	878.31	559.73	1438.04	4343	7045	0
			300	0	994.87	559.73	1554.6	4343	5246	0
				25	1062.14	559.73	1621.87	4343	6214	0
				50	1129.42	559.73	1689.15	4343	7045	0
875	50	50	100	0	374.52	331.87	706.39	4295	5278	0
				25	429.09	331.87	760.96	4295	6668	0
				50	483.66	331.87	815.53	4295	7810	0
			200	0	606.22	331.87	938.09	4295	5278	0
				25	660.8	331.87	992.67	4295	6668	0
				50	715.37	331.87	1047.24	4295	7810	0
			300	0	837.93	331.87	1169.8	4295	5278	0
				25	892.5	331.87	1224.37	4295	6668	0
				50	947.07	331.87	1278.94	4295	7810	0
	75	75	100	0	429.09	471.79	900.88	4341	5248	0
				25	483.66	471.79	955.45	4341	6255	0
				50	538.23	471.79	1010.02	4341	7128	0
			200	0	660.8	471.79	1132.59	4341	5248	0
				25	715.37	471.79	1187.16	4341	6255	0
				50	769.94	471.79	1241.73	4341	7128	0
			300	0	892.5	471.79	1364.29	4341	5248	0
				25	947.07	471.79	1418.86	4341	6255	0
				50	1001.64	471.79	1473.43	4341	7128	0
925	50	50	100	0	348.25	301.3	649.55	4292	5280	0
				25	396.46	301.3	697.76	4292	6703	0
				50	444.66	301.3	745.96	4292	7883	0
			200	0	569.49	301.3	870.79	4292	5280	0
				25	617.69	301.3	918.99	4292	6703	0
				50	665.9	301.3	967.2	4292	7883	0
			300	0	790.72	301.3	1092.02	4292	5280	0
				25	838.93	301.3	1140.23	4292	6703	0
				50	887.13	301.3	1188.43	4292	7883	0
	50	20	100	0	348.25	301.3	649.55	7119	8439	0
				25	396.46	301.3	697.76	7119	10211	0
				50	444.66	301.3	745.96	7119	11579	0
			200	0	569.49	301.3	870.79	7119	8439	0
				25	617.69	301.3	918.99	7119	10211	0
				50	665.9	301.3	967.2	7119	11579	0
			300	0	790.72	301.3	1092.02	7119	8439	0
				25	838.93	301.3	1140.23	7119	10211	0
				50	887.13	301.3	1188.43	7119	11579	0
	75	75	100	0	396.46	428.1	824.56	4339	5250	0
				25	444.66	428.1	872.76	4339	6280	0
				50	492.87	428.1	920.97	4339	7177	0
			200	0	617.69	428.1	1045.79	4339	5250	0
				25	665.9	428.1	1094	4339	6280	0
				50	714.1	428.1	1142.2	4339	7177	0
			300	0	838.93	428.1	1267.03	4339	5250	0
				25	887.13	428.1	1315.23	4339	6280	0
				50	935.34	428.1	1363.44	4339	7177	0
	75	20	100	0	396.46	428.1	824.56	8890	10211	0
				25	444.66	428.1	872.76	8890	11579	0
				50	492.87	428.1	920.97	8890	12679	0
			200	0	617.69	428.1	1045.79	8890	10211	0
				25	665.9	428.1	1094	8890	11579	0
				50	714.1	428.1	1142.2	8890	12679	0
			300	0	838.93	428.1	1267.03	8890	10211	0
				25	887.13	428.1	1315.23	8890	11579	0
				50	935.34	428.1	1363.44	8890	12679	0

Table 3.2: 2014 2BLO nominal missions

All fuel piloted nominal missions
masses in mT, ΔVs in kps

Isp	Transfer vehicle masses Nominal	Abort	Cargo Payload	Samples Returned	Cargo	MLEOs Piloted	Total	ΔV available for aborts at mission phase Outbound	From Mars	Inbound
800	50	50	100	0	251.11	855.24	1106.35	9387	5274	0
				25	251.11	1033.55	1284.66	10565	6608	0
				50	251.11	1211.85	1462.96	11505	7690	0
			200	0	502.21	855.24	1357.45	9387	5274	0
				25	502.21	1033.55	1535.76	10565	6608	0
				50	502.21	1211.85	1714.06	11505	7690	0
			300	0	753.32	855.24	1608.56	9387	5274	0
				25	753.32	1033.55	1786.87	10565	6608	0
				50	753.32	1211.85	1965.17	11505	7690	0
	75	75	100	0	251.11	1199.93	1451.04	9344	5246	0
				25	251.11	1378.24	1629.35	10204	6214	0
				50	251.11	1556.54	1807.65	10934	7045	0
			200	0	502.21	1199.93	1702.14	9344	5246	0
				25	502.21	1378.24	1880.45	10204	6214	0
				50	502.21	1556.54	2058.75	10934	7045	0
			300	0	753.32	1199.93	1953.25	9344	5246	0
				25	753.32	1378.24	2131.56	10204	6214	0
				50	753.32	1556.54	2309.86	10934	7045	0
875	50	50	100	0	231.7	676.86	908.56	9449	5278	0
				25	231.7	808.69	1040.39	10699	6668	0
				50	231.7	940.51	1172.21	11714	7810	0
			200	0	463.4	676.86	1140.26	9449	5278	0
				25	463.4	808.69	1272.08	10699	6668	0
				50	463.4	940.51	1403.91	11714	7810	0
			300	0	695.11	676.86	1371.97	9449	5278	0
				25	695.11	808.69	1503.8	10699	6668	0
				50	695.11	940.51	1635.62	11714	7810	0
	75	75	100	0	231.7	948.61	1180.31	9403	5248	0
				25	231.7	1080.44	1312.14	10314	6255	0
				50	231.7	1212.27	1443.97	11095	7128	0
			200	0	463.4	948.61	1412.01	9403	5248	0
				25	463.4	1080.44	1543.84	10314	6255	0
				50	463.4	1212.27	1675.67	11095	7128	0
			300	0	695.11	948.61	1643.72	9403	5248	0
				25	695.11	1080.44	1775.55	10314	6255	0
				50	695.11	1212.27	1907.38	11095	7128	0
925	50	50	100	0	221.24	592.48	813.72	9484	5280	0
				25	221.24	702.99	924.23	10776	6703	0
				50	221.24	813.5	1034.74	11835	7883	0
			200	0	442.47	592.48	1034.95	9484	5280	0
				25	442.47	702.99	1145.46	10776	6703	0
				50	442.47	813.5	1255.97	11835	7883	0
			300	0	663.71	592.48	1256.19	9484	5280	0
				25	663.71	702.99	1366.7	10776	6703	0
				50	663.71	813.5	1477.21	11835	7883	0
	50	20	100	0	221.24	592.48	813.72	13315	8439	0
				25	221.24	702.99	924.23	14626	10211	0
				50	221.24	813.5	1034.74	15644	11579	0
			200	0	442.47	592.48	1034.95	13315	8439	0
				25	442.47	702.99	1145.46	14626	10211	0
				50	442.47	813.5	1255.97	15644	11579	0
			300	0	663.71	592.48	1256.19	13315	8439	0
				25	663.71	702.99	1366.7	14626	10211	0
				50	663.71	813.5	1477.21	15644	11579	0
	75	75	100	0	221.24	829.78	1051.02	9435	5250	0
				25	221.24	940.29	1161.53	10375	6270	0
				50	221.24	1050.8	1272.04	11188	7177	0
			200	0	442.47	829.78	1272.25	9435	5250	0
				25	442.47	940.29	1382.76	10375	6270	0
				50	442.47	1050.8	1493.27	11188	7177	0
			300	0	663.71	829.78	1493.49	9435	5250	0
				25	663.71	940.29	1604	10375	6270	0
				50	663.71	1050.8	1714.51	11188	7177	0
	75	20	100	0	221.24	829.78	1051.02	15140	10211	0
				25	221.24	940.29	1161.53	16055	11579	0
				50	221.24	1050.8	1272.04	16801	12679	0
			200	0	442.47	829.78	1272.25	15140	10211	0
				25	442.47	940.29	1382.76	16055	11579	0
				50	442.47	1050.8	1493.27	16801	12679	0
			300	0	663.71	829.78	1493.49	15140	10211	0
				25	663.71	940.29	1604	16055	11579	0
				50	663.71	1050.8	1714.51	16801	12679	0

Table 3.3: 2015 Venus swingby nominal missions

Split fuel nominal missions
masses in mT, ΔVs in km/sec

Isp	Transfer vehicle masses Nominal	Abort	Cargo Payload	Samples Returned	Cargo	IMLEOs Piloted	Total	ΔV available for aborts at mission phase Outbound	From Mars after rendezvous	Inbound
800	50	50	100	0	419.18	183.68	602.86	3017	5018	0
				25	479.67	183.68	663.35	3017	6278	0
				50	540.16	183.68	723.84	3017	7314	0
			200	0	670.29	183.68	853.97	3017	5018	0
				25	730.78	183.68	914.46	3017	6278	0
				50	791.27	183.68	974.95	3017	7314	0
			300	0	921.39	183.68	1105.07	3017	5018	0
				25	981.88	183.68	1165.56	3017	6278	0
				50	1042.37	183.68	1226.05	3017	7314	0
	75	75	100	0	479.67	260.17	739.84	3052	4956	0
				25	540.16	260.17	800.33	3052	5874	0
				50	600.65	260.17	860.82	3052	6669	0
			200	0	730.78	260.17	990.95	3052	4956	0
				25	791.27	260.17	1051.44	3052	5874	0
				50	851.76	260.17	1111.93	3052	6669	0
			300	0	981.88	260.17	1242.05	3052	4956	0
				25	1042.37	260.17	1302.54	3052	5874	0
				50	1102.87	260.17	1363.04	3052	6669	0
875	50	50	100	0	370.47	166.95	537.42	3015	5024	0
				25	419.71	166.95	586.66	3015	6335	0
				50	468.94	166.95	635.89	3015	7426	0
			200	0	602.17	166.95	769.12	3015	5024	0
				25	651.41	166.95	818.36	3015	6335	0
				50	700.64	166.95	867.59	3015	7426	0
			300	0	833.88	166.95	1000.83	3015	5024	0
				25	883.11	166.95	1050.06	3015	6335	0
				50	932.34	166.95	1099.29	3015	7426	0
	75	75	100	0	419.71	236.27	655.98	3050	4961	0
				25	468.94	236.27	705.21	3050	5914	0
				50	518.17	236.27	754.44	3050	6746	0
			200	0	651.41	236.27	887.68	3050	4961	0
				25	700.64	236.27	936.91	3050	5914	0
				50	749.88	236.27	986.15	3050	6746	0
			300	0	883.11	236.27	1119.38	3050	4961	0
				25	932.34	236.27	1168.61	3050	5914	0
				50	981.58	236.27	1217.85	3050	6746	0
925	50	50	100	0	345.21	158.05	503.26	3014	5028	0
				25	388.78	158.05	546.83	3014	6370	0
				50	432.36	158.05	590.41	3014	7494	0
			200	0	566.45	158.05	724.5	3014	5028	0
				25	610.02	158.05	768.07	3014	6370	0
				50	653.59	158.05	811.64	3014	7494	0
			300	0	787.69	158.05	945.74	3014	5028	0
				25	831.26	158.05	989.31	3014	6370	0
				50	874.83	158.05	1032.88	3014	7494	0
	50	20	100	0	345.21	158.05	503.26	5272	8111	0
				25	388.78	158.05	546.83	5272	9809	0
				50	432.26	158.05	590.31	5272	11138	0
			200	0	566.45	158.05	724.5	5272	8111	0
				25	610.02	158.05	768.07	5272	9809	0
				50	653.59	158.05	811.64	5272	11138	0
			300	0	787.69	158.05	945.74	5272	8111	0
				25	831.26	158.05	989.31	5272	9809	0
				50	874.83	158.05	1032.88	5272	11138	0
	75	75	100	0	388.78	223.57	612.35	3049	4964	0
				25	432.36	223.57	655.93	3049	5937	0
				50	475.93	223.57	699.5	3049	6792	0
			200	0	610.02	223.57	833.59	3049	4964	0
				25	653.59	223.57	877.16	3049	5937	0
				50	697.16	223.57	920.73	3049	6792	0
			300	0	831.26	223.57	1054.83	3049	4964	0
				25	874.83	223.57	1098.4	3049	5937	0
				50	918.4	223.57	1141.97	3049	6792	0
	75	20	100	0	388.78	223.57	612.35	6791	9809	0
				25	432.36	223.57	655.93	6791	11138	0
				50	475.93	223.57	699.5	6791	12217	0
			200	0	610.02	223.57	833.59	6791	9809	0
				25	653.59	223.57	877.16	6791	11138	0
				50	697.16	223.57	920.73	6791	12217	0
			300	0	831.26	223.57	1054.83	6791	9809	0
				25	874.83	223.57	1098.4	6791	11138	0
				50	918.4	223.57	1141.97	6791	12217	0

Table 3.3: 2015 Venus swingby nominal missions

All fuel piloted nominal missions
masses in mT, ΔVs in km/sec

Isp	Transfer vehicle masses Nominal	Abort	Cargo Payload	Samples Returned	IMLEOs Cargo	Piloted	Total	ΔV available for aborts at mission phase Outbound	From Mars	Inbound
800	50	50	100	0	251.11	388.46	639.57	7998	5017	0
				25	251.11	462.17	713.28	9155	6278	0
				50	251.11	535.87	786.98	10098	7314	0
			200	0	502.21	388.46	890.67	7998	5017	0
				25	502.21	462.17	964.38	9155	6278	0
				50	502.21	535.87	1038.08	10098	7314	0
			300	0	753.32	388.46	1141.78	7998	5017	0
				25	753.32	462.17	1215.49	9155	6278	0
				50	753.32	535.87	1289.19	10098	7314	0
	75	75	100	0	251.11	538.66	789.77	7915	4956	0
				25	251.11	612.36	863.47	8763	5874	0
				50	251.11	686.06	937.17	9492	6669	0
			200	0	502.21	538.66	1040.87	7915	4956	0
				25	502.21	612.36	1114.57	8763	5874	0
				50	502.21	686.06	1188.27	9492	6669	0
			300	0	753.32	538.66	1291.98	7915	4956	0
				25	753.32	612.36	1365.68	8763	5874	0
				50	753.32	686.06	1439.38	9492	6669	0
875	50	50	100	0	231.7	333.02	564.72	8043	5024	0
				25	231.7	391.95	623.65	9260	6335	0
				50	231.7	450.87	682.57	10266	7426	0
			200	0	463.4	333.02	796.42	8043	5024	0
				25	463.4	391.95	855.35	9260	6335	0
				50	463.4	450.87	914.27	10266	7426	0
			300	0	695.11	333.02	1028.13	8043	5024	0
				25	695.11	391.95	1087.06	9260	6335	0
				50	695.11	450.87	1145.98	10266	7426	0
	75	75	100	0	231.7	461.27	692.97	7955	4961	0
				25	231.7	520.2	751.9	8845	5914	0
				50	231.7	579.12	810.82	9618	6746	0
			200	0	463.4	461.27	924.67	7955	4961	0
				25	463.4	520.2	983.6	8845	5914	0
				50	463.4	579.12	1042.52	9618	6746	0
			300	0	695.11	461.27	1156.38	7955	4961	0
				25	695.11	520.2	1215.31	8845	5914	0
				50	695.11	579.12	1274.23	9618	6746	0
925	50	50	100	0	221.24	304.91	526.15	8069	5028	0
				25	221.24	356.53	577.77	9321	6370	0
				50	221.24	408.15	629.39	10365	7494	0
			200	0	442.47	304.91	747.38	8069	5028	0
				25	442.47	356.53	799	9321	6370	0
				50	442.47	408.15	850.62	10365	7494	0
			300	0	663.71	304.91	968.62	8069	5028	0
				25	663.71	356.53	1020.24	9321	6370	0
				50	663.71	408.15	1071.86	10365	7494	0
	50	20	100	0	221.24	304.91	526.15	11788	8111	0
				25	221.24	356.53	577.77	13145	9809	0
				50	221.24	408.15	629.39	14216	11138	0
			200	0	442.47	304.91	747.38	11788	8111	0
				25	442.47	356.53	799	13145	9809	0
				50	442.47	408.15	850.62	14216	11138	0
			300	0	663.71	304.91	968.62	11788	8111	0
				25	663.71	356.53	1020.24	13145	9809	0
				50	663.71	408.15	1071.86	14216	11138	0
	75	75	100	0	221.24	422.05	643.29	7978	4964	0
				25	221.24	473.67	694.91	8892	5937	0
				50	221.24	525.28	746.52	9691	6792	0
			200	0	442.47	422.05	864.52	7978	4964	0
				25	442.47	473.67	916.14	8892	5937	0
				50	442.47	525.28	967.75	9691	6792	0
			300	0	663.71	422.05	1085.76	7978	4964	0
				25	663.71	473.67	1137.38	8892	5937	0
				50	663.71	525.28	1188.99	9691	6792	0
	75	20	100	0	221.24	422.05	643.29	13598	9809	0
				25	221.24	473.67	694.91	14583	11138	0
				50	221.24	525.28	746.52	15395	12217	0
			200	0	442.47	422.05	864.52	13598	9809	0
				25	442.47	473.67	916.14	14583	11138	0
				50	442.47	525.28	967.75	15395	12217	0
			300	0	663.71	422.05	1085.76	13598	9809	0
				25	663.71	473.67	1137.38	14583	11138	0
				50	663.71	525.28	1188.99	15395	12217	0

Table 3.4: 2015 Venus swingby abort mass impacts - split fuel missions

Abort location	Abort insertion	ΔVs braking	Transfer nominal	Vehicles abort	Cargo payload	Samples	piloted	MLEOs cargo	TOTAL	abort outbound	ΔV available during mission phases abort from Mars before cargo mission	after rendezvous	nominal from Mars	abort inbound
Inbound	5000	0	50	50	200	25	158.05	801.6	959.65	3014	0	10305	8280	5000
				20	200	25	158.05	703.09	861.14	5272	0	12349	6713	5000
			75	75	200	25	223.57	927.27	1150.84	3049	0	10071	8570	5000
				20	200	25	223.57	746.66	970.23	6791	0	13228	6331	5000
	2500	2500	50	50	200	25	158.05	793.38	951.43	3014	0	10177	8162	4842
				20	200	25	158.05	696.58	854.63	5272	0	12204	6595	4740
			75	75	200	25	223.57	917.62	1141.19	3049	0	9963	8468	4870
				20	200	25	223.57	740.15	963.72	6791	0	13106	6234	4740
	10000	0	50	50	200	25	158.05	1188.76	1346.81	3014	0	14331	12201	10000
				20	200	25	158.05	891.16	1049.21	5272	0	15360	9437	10000
			75	75	200	25	223.57	1480.33	1703.9	3049	0	14222	12648	10000
				20	200	25	223.57	934.73	1158.3	6791	0	15845	8648	10000
				20	200	50	223.57	978.3	1201.87	6791	0	16278	8092	10000
	5000	5000	50	50	200	25	158.05	1136.62	1294.67	3014	0	13938	11802	9510
				20	200	25	158.05	857.56	1015.61	5272	0	14945	9027	9344
			75	75	200	25	223.57	1412.32	1635.89	3049	0	13858	12278	9556
				20	200	25	223.57	901.13	1124.7	6791	0	15476	8289	9344
	15000	0	50	50	200	25	158.05	2094.53	2252.58	3014	0	18236	16402	15000
				20	200	25	158.05	1331.16	1489.21	5272	0	18631	13157	15000
			75	75	200	25	223.57	2774.25	2997.82	3049	0	18197	16858	15000
				20	200	25	223.57	1374.73	1598.3	6791	0	18830	12062	15000
	7500	7500	50	50	200	25	158.05	1797.66	1955.71	3014	0	17345	15404	13831
				20	200	25	158.05	1166.51	1324.56	5272	0	17730	12035	13639
			75	75	200	25	223.57	2367.18	2590.75	3049	0	17335	15916	13884
				20	200	25	223.57	1210.08	1433.65	6791	0	17994	11003	13639
From Mars	5000	0	50	50	200	25	NOM							
				20	200	25	NOM							
			75	75	200	25	NOM							
				20	200	25	NOM							
	2500	2500	50	50	200	25	NOM							
				20	200	25	NOM							
			75	75	200	25	NOM							
				20	200	25	NOM							
	10000	0	50	50	200	25	158.05	782.17	940.22	3014	0	10000	7998	0
				20	200	25	158.05	615.71	773.76	5272	0	10000	4943	0
			75	75	200	25	223.57	920.9	1144.47	3049	0	10000	8503	0
				20	200	25	NOM							
	5000	5000	50	50	200	25	158.05	752.88	910.93	3014	0	9510	7550	0
				20	200	25	NOM							
			75	75	200	25	223.57	882.85	1106.42	3049	0	9556	8085	0
				20	200	25	NOM							
	15000	0	50	50	200	25	158.05	1288.82	1446.87	3014	0	15000	12891	0
				20	200	25	158.05	861.82	1019.87	5272	0	15000	9081	0
			75	75	200	25	223.57	1644.65	1868.22	3049	0	15000	13447	0
				20	200	25	223.57	861.82	1085.39	6791	0	15000	7843	0
	7500	7500	50	50	200	25	158.05	1122.76	1280.81	3014	0	13831	11693	0
				20	200	25	158.05	769.73	927.78	5272	0	13639	7812	0
			75	75	200	25	223.57	1416.96	1640.53	3049	0	13884	12304	0
				20	200	25	223.57	769.73	993.3	6791	0	13639	6602	0
Piloted	5000	0	50	50	200	25	291.91	497.02	788.93	7940	5000	6370	4811	0
				20	200	25	266.63	552.12	818.75	9193	5000	9809	4811	0
			75	75	200	25	411.84	499.67	911.51	7940	5000	5937	4811	0
				20	200	25	292.15	595.69	887.84	10075	5000	11138	4811	0
	2500	2500	50	50	200	25	286.46	501.62	788.08	7790	4842	6370	4811	0
				20	200	25	222.32	555.77	778.09	8990	4740	9809	4811	0
			75	75	200	25	405.44	500.07	905.51	7817	4870	5937	4811	0
				20	200	25	287.84	599.34	887.18	9899	4740	11138	4811	0
	10000	0	50	50	200	25	548.45	452.61	1001.06	12619	10000	10000	7998	0
				20	200	25	351.25	452.61	803.86	13213	10000	10000	4943	0
			75	75	200	25	778.31	452.61	1230.92	12619	10000	10000	8503	0
				20	200	25	416.78	490.5	907.28	13661	10000	11138	4811	0
	5000	5000	50	50	200	25	513.75	452.61	966.36	12166	9510	9510	7550	0
				20	200	25	328.99	465.72	794.71	12677	9344	9809	4811	0
			75	75	200	25	733.24	452.61	1185.85	12211	9556	9556	8085	0
				20	200	25	394.51	509.26	903.77	13172	9344	11138	4811	0
	15000	0	50	50	200	25	1148.64	452.61	1601.25	17086	15000	15000	12891	0
				20	200	25	642.81	452.61	1095.42	17308	15000	15000	9081	0
			75	75	200	25	1635.69	452.61	2088.3	17086	15000	15000	13447	0
				20	200	25	708.33	452.61	1160.94	17484	15000	15000	7843	0
	7500	7500	50	50	200	25	951.93	452.61	1404.54	16086	13831	13831	11693	0
				20	200	25	533.71	452.61	986.32	16198	13639	13639	7812	0
			75	75	200	25	1365.96	452.61	1818.57	16112	13884	13884	12304	0
				20	200	25	599.23	452.61	1051.84	16433	13639	13639	6662	0

Table 3.5: 2015 Venus swingby abort mass impacts - all fuel piloted missions

Abort location	Abort insertion	Abort ΔVs braking	Transfer Vehicles nominal	abort	Samples	Piloted IMLEO	ΔV available during mission phases: abort outbound	abort from Mars	nominal from Mars	abort inbound	TOTAL IMLEO Cargo payload = 100	200	300
Inbound	5000	0	50	50	25	576.57	12916	10305	8280	5000	797.81	1019.04	1240.28
			50	20	25	459.86	15164	12349	6713	5000	681.1	902.33	1123.57
			75	75	25	790.96	12698	10071	8570	5000	1012.2	1233.43	1454.67
			75	20	25	577	16135	13228	6331	5000	798.24	1019.47	1240.71
	2500	2500	50	50	25	566.82	12801	10177	8162	4842	788.06	1009.29	1230.53
			50	20	25	452.14	15046	12204	6595	4740	673.38	894.61	1115.85
			75	75	25	779.52	12599	9963	8468	4870	1000.76	1221.99	1443.23
			75	20	25	569.28	16042	13106	6234	4740	790.52	1011.75	1232.99
	10000	0	50	50	25	1035.2	16513	14331	12201	10000	1256.44	1477.67	1698.91
			50	20	25	682.65	17614	15360	9437	10000	903.89	1125.12	1346.36
			75	75	25	1446.14	16415	14222	12648	10000	1667.38	1888.61	2109.85
			75	20	25	799.79	18147	15845	8648	10000	1021.03	1242.26	1463.5
	5000	5000	50	50	25	973.16	16169	13938	11802	9510	1194.4	1415.63	1636.87
			50	20	25	642.85	17278	14945	9027	9344	864.09	1085.32	1306.56
			75	75	25	1365.56	16096	13858	12278	9556	1586.8	1808.03	2029.27
			75	20	25	759.99	17863	15476	8289	9344	981.23	1202.46	1423.7
	15000	0	50	50	25	2108.21	19816	18236	16402	15000	2329.45	2550.68	2771.92
			50	20	25	1203.89	20218	18631	13157	15000	1425.13	1646.36	1867.6
			75	75	25	2978.95	19783	18197	16858	15000	3200.19	3421.42	3642.66
			75	20	25	1321.03	20432	18830	12062	15000	1542.27	1763.5	1984.74
	7500	7500	50	50	25	1756.52	19081	17345	15404	13831	1977.76	2198.99	2420.23
			50	20	25	1008.85	19509	17730	12035	13639	1230.09	1451.32	1672.56
			75	75	25	2496.73	19072	17335	15916	13884	2717.97	2939.2	3160.44
			75	20	25	1128.98	19796	17994	11003	13639	1350.22	1571.45	1792.69
	20000	0	50	50	25	5792.98	22625	21812	20709	20000	6014.22	6235.45	6456.69
			50	20	25	2993.85	22701	21891	18138	20000	3215.09	3436.32	3657.56
			75	75	25	8242.72	22619	21804	21014	20000	8463.96	8685.19	8906.43
			75	20	25	3110.99	22744	21934	17079	20000	3332.23	3553.46	3774.7
	10000	10000	50	50	25	3331.51	21333	20130	18616	17574	3552.75	3773.98	3995.22
			75	75	25	4773.1	21346	20147	19056	17623	4994.34	5215.57	5436.81
			75	20	25	1859.31	21553	20319	14214	17394	2080.55	2301.78	2523.02
From Mars	5000	0	50	50	25	NOM							
			50	20	25	NOM							
			75	75	25	NOM							
			75	20	25	NOM							
	2500	2500	50	50	25	NOM							
			50	20	25	NOM							
			75	75	25	NOM							
			75	20	25	NOM							
	10000	0	50	50	25	560.47	12665	10000	7998	0	781.71	1002.94	1224.18
			50	20	25	363.27	13298	10000	4943	0	584.51	805.74	1026.98
			75	75	25	790.32	12651	10000	8503	0	1011.56	1232.79	1454.03
			75	20	25	NOM							
	5000	5000	50	50	25	525.76	12219	9510	7550	0	747	968.23	1189.47
			50	20	25	NOM							
			75	75	25	745.25	12246	9556	8085	0	966.49	1187.72	1408.96
			75	20	25	NOM							
From Mars	15000	0	50	50	25	1160.66	17103	15000	12891	0	1381.9	1603.13	1824.37
			50	20	25	654.82	17341	15000	9081	0	876.06	1097.29	1318.53
			75	75	25	1647.71	17098	15000	13447	0	1868.95	2090.18	2311.42
			75	20	25	720.34	17515	15000	7843	0	941.58	1162.81	1384.05
	7500	7500	50	50	25	963.94	16088	13831	11693	0	1185.18	1406.41	1627.65
			50	20	25	545.72	16242	13639	7812	0	766.96	988.19	1209.43
			75	75	25	1377.97	16128	13884	12304	0	1599.21	1820.44	2041.68
			75	20	25	611.25	16474	13639	6662	0	832.49	1053.72	1274.96
	20000	0	50	50	25	3221.74	21233	20000	18459	0	3442.98	3664.21	3885.45
			50	20	25	1656.04	21281	20000	15045	0	1877.28	2098.51	2319.75
			75	75	25	4592.01	21232	20000	18887	0	4813.25	5034.48	5255.72
			75	20	25	1721.56	21318	20000	13720	0	1942.8	2164.03	2385.27
	10000	10000	50	50	25	1844.91	19276	17574	15657	0	2066.15	2287.38	2508.62
			50	20	25	955.91	19254	17394	11638	0	1177.15	1398.38	1619.62
			75	75	25	2651.27	19314	17623	16229	0	2872.51	3093.74	3314.98
			75	20	25	1021.43	19347	17394	10296	0	1242.67	1463.9	1685.14
Outbound	5000	0	50	50	25	NOM							
			50	20	25	NOM							
			75	75	25	NOM							
			75	20	25	NOM							
	2500	2500	50	50	25	NOM							
			50	20	25	NOM							
			75	75	25	NOM							
			75	20	25	NOM							
	10000	0	50	50	25	389.09	10000	7100	5428	0	610.33	831.56	1052.8
			50	20	25	NOM							
			75	75	25	547.12	10000	7124	5859	0	768.36	989.59	1210.83
			75	20	25	NOM							
	5000	5000	50	50	25	365.23	9510	6573	4981	0	586.47	807.7	1028.94
			50	20	25	NOM							
			75	75	25	NOM							
			75	20	25	NOM							
	15000	0	50	50	25	801.72	15000	12597	10465	0	1022.96	1244.19	1465.43
			50	20	25	453.96	15000	12106	6517	0	675.2	896.43	1117.67
			75	75	25	1136.56	15000	12606	11025	0	1357.8	1579.03	1800.27
			75	20	25	499.01	15000	11694	5190	0	720.25	941.48	1162.72
	7500	7500	50	50	25	666.48	13831	11288	9203	0	887.72	1108.95	1330.19
			50	20	25	378.95	13639	10423	5421	0	600.19	821.42	1042.66
			75	75	25	951.12	13884	11359	9803	0	1172.36	1393.59	1614.83
			75	20	25	NOM							
	20000	0	50	50	25	2218.71	20000	18458	16654	0	2439.95	2661.18	2882.42
			50	20	25	1142.29	20000	18343	12789	0	1363.53	1584.76	1806
			75	75	25	3160.76	20000	18460	17149	0	3382	3603.23	3824.47
			75	20	25	1187.34	20000	18251	11319	0	1408.58	1629.81	1851.05
	10000	10000	50	50	25	1272.14	17574	15549	13465	0	1493.38	1714.61	1935.85
			50	20	25	660.96	17394	15066	9145	0	882.2	1103.43	1324.67
			75	75	25	1826.51	17623	15612	14083	0	2047.75	2268.98	2490.22
			75	20	25	706	17394	14842	7699	0	927.24	1148.47	1369.71

Table 3.8: 2015 deep space manuever nominal missions

Split fuel nominal missions
masses in mT, ΔVs in kps

Isp	Transfer vehicle masses Nominal	Abort	Cargo Payload	Samples Returned	IMLEOs Cargo	Piloted	Total	ΔV available for aborts at mission phase Outbound	From Mars after rendezvous	Inbound before DSM
800	50	50	100	0	517.42	186.65	704.07	3163	6839	2799
				25	614.01	186.65	800.66	3163	8281	3674
				50	710.6	186.65	897.25	3163	9417	4445
			200	0	768.52	186.65	955.17	3163	6839	2799
				25	865.11	186.65	1051.76	3163	8281	3674
				50	961.71	186.65	1148.36	3163	9417	4445
			300	0	1019.63	186.65	1206.28	3163	6839	2799
				25	1116.22	186.65	1302.87	3163	8281	3674
				50	1212.81	186.65	1399.46	3163	9417	4445
	75	75	100	0	614.01	264.63	878.64	3199	6754	2771
				25	710.6	264.63	975.23	3199	7817	3399
				50	807.19	264.63	1071.82	3199	8706	3971
			200	0	865.11	264.63	1129.74	3199	6754	2771
				25	961.71	264.63	1226.34	3199	7817	3399
				50	1058.3	264.63	1322.93	3199	8706	3971
			300	0	1116.22	264.63	1380.85	3199	6754	2771
				25	1212.81	264.63	1477.44	3199	7817	3399
				50	1309.41	264.63	1574.04	3199	8706	3971
875	50	50	100	0	448.75	163.96	612.71	3161	6873	2800
				25	526.38	163.96	690.34	3161	8397	3697
				50	604	163.96	767.96	3161	9613	4491
			200	0	680.45	163.96	844.41	3161	6873	2800
				25	758.08	163.96	922.04	3161	8397	3697
				50	835.71	163.96	999.67	3161	9613	4491
			300	0	912.15	163.96	1076.11	3161	6873	2800
				25	989.78	163.96	1153.74	3161	8397	3697
				50	1067.41	163.96	1231.37	3161	9613	4491
	75	75	100	0	526.38	239.92	766.3	3197	6783	2772
				25	604	239.92	843.92	3197	7903	3414
				50	681.63	239.92	921.55	3197	8850	4002
			200	0	758.08	239.92	998	3197	6783	2772
				25	835.71	239.92	1075.63	3197	7903	3414
				50	913.33	239.92	1153.25	3197	8850	4002
			300	0	989.78	239.92	1229.7	3197	6783	2772
				25	1067.41	239.92	1307.33	3197	7903	3414
				50	1145.04	239.92	1384.96	3197	8850	4002
925	50	50	100	0	413.71	160.17	573.88	3159	6892	2801
				25	481.91	160.17	642.08	3159	8465	3710
				50	550.12	160.17	710.29	3159	9731	4519
			200	0	634.95	160.17	795.12	3159	6892	2801
				25	703.15	160.17	863.32	3159	8465	3710
				50	771.35	160.17	931.52	3159	9731	4519
			300	0	856.18	160.17	1016.35	3159	6892	2801
				25	924.39	160.17	1084.56	3159	8465	3710
				50	992.59	160.17	1152.76	3159	9731	4519
	50	20	100	0	413.71	160.17	573.88	5491	10436	4947
				25	481.91	160.17	642.08	5491	12226	6298
				50	550.12	160.17	710.29	5491	13571	7430
			200	0	634.95	160.17	795.12	5491	10436	4947
				25	703.15	160.17	863.32	5491	12226	6298
				50	771.35	160.17	931.52	5491	13571	7430
			300	0	856.18	160.17	1016.35	5491	10436	4947
				25	924.39	160.17	1084.56	5491	12226	6298
				50	992.59	160.17	1152.76	5491	13571	7430
	75	75	100	0	481.91	226.79	708.7	3196	6800	2772
				25	550.12	226.79	776.91	3196	7954	3422
				50	618.32	226.79	845.11	3196	8935	4020
			200	0	703.15	226.79	929.94	3196	6800	2772
				25	771.35	226.79	998.14	3196	7954	3422
				50	839.56	226.79	1066.35	3196	8935	4020
			300	0	924.39	226.79	1151.18	3196	6800	2772
				25	992.59	226.79	1219.38	3196	7954	3422
				50	1060.79	226.79	1287.58	3196	8935	4020
	75	20	100	0	481.91	226.79	708.7	7046	12226	6298
				25	550.12	226.79	776.91	7046	13571	7430
				50	618.32	226.79	845.11	7046	14629	8398
			200	0	703.15	226.79	929.94	7046	12226	6298
				25	771.35	226.79	998.14	7046	13571	7430
				50	839.56	226.79	1066.35	7046	14629	8398
			300	0	924.39	226.79	1151.18	7046	12226	6298
				25	992.59	226.79	1219.38	7046	13571	7430
				50	1060.79	226.79	1287.58	7046	14629	8398

Table 3.6: 2015 deep space manuever nominal missions

All fuel piloted nominal missions
masses in mT, ΔVs in kps

Isp	Transfer vehicle masses Nominal	Abort	Cargo Payload	Samples Returned	IMLEOs Cargo	Piloted	Total	ΔV available for aborts at mission phase Outbound	From Mars	Inbound before DSM
800	50	50	100	0	251.11	517.46	768.57	9834	6839	2799
				25	251.11	637.45	888.56	1121	8281	3675
				50	251.11	757.43	1008.54	12122	9417	4445
			200	0	502.21	517.46	1019.67	9834	6839	2799
				25	502.21	637.45	1139.66	1121	8281	3675
				50	502.21	757.43	1259.64	12122	9417	4445
			300	0	753.32	517.46	1270.78	9834	6839	2799
				25	753.32	637.45	1390.77	1121	8281	3675
				50	753.32	757.43	1510.75	12122	9417	4445
	75	75	100	0	251.11	715.43	966.54	9727	6754	2771
				25	251.11	835.42	1086.53	10683	7817	3399
				50	251.11	955.4	1206.51	11476	8706	3971
			200	0	502.21	715.43	1217.64	9727	6754	2771
				25	502.21	835.42	1337.63	10683	7817	3399
				50	502.21	955.4	1457.61	11476	8706	3971
			300	0	753.32	715.43	1468.75	9727	6754	2771
				25	753.32	835.42	1588.74	10683	7817	3399
				50	753.32	955.4	1708.72	11476	8706	3971
875	50	50	100	0	231.7	433.75	665.45	9931	6873	2800
				25	231.7	528.29	759.99	11313	8397	3697
				50	231.7	622.85	854.55	12405	9613	4491
			200	0	463.4	433.75	897.15	9931	6873	2800
				25	463.4	528.29	991.69	11313	8397	3697
				50	463.4	622.85	1086.25	12405	9613	4491
			300	0	695.11	433.75	1128.86	9931	6873	2800
				25	695.11	528.29	1223.4	11313	8397	3697
				50	695.11	622.85	1317.96	12405	9613	4491
	75	75	100	0	231.7	598.85	830.55	9815	6783	2772
				25	231.7	693.4	925:1	10838	7903	3414
				50	231.7	787.96	1019.66	11697	8850	4002
			200	0	463.4	598.85	1062.25	9815	6783	2772
				25	463.4	693.4	1156.8	10838	7903	3414
				50	463.4	787.96	1251.36	11697	8850	4002
			300	0	695.11	598.85	1293.96	9815	6783	2772
				25	695.11	693.4	1388.51	10838	7903	3414
				50	695.11	787.96	1483.07	11697	8850	4002
925	50	50	100	0	221.24	392.01	613.25	9986	6892	2801
				25	221.24	474.16	695.4	11425	8465	3710
				50	221.24	556.31	777.55	12572	9731	4519
			200	0	442.47	392.01	834.48	9986	6892	2801
				25	442.47	474.16	916.63	11425	8465	3710
				50	442.47	556.31	998.78	12572	9731	4519
			300	0	663.71	392.01	1055.72	9986	6892	2801
				25	663.71	474.16	1137.87	11425	8465	3710
				50	663.71	556.31	1220.02	12572	9731	4519
	50	20	100	0	221.24	392.01	613.25	13834	10436	4947
				25	221.24	474.16	695.4	15255	12226	6298
				50	221.24	556.31	777.55	16326	13571	7430
			200	0	442.47	392.01	834.48	13834	10436	4947
				25	442.47	474.16	916.63	15255	12226	6298
				50	442.47	556.31	998.78	16326	13571	7430
			300	0	663.71	392.01	1055.72	13834	10436	4947
				25	663.71	474.16	1137.87	15255	12226	6298
				50	663.71	556.31	1220.02	16326	13571	7430
	75	75	100	0	221.24	540.78	762.02	9865	6800	2772
				25	221.24	622.93	844.17	10927	7954	3422
				50	221.24	705.08	926.32	11826	8935	4020
			200	0	442.47	540.78	983.25	9865	6800	2772
				25	442.47	622.93	1065.4	10927	7954	3422
				50	442.47	705.08	1147.55	11826	8935	4020
			300	0	663.71	540.78	1204.49	9865	6800	2772
				25	663.71	622.93	1286.64	10927	7954	3422
				50	663.71	705.08	1368.79	11826	8935	4020
	75	20	100	0	221.24	540.78	762.02	15565	12226	6298
				25	221.24	622.93	844.17	16566	13571	7430
				50	221.24	705.08	926.32	17360	14629	8398
			200	0	442.47	540.78	983.25	15565	12226	6298
				25	442.47	622.93	1065.4	16566	13571	7430
				50	442.47	705.08	1147.55	17360	14629	8398
			300	0	663.71	540.78	1204.49	15565	12226	6298
				25	663.71	622.93	1286.64	16566	13571	7430
				50	663.71	705.08	1368.79	17360	14629	8398

Table 3.7: 2015 deep space maneuver abort mass impacts - split fuel missions

Abort location	Abort insertion	ΔVs braking	Transfer nominal	Vehicles abort	Cargo payload	Samples	piloted	MLEOs cargo	TOTAL	abort outbound	ΔV available during mission phases: abort from Mars before cargo	abort from Mars after mission	nominal from Mars rendezvous	inbound before DSM	abort after DSM
Inbound	5000	0	50	50	200	25	156.64	942.46	1099.1	3159	0	12073	9807	8070	5000
				20	200	25	156.64	819.4	976.04	5491	0	14340	8311	9556	5000
			75	75	200	25	221.78	1113.21	1334.99	3196	0	11797	9607	7916	5000
				20	200	25	221.78	887.6	1109.38	7046	0	15251	7969	10263	5000
	2500	2500	50	50	200	25	156.64	932.18	1088.82	3159	0	11957	9695	7930	4842
				20	200	25	156.64	811.27	967.91	5491	0	14218	8199	9374	4740
			75	75	200	25	221.78	1101.15	1322.93	3196	0	11697	10015	7799	4870
				20	200	25	221.78	879.47	1101.25	7046	0	15152	7877	10102	4740
	10000	0	50	50	200	25	156.64	1426.06	1582.7	3159	0	15750	13525	12516	10000
				20	200	25	156.64	1054.32	1210.96	5491	0	16891	10910	13254	10000
			75	75	200	25	221.78	1804.05	2025.83	3196	0	15623	13977	12444	10000
				20	200	25	221.78	1122.52	1344.3	7046	0	17401	10187	13629	10000
	5000	5000	50	50	200	25	156.64	1360.64	1517.28	3159	0	15394	13149	12081	9510
				20	200	25	156.64	1012.35	1168.99	5491	0	16538	10520	12751	9344
			75	75	200	25	221.78	1719.09	1940.87	3196	0	15290	13629	12044	9556
				20	200	25	221.78	1080.55	1302.33	7046	0	17096	9845	13163	9344
	15000	0	50	50	200	25	160.17	2557.47	2717.64	3159	0	19243	17432	16907	15000
				20	200	25	160.17	1603.93	1764.1	5491	0	19674	14423	17194	15000
			75	75	200	25	226.79	3420.29	3647.08	3196	0	19199	17877	16880	15000
				20	200	25	226.79	1672.13	1898.92	7046	0	19884	13426	17346	15000
	7500	7500	50	50	200	25	160.17	2186.64	2346.81	3159	0	18455	16513	15893	13831
				20	200	25	160.17	1398.27	1558.44	5491	0	18909	13369	16110	13639
			75	75	200	25	226.79	2911.82	3138.61	3196	0	18433	17015	15904	13884
				20	200	25	226.79	1466.47	1693.26	7046	0	19187	12425	16312	13639
From Mars	5000	0	50	50	200	25	NOM								
				20	200	25	NOM								
			75	75	200	25	NOM								
				20	200	25	NOM								
	2500	2500	50	50	200	25	NOM								
				20	200	25	NOM								
			75	75	200	25	NOM								
				20	200	25	NOM								
	10000	0	50	50	200	25	156.64	787.75	944.39	3159	0	10000	7862	3710	0
				20	200	25	NOM								
			75	75	200	25	221.78	926.47	1148.25	3196	0	10000	8394	3422	0
				20	200	25	NOM								
	5000	5000	50	50	200	25	156.64	758.45	915.09	3159	0	9510	7418	3710	0
				20	200	25	NOM								
			75	75	200	25	221.78	888.42	1110.2	3196	0	9556	7979	3422	0
				20	200	25	NOM								
	15000	0	50	50	200	25	160.17	1294.39	1454.56	3159	0	15000	12737	3710	0
				20	200	25	160.17	867.4	1027.57	5491	0	15000	8937	6298	0
			75	75	200	25	226.79	1650.22	1877.01	3196	0	15000	13328	3422	0
				20	200	25	226.79	867.4	1094.19	7046	0	15000	7737	7430	0
	7500	7500	50	50	200	25	160.17	1128.34	1288.51	3159	0	13831	11540	3710	0
				20	200	25	160.17	775.3	935.47	5491	0	13639	7677	6298	0
			75	75	200	25	226.79	1422.53	1649.32	3196	0	13884	12185	3422	0
				20	200	25	226.79	775.3	1002.09	7046	0	13639	6565	7430	0
Piloted	5000	0	50	50	200	25	289.74	590.15	879.89	8080	5000	8465	6490	3710	0
				20	200	25	224.83	645.25	870.08	9373	5000	12226	6490	6298	0
			75	75	200	25	408.98	612.43	1021.41	8080	5000	7954	6510	3422	0
				20	200	25	289.96	713.46	1003.44	10278	5000	13571	6510	7430	0
	2500	2500	50	50	200	25	284.32	594.75	879.07	7929	4842	8465	6490	3710	0
				20	200	25	220.54	648.89	869.43	9172	4740	12226	6490	6298	0
			75	75	200	25	402.62	617.83	1020.45	7956	4870	7954	6510	3422	0
				20	200	25	285.69	717.1	1002.79	10105	4740	13571	6510	7430	0
	10000	0	50	50	200	25	544.83	458.19	1003.02	12740	10000	10000	7862	3710	0
				20	200	25	348.75	540.06	888.81	13354	10000	12226	6490	6298	0
			75	75	200	25	773.38	458.19	1231.57	12740	10000	10000	8394	3422	0
				20	200	25	413.9	608.26	1022.16	13814	10000	13571	6510	7430	0
	5000	5000	50	50	200	25	510.32	458.19	968.51	12291	9510	9510	7418	3710	0
				20	200	25	326.61	558.85	885.46	12823	9344	12226	6490	6298	0
			75	75	200	25	728.56	458.19	1186.75	12334	9556	9556	7979	3422	0
				20	200	25	391.76	627.05	1018.81	13332	9344	13571	6510	7430	0
	15000	0	50	50	200	25	1167.38	458.19	1625.57	17180	15000	15000	12737	3710	0
				20	200	25	653.07	458.19	1111.26	17409	15000	15000	8937	6298	0
			75	75	200	25	1662.6	458.19	2120.79	17180	15000	15000	13328	3422	0
				20	200	25	719.69	458.19	1177.88	17589	15000	15000	7737	7430	0
	7500	7500	50	50	200	25	967.37	458.19	1425.56	16167	13831	13831	11540	3710	0
				20	200	25	542.14	458.19	1000.33	16310	13639	13639	7677	6298	0
			75	75	200	25	1388.35	458.19	1846.54	16213	13884	13884	12185	3422	0
				20	200	25	608.76	458.19	1066.95	16551	13639	13639	6565	7430	0

Table 3.8: 2015 deep space maneuver abort mass impacts - all fuel piloted missions

Abort location	Abort insertion	ΔVs braking	Transfer nominal	Vehicles abort	Samples	Piloted IMLEO	ΔV available during mission phases: abort outbound	abort from Mars	nominal from Mars	inbound abort before DSM	inbound abort after DSM	TOTAL IMLEO Cargo payload = 100	200	300
Inbound	5000	0	50	50	25	755.37	14646	12073	9807	8070	5000	976.61	1197.84	1419.08
				20	25	607.15	16915	14340	831.1	9556	5000	828.39	1049.62	1270.86
			75	75	25	1027.67	14391	11797	10113	7916	5000	1248.91	1470.14	1691.38
				20	25	755.92	17810	15251	7969	10263	5000	977.16	1198.39	1419.63
	2500	2500	50	50	25	743	14543	11957	9695	7930	4842	964.24	1185.47	1406.71
				20	25	597.35	16818	14218	8199	9374	4740	818.59	1039.82	1261.06
			75	75	25	1013.14	14301	11697	10015	7799	4870	1234.38	1455.61	1676.85
				20	25	746.12	17735	15152	7877	10102	4740	967.36	1188.59	1409.83
	10000	0	50	50	25	1337.87	17834	15750	13525	12516	10000	1559.11	1780.34	2001.58
				20	25	890.11	18939	16891	10910	13254	10000	1111.35	1332.58	1553.82
			75	75	25	1859.78	17722	15623	13977	12444	10000	2081.02	2302.25	2523.49
				20	25	1038.88	19434	17401	10187	13629	10000	1260.12	1481.35	1702.59
	5000	5000	50	50	25	1259.07	17532	15394	13149	12081	9510	1480.31	1701.54	1922.78
				20	25	839.56	18661	16538	10520	12751	9344	1060.8	1282.03	1503.27
			75	75	25	1757.44	17439	15290	13629	12044	9556	1978.68	2199.91	2421.15
				20	25	988.33	19204	17096	9845	13163	9344	1209.57	1430.8	1652.04
	15000	0	50	50	25	2700.66	20693	19243	17432	16907	15000	2921.9	3143.13	3364.37
				20	25	1552.11	21089	19674	14423	17194	15000	1773.35	1994.58	2215.82
			75	75	25	3806.55	20656	19199	17877	16880	15000	4027.79	4249.02	4470.26
				20	25	1700.89	21287	19884	13426	17346	15000	1922.13	2143.36	2364.6
	7500	7500	50	50	25	2253.99	20065	18455	16513	15893	13831	2475.23	2696.46	2917.7
				20	25	1304.39	20505	18909	13369	16110	13639	1525.63	1746.86	1968.1
			75	75	25	3194.09	20045	18433	17015	15905	13884	3415.33	3636.56	3857.8
				20	25	1453.17	20772	19187	12425	16312	13639	1674.41	1895.64	2116.88
	20000	0	50	50	25	7380.53	23039	22328	21302	21096	20000	7601.77	7823	8044.24
				20	25	3825.47	23111	22412	19012	21156	20000	4046.71	4267.94	4489.18
			75	75	25	10491.9	23033	22320	21585	21090	20000	10713.1	10934.3	11155.6
				20	25	3974.24	23151	22456	18078	21189	20000	4195.48	4416.71	4637 95
	10000	10000	50	50	25	4254.32	21972	20894	19443	19099	17574	4475.56	4696.79	4918.03
				20	25	2235.76	22088	21008	16471	19101	17394	2457	2678.23	2899.47
			75	75	25	6085.22	21978	20904	19860	19126	17623	6306.46	6527.69	6748.93
				20	25	2384.53	22193	21122	15440	19185	17394	2605.77	2827	3048.24
From Mars	5000	0	50	50	25	NOM								
				20	25	NOM								
			75	75	25	NOM								
				20	25	NOM								
	2500	2500	50	50	25	NOM								
				20	25	NOM								
			75	75	25	NOM								
				20	25	NOM								
	10000	0	50	50	25	576.06	12815	10000	7862	3710	0	797.3	1018.53	1239.77
				20	25	NOM								
			75	75	25	809.77	12792	10000	8394	3422	0	1031.01	1252.24	1473.48
				20	25	NOM								
	5000	5000	50	50	25	540.77	12373	9510	7418	3710	0	762.01	983.24	1204.48
				20	25	NOM								
			75	75	25	763.94	12390	9556	7979	3422	0	985.18	1206.41	1427.65
				20	25	NOM								
	15000	0	50	50	25	1186.31	17207	15000	12737	3710	0	1407.55	1628.78	1850.02
				20	25	672	17461	15000	8937	6298	0	893.24	1114.47	1335.71
			75	75	25	1685.53	17199	15000	13328	3422	0	1906.77	2128	2349.24
				20	25	738.62	17639	15000	7737	7430	0	959.86	1181.09	1402.33
	7500	7500	50	50	25	986.3	16202	13831	11540	3710	0	1207.54	1428.77	1650.01
				20	25	561.07	16380	13639	7677	6298	0	782.31	1003.54	1224.78
			75	75	25	1407.28	16238	13884	12185	3422	0	1628.52	1849.75	2070.99
				20	25	627.69	16617	13639	6565	7430	0	848.93	1070.16	1291.4
	20000	0	50	50	25	3281.96	21287	20000	18338	3710	0	3503.2	3724.43	3945.67
				20	25	1690	21339	20000	14897	6298	0	1911.24	2132.47	2353.71
			75	75	25	4675.22	21286	20000	18797	3422	0	4896.46	5117.69	5338.93
				20	25	1756.63	21377	20000	13601	7430	0	1977.87	2199.1	2420.34
	10000	10000	50	50	25	1882.05	19355	17574	15513	3710	0	2103.29	2324.52	2545.76
				20	25	978.13	19343	17394	11485	6298	0	1199.37	1420.6	1641.84
			75	75	25	2701.93	19392	17623	16119	3422	0	2923.17	3144.4	3365.64
				20	25	1044.75	19439	17394	10180	7430	0	1265.99	1487.22	1708.46
Outbound	5000	0	50	50	25	NOM								
				20	25	NOM								
			75	75	25	NOM								
				20	25	NOM								
	2500	2500	50	50	25	NOM								
				20	25	NOM								
			75	75	25	NOM								
				20	25	NOM								
	10000	0	50	50	25	NOM								
				20	25	NOM								
			75	75	25	NOM								
				20	25	NOM								
	5000	5000	50	50	25	NOM								
				20	25	NOM								
			75	75	25	NOM								
				20	25	NOM								
	15000	0	50	50	25	804.66	15000	12453	10175	3710	0	1025.9	1247.13	1468.37
				20	25	NOM								
			75	75	25	1138.96	15000	12470	10771	3422	0	1360.2	1581.43	1802.67
				20	25	NOM								
	7500	7500	50	50	25	669.63	13831	11134	8913	3710	0	890.87	1112.1	1333.34
				20	25	NOM								
			75	75	25	953.82	13834	11213	9548	3422	0	1175.06	1396.29	1617.53
				20	25	NOM								
	20000	0	50	50	25	2219.36	20000	18370	16415	3710	0	2440.6	2661.83	2883.07
				20	25	1144.68	20000	18242	12509	6298	0	1365.92	1587.15	1808.39
			75	75	25	3159.89	20000	18373	16948	3422	0	3381.13	3602.36	3823.6
				20	25	1189.65	20000	18143	11067	7430	0	1410.89	1632.12	1853.36
	10000	10000	50	50	25	1274.32	17574	15432	13189	3710	0	1495.56	1716.79	1938.03
				20	25	664.12	17394	14916	8855	6298	0	885.36	1106.59	1327.83
			75	75	25	1827.79	17623	15499	13847	3422	0	2049.03	2270.26	2491.5
				20	25	709.09	17394	14675	7445	7430	0	930.33	1151.56	1372.8

Table 3.9: 2014 minimum energy nominal missions

Split fuel nominal missions
masses in mT, ΔVs in kps

Isp	Transfer vehicle masses Nominal	Abort	Cargo Payload	Samples Returned	MLEOs Cargo	Piloted	Total	ΔV available for aborts at mission phase Outbound	From Mars after rendezvous	Inbound
800	50	50	100	0	320.56	149.04	469.6	2690	2028	0
				25	338.7	149.04	487.74	2690	2705	0
				50	356.83	149.04	505.87	2690	3318	0
			200	0	557.14	149.04	706.18	2690	2028	0
				25	575.27	149.04	724.31	2690	2705	0
				50	593.4	149.04	742.44	2690	3318	0
			300	0	793.71	149.04	942.75	2690	2028	0
				25	811.84	149.04	960.88	2690	2705	0
				50	829.98	149.04	979.02	2690	3318	0
	75	75	100	0	338.7	211.81	550.51	2721	2002	0
				25	356.83	211.81	568.64	2721	2485	0
				50	374.96	211.81	586.77	2721	2935	0
			200	0	575.27	211.81	787.08	2721	2002	0
				25	593.4	211.81	805.21	2721	2485	0
				50	611.54	211.81	823.35	2721	2935	0
			300	0	811.84	211.81	1023.65	2721	2002	0
				25	829.98	211.81	1041.79	2721	2485	0
				50	848.11	211.81	1059.92	2721	2935	0
875	50	50	100	0	293.34	137.81	431.15	2688	2030	0
				25	308.52	137.81	446.33	2688	2718	0
				50	323.7	137.81	461.51	2688	3346	0
			200	0	512.79	137.81	650.6	2688	2030	0
				25	527.97	137.81	665.78	2688	2718	0
				50	543.16	137.81	680.97	2688	3346	0
			300	0	732.25	137.81	870.06	2688	2030	0
				25	747.43	137.81	885.24	2688	2718	0
				50	762.61	137.81	900.42	2688	3346	0
	75	75	100	0	308.52	195.73	504.25	2720	2003	0
				25	323.7	195.73	519.43	2720	2494	0
				50	338.88	195.73	534.61	2720	2953	0
			200	0	527.97	195.73	723.7	2720	2003	0
				25	543.16	195.73	738.89	2720	2494	0
				50	558.34	195.73	754.07	2720	2953	0
			300	0	747.43	195.73	943.16	2720	2003	0
				25	762.61	195.73	958.34	2720	2494	0
				50	777.79	195.73	973.52	2720	2953	0
925	50	50	100	0	278.76	131.75	410.51	2687	2030	0
				25	292.41	131.75	424.16	2687	2725	0
				50	306.07	131.75	437.82	2687	3362	0
			200	0	488.94	131.75	620.69	2687	2030	0
				25	502.59	131.75	634.34	2687	2725	0
				50	516.25	131.75	648	2687	3362	0
			300	0	699.12	131.75	830.87	2687	2030	0
				25	712.77	131.75	844.52	2687	2725	0
				50	726.42	131.75	858.17	2687	3362	0
	50	20	100	0	278.76	131.75	410.51	4771	3720	0
				25	292.41	131.75	424.16	4771	4830	0
				50	306.07	131.75	437.82	4771	5793	0
			200	0	488.94	131.75	620.69	4771	3720	0
				25	502.59	131.75	634.34	4771	4830	0
				50	516.25	131.75	648	4771	5793	0
			300	0	699.12	131.75	830.87	4771	3720	0
				25	712.77	131.75	844.52	4771	4830	0
				50	726.42	131.75	858.17	4771	5793	0
	75	75	100	0	292.41	187.06	479.47	2719	2004	0
				25	306.07	187.06	493.13	2719	2498	0
				50	319.72	187.06	506.78	2719	2963	0
			200	0	502.59	187.06	689.65	2719	2004	0
				25	516.25	187.06	703.31	2719	2498	0
				50	529.9	187.06	716.96	2719	2963	0
			300	0	712.77	187.06	899.83	2719	2004	0
				25	726.42	187.06	913.48	2719	2498	0
				50	740.08	187.06	927.14	2719	2963	0
	75	20	100	0	292.41	187.06	479.47	6202	4830	0
				25	306.07	187.06	493.13	6202	5793	0
				50	319.72	187.06	506.78	6202	6640	0
			200	0	502.59	187.06	689.65	6202	4830	0
				25	516.25	187.06	703.31	6202	5793	0
				50	529.9	187.06	716.96	6202	6640	0
			300	0	712.77	187.06	899.83	6202	4830	0
				25	726.42	187.06	913.48	6202	5793	0
				50	740.08	187.06	927.14	6202	6640	0

All fuel piloted nominal missions
masses in mT, ΔVs in kps

Isp	Transfer vehicle masses Nominal	Abort	Cargo Payload	Samples Returned	MLEOs Cargo	Piloted	Total	ΔV available for aborts at mission phase Outbound	From Mars	Inbound
800	50	50	100	0	236.57	238.18	474.75	5143	2028	0
				25	236.57	257.43	494	5755	2705	0
				50	236.57	276.68	513.25	6309	3318	0
			200	0	473.15	238.18	711.33	5143	2028	0
				25	473.15	257.43	730.58	5755	2705	0
				50	473.15	276.68	749.83	6309	3318	0
			300	0	709.72	238.18	947.9	5143	2028	0
				25	709.72	257.43	967.15	5755	2705	0
				50	709.72	276.68	986.4	6309	3318	0
	75	75	100	0	236.57	320.21	556.78	5005	2002	0
				25	236.57	339.46	576.03	5449	2485	0
				50	236.57	358.7	595.27	5862	2935	0
			200	0	473.15	320.21	793.36	5005	2002	0
				25	473.15	339.46	812.61	5449	2485	0
				50	473.15	358.7	831.85	5862	2935	0
			300	0	709.72	320.21	1029.93	5005	2002	0
				25	709.72	339.46	1049.18	5449	2485	0
				50	709.72	358.7	1068.42	5862	2935	0
875	50	50	100	0	219.45	215.82	435.27	5171	2030	0
				25	219.45	231.85	451.3	5798	2718	0
				50	219.45	247.88	467.33	6370	3346	0
			200	0	438.91	215.82	654.73	5171	2030	0
				25	438.91	231.85	670.76	5798	2718	0
				50	438.91	247.88	686.79	6370	3346	0
			300	0	658.36	215.82	874.18	5171	2030	0
				25	658.36	231.85	890.21	5798	2718	0
				50	658.36	247.88	906.24	6370	3346	0
	75	75	100	0	219.45	289.77	509.22	5026	2003	0
				25	219.45	305.8	525.25	5480	2494	0
				50	219.45	321.83	541.28	5906	2953	0
			200	0	438.91	289.77	728.68	5026	2003	0
				25	438.91	305.8	744.71	5480	2494	0
				50	438.91	321.83	760.74	5906	2953	0
			300	0	658.36	289.77	948.13	5026	2003	0
				25	658.36	305.8	964.16	5480	2494	0
				50	658.36	321.83	980.19	5906	2953	0
925	50	50	100	0	210.18	203.94	414.12	5187	2030	0
				25	210.18	218.31	428.49	5823	2725	0
				50	210.18	232.68	442.86	6406	3362	0
			200	0	420.36	203.94	624.3	5187	2030	0
				25	420.36	218.31	638.67	5823	2725	0
				50	420.36	232.68	653.04	6406	3362	0
			300	0	630.54	203.94	834.48	5187	2030	0
				25	630.54	218.31	848.85	5823	2725	0
				50	630.54	232.68	863.22	6406	3362	0
	50	20	100	0	210.18	203.94	414.12	8319	3720	0
				25	210.18	218.31	428.49	9132	4830	0
				50	210.18	232.68	442.86	9853	5793	0
			200	0	420.36	203.94	624.3	8319	3720	0
				25	420.36	218.31	638.67	9132	4830	0
				50	420.36	232.68	653.04	9853	5793	0
			300	0	630.54	203.94	834.48	8319	3720	0
				25	630.54	218.31	848.85	9132	4830	0
				50	630.54	232.68	863.22	9853	5793	0
	75	75	100	0	210.18	273.62	483.8	5039	2004	0
				25	210.18	287.99	498.17	5499	2498	0
				50	210.18	302.36	512.54	5931	2963	0
			200	0	420.36	273.62	693.98	5039	2004	0
				25	420.36	287.99	708.35	5499	2498	0
				50	420.36	302.36	722.72	5931	2963	0
			300	0	630.54	273.62	904.16	5039	2004	0
				25	630.54	287.99	918.53	5499	2498	0
				50	630.54	302.36	932.9	5931	2963	0
	75	75	100	0	210.18	273.62	483.8	9915	4830	0
				25	210.18	287.99	498.17	10554	5793	0
				50	210.18	302.36	512.54	11130	6640	0
			200	0	420.36	273.62	693.98	9915	4830	0
				25	420.36	287.99	708.35	10554	5793	0
				50	420.36	302.36	722.72	11130	6640	0
			300	0	630.54	273.62	904.16	9915	4830	0
				25	630.54	287.99	918.53	10554	5793	0
				50	630.54	302.36	932.9	11130	6640	0

Table 3.10: 2014 minimum energy abort mass impacts - split fuel missions

Abort location	Abort insertion	ΔVs braking	Transfer nominal	Vehicles abort	Cargo payload	Samples	piloted	MLEOs cargo	TOTAL	ΔV available during mission phases: abort outbound	abort from Mars before cargo mission	abort from Mars after rendezvous	nominal from Mars	abort inbound
Inbound	5000	0	50	50	200	25	131.75	630.85	762.6	2687	0	7240	5573	5000
				20	200	25	131.75	564.9	696.65	4771	0	8426	3927	5000
			75	75	200	25	187.06	699.47	886.53	2719	0	7120	5876	5000
				20	200	25	187.06	578.55	765.61	6202	0	9010	3524	5000
	2500	2500	50	50	200	25	131.75	625.34	757.09	2687	0	7096	5449	4842
				20	200	25	131.75	560.54	692.29	4771	0	8229	3804	4740
			75	75	200	25	187.06	693	880.06	2719	0	6999	5768	4870
				20	200	25	187.06	574.19	761.25	6202	0	8829	3424	4740
	10000	0	50	50	200	25	131.75	890.04	1021.79	2687	0	11833	9758	10000
				20	200	25	131.75	690.8	822.55	4771	0	12417	6798	10000
			75	75	200	25	187.06	1069.72	1256.78	2719	0	11776	10236	10000
				20	200	25	187.06	704.46	891.52	6202	0	12720	5958	10000
	5000	5000	50	50	200	25	131.75	854.98	986.73	2687	0	11383	9326	9510
				20	200	25	131.75	668.31	800.06	4771	0	11878	6363	9344
			75	75	200	25	187.06	1024.19	1211.25	2719	0	11364	9835	9556
				20	200	25	187.06	681.96	869.02	6202	0	12212	5579	9344
	15000	0	50	50	200	25	131.75	1496.42	1628.17	2687	0	16394	14400	15000
				20	200	25	131.75	985.37	1117.12	4771	0	16621	10797	15000
			75	75	200	25	187.06	1935.96	2123.02	2719	0	16372	14911	15000
				20	200	25	187.06	999.02	1186.08	6202	0	16743	9601	15000
	7500	7500	50	50	200	25	131.75	1297.68	1429.43	2687	0	15336	13277	13831
				20	200	25	131.75	875.14	1006.89	4771	0	15466	9578	13639
			75	75	200	25	187.06	1663.44	1850.5	2719	0	15357	13844	13884
				20	200	25	187.06	888.8	1075.86	6202	0	15628	8461	13639
From Mars	5000	0	50	50	200	25	131.75	557.22	688.97	2687	0	5000	3709	0
				20	200	25	131.75	504.87	636.62	4771	0	5000	2024	0
			75	75	200	25	187.06	600.85	787.91	2719	0	5000	4019	0
				20	200	25	187.06	NOM						
	2500	2500	50	50	200	25	131.75	552.85	684.6	2687	0	4842	3581	0
				20	200	25	131.75	NOM						
			75	75	200	25	187.06	595.72	782.78	2719	0	4870	3908	0
				20	200	25	187.06	NOM						
	10000	0	50	50	200	25	131.75	762.96	894.71	2687	0	10000	8030	0
				20	200	25	131.75	604.81	736.56	4771	0	10000	4967	0
			75	75	200	25	187.06	894.74	1081.8	2719	0	10000	8528	0
				20	200	25	187.06	604.81	791.87	6202	0	10000	4103	0
	5000	5000	50	50	200	25	131.75	735.12	866.87	2687	0	9510	7581	0
				20	200	25	131.75	586.95	718.7	4771	0	9344	4520	0
			75	75	200	25	187.06	858.6	1045.66	2719	0	9556	8110	0
				20	200	25	187.06	586.95	774.01	6202	0	9344	3715	0
	15000	0	50	50	200	25	131.75	1244.28	1376.03	2687	0	15000	12926	0
				20	200	25	131.75	838.62	970.37	4771	0	15000	9114	0
			75	75	200	25	187.06	1582.32	1769.38	2719	0	15000	13474	0
				20	200	25	187.06	838.62	1025.68	6202	0	15000	7867	0
	7500	7500	50	50	200	25	131.75	1086.52	1218.27	2687	0	13831	11728	0
				20	200	25	131.75	751.13	882.88	4771	0	13639	7843	0
			75	75	200	25	187.06	1366.01	1553.07	2719	0	13884	12332	0
				20	200	25	187.06	751.13	938.19	6202	0	13639	6684	0
	20000	0	50	50	200	25	131.75	2897.17	3028.92	2687	0	20000	18487	0
				20	200	25	131.75	1641.55	1773.3	4771	0	20000	15079	0
			75	75	200	25	187.06	3943.51	4130.57	2719	0	20000	18908	0
				20	200	25	187.06	1641.55	1828.61	6202	0	20000	13747	0
	10000	10000	50	50	200	25	131.75	1793.02	1924.77	2687	0	17574	15691	0
				20	200	25	131.75	1080.08	1211.83	4771	0	17394	11673	0
			75	75	200	25	187.06	2387.13	2574.19	2719	0	17623	16254	0
				20	200	25	187.06	1080.08	1267.14	6202	0	17394	10323	0
Piloted	5000	0	50	50	200	25	244.75	449.87	694.62	7627	5000	5000	3709	0
				20	200	25	189.64	449.87	639.51	8782	5000	5000	2024	0
			75	75	200	25	345.98	449.87	795.85	7627	5000	5000	4019	0
				20	200	25	244.95	461.24	706.19	9607	5000	5793	1941	0
	2500	2500	50	50	200	25	240.15	449.87	690.02	7475	4842	4842	3581	0
				20	200	25	186	451.05	637.05	8574	4740	4830	1941	0
			75	75	200	25	340.58	449.87	790.45	7503	4870	4870	3908	0
				20	200	25	241.31	464.7	706.01	9425	4740	5793	1941	0
	10000	0	50	50	200	25	461.31	449.87	911.18	12344	10000	10000	8030	0
				20	200	25	294.84	449.87	744.71	12893	10000	10000	4967	0
			75	75	200	25	655.34	449.87	1105.21	12344	10000	10000	8528	0
				20	200	25	350.15	449.87	800.02	13310	10000	10000	4103	0
	5000	5000	50	50	200	25	432.01	449.87	881.88	11889	9510	9510	7581	0
				20	200	25	276.05	449.87	725.92	12345	9344	9344	4520	0
			75	75	200	25	617.29	449.87	1067.16	11932	9556	9556	8110	0
				20	200	25	331.36	449.87	781.23	12806	9344	9344	3715	0
	15000	0	50	50	200	25	967.95	449.87	1417.82	16873	15000	15000	12926	0
				20	200	25	540.96	449.87	990.83	17079	15000	15000	9114	0
			75	75	200	25	1379.09	449.87	1828.96	16873	15000	15000	13474	0
				20	200	25	596.26	449.87	1046.13	17243	15000	15000	7867	0
	7500	7500	50	50	200	25	801.89	449.87	1251.76	15836	13831	13831	11728	0
				20	200	25	448.86	449.87	898.73	15943	13639	13639	7843	0
			75	75	200	25	1151.4	449.87	1601.27	15883	13884	13884	12332	0
				20	200	25	504.17	449.87	954.04	16162	13639	13639	6684	0

Table 3.11: 2014 minimum energy abort mass impacts - all fuel piloted missions

Abort location	Abort ΔVs insertion	ΔVs braking	Transfer nominal	Vehicles abort	Samples	Piloted IMLEO	ΔV available during mission phases: abort outbound	abort from Mars	nominal from Mars	abort inbound	TOTAL IMLEO Cargo payload = 100	200	300
Inbound	5000	0	50	50	25	347.47	9923	7240	5573	5000	557.65	767.83	978.01
				20	25	278.05	11829	8426	3927	5000	468.23	698.41	908.59
			75	75	25	475.01	9763	7120	5876	5000	685.19	895.37	1105.55
				20	25	347.73	12759	9010	3524	5000	557.91	768.09	978.27
	2500	2500		50	25	341.68	9790	7096	5449	4842	551.86	762.04	972.22
				20	25	273.46	11672	8229	3804	4740	483.64	693.82	904
			75	75	25	468.2	9650	6999	5768	4870	678.38	888.56	1098.74
				20	25	343.14	12627	8829	3424	4740	553.32	763.5	973.68
	10000	0	50	50	25	620.3	14107	11833	9758	10000	830.48	1040.66	1250.84
				20	25	410.58	15048	12417	6798	10000	620.76	830.94	1041.12
			75	75	25	864.74	14033	11776	10236	10000	1074.92	1285.1	1495.28
				20	25	480.26	15549	12720	5958	10000	690.44	900.62	1110.8
	5000	5000	50	50	25	583.39	13702	11383	9326	9510	793.57	1003.75	1213.93
				20	25	386.9	14608	11878	6363	9344	597.08	807.26	1017.44
			75	75	25	816.81	13660	11364	9835	9556	1026.99	1237.17	1447.35
				20	25	456.58	15159	12212	5579	9344	666.76	876.94	1087.12
	15000	0	50	50	25	1258.58	18116	16394	14400	15000	1468.76	1678.94	1889.12
				20	25	720.64	18472	16621	10797	15000	930.82	1141	1351.18
			75	75	25	1776.55	18089	16372	14911	15000	1986.73	2196.91	2407.09
				20	25	790.32	18674	16743	9601	15000	1000.5	1210.68	1420.86
	7500	7500	50	50	25	1049.38	17204	15336	13277	13831	1259.56	1469.74	1679.92
				20	25	604.62	17534	15466	9578	13639	814.8	1024.98	1235.16
			75	75	25	1489.69	17211	15357	13844	13844	1699.87	1910.05	2120.23
				20	25	674.3	17804	15628	8461	13639	884.48	1094.66	1304.84
From Mars	5000	0	50	50	25	275.81	7908	5000	3709	0	485.99	696.17	906.35
				20	25	220.71	9258	5000	2024	0	430.89	641.07	851.25
			75	75	25	377.04	7625	5000	4019	0	587.22	797.4	1007.58
				20	25	NOM				0			
	2500	2500	50	50	25	271.21	7762	4842	3581	0	481.39	691.57	901.75
				20	25	NOM				0			
			75	75	25	371.64	7704	4870	3908	0	581.82	792	1002.18
				20	25	NOM				0			
	10000	0	50	50	25	492.37	12474	10000	8030	0	702.55	912.73	1122.91
				20	25	325.9	13131	10000	4967	0	536.08	746.26	956.44
			75	75	25	686.4	12435	10000	8528	0	896.58	1106.76	1316.94
				20	25	381.21	13530	10000	4103	0	591.39	801.57	1011.75
	5000	5000	50	50	25	463.07	12030	9510	7581	0	673.25	883.43	1093.61
				20	25	307.11	12609	9344	4520	0	517.29	727.47	937.65
			75	75	25	648.35	12030	9556	8110	0	858.53	1068.71	1278.89
				20	25	362.42	13049	9344	3715	0	572.6	782.78	992.96
	15000	0	50	50	25	999.01	16921	15000	12926	0	1209.19	1419.37	1629.55
				20	25	572.02	17172	15000	9114	0	782.2	992.38	1202.56
			75	75	25	1410.15	16907	15000	13474	0	1620.33	1830.51	2040.69
				20	25	627.33	17331	15000	7867	0	837.51	1047.69	1257.87
	7500	7500	50	50	25	832.96	15898	13831	11728	0	1043.14	1253.32	1463.5
				20	25	479.92	16067	13639	7843	0	690.1	900.28	1110.46
			75	75	25	1182.46	15926	13884	12332	0	1392.64	1602.82	1813
				20	25	535.23	16280	13639	6684	0	745.41	955.59	1165.77
Outbound	5000	0	50	50	25	NOM							
				20	25	NOM							
			75	75	25	NOM							
				20	25	NOM							
	2500	2500	50	50	25	NOM							
				20	25	NOM							
			75	75	25	NOM							
				20	25	NOM							
	10000	0	50	50	25	355.05	10000	7283	5610	0	565.23	775.41	985.59
				20	25	235.83	10000	5987	2524	0	446.01	656.19	866.37
			75	75	25	494.01	10000	7348	6080	0	704.19	914.37	1124.55
				20	25	NOM							
	5000	5000	50	50	25	334.06	9510	6748	5153	0	544.24	754.42	964.6
				20	25	222.36	9344	5115	2080	0	432.54	642.72	852.9
			75	75	25	466.76	9556	6867	5650	0	676.94	887.12	1097.3
				20	25	NOM							
	15000	0	50	50	25	717.9	15000	12815	10715	0	928.08	1138.26	1348.44
				20	25	412.09	15000	12323	6721	0	622.27	832.45	1042.63
			75	75	25	1012.35	15000	12841	11285	0	1222.53	1432.71	1642.89
				20	25	451.7	15000	11985	5401	0	661.88	872.06	1082.24
	7500	7500	50	50	25	598.97	13831	11505	9443	0	809.15	1019.33	1229.51
				20	25	346.13	13639	10635	5419	0	556.31	766.49	976.67
			75	75	25	849.28	13884	11597	10061	0	1059.46	1269.64	1479.82
				20	25	385.74	13639	10148	4194	0	595.92	806.1	1016.28
	20000	0	50	50	25	1963.95	20000	18628	16880	0	2174.13	2384.31	2594.49
				20	25	1017.39	20000	18515	13044	0	1227.57	1437.75	1647.93
			75	75	25	2792.37	20000	18634	17386	0	3002.55	3212.73	3422.91
				20	25	1057	20000	18436	11579	0	1267.18	1477.36	1687.54
	10000	10000	50	50	25	1131.57	17574	15754	13717	0	1341.75	1551.93	1762.11
				20	25	594.12	17394	15274	9385	0	804.3	1014.48	1224.66
			75	75	25	1619.07	17623	15825	14334	0	1829.25	2039.43	2249.61
				20	25	633.73	17394	15081	7942	0	843.91	1054.09	1264.27

4.0 ANALYSIS

This chapter analyzes the data from the previous two chapters to discover what type of aborts can be obtained at "reasonable" cost, and which mission type allows the best abort scenario for the least IMLEO.

First the delta-Vs required to obtain various speeds of Earth return are compared for the mission types under consideration, and then the trajectory data is combined with the mass study results to discover which missions allow the fastest aborts for the least initial mass to low Earth orbit (IMLEO).

4.1 Analysis of abort trajectories across mission types

Table 4.1 shows, for each mission, the total delta-V necessary so that the desired return to Earth (RTE) time is available for the duration of that phase of the mission (i.e. the maximum total delta-V for that RTE over that phase). It also shows the total delta-V which must be available throughout the entire mission for the given RTE time to be available for the duration of the entire Earth-Mars-Earth mission, which is the largest of the individual phases' maximum delta-Vs for that RTE time.

The table also shows for each mission phase the mission type which requires the lowest total delta-V for each RTE time, as well as the delta-Vs in question.

Empty entries on inbound abort rows represent cases where an inbound abort taking that long would return the crew to Earth after the nominal mission would have, and so were not considered. The "anomaly spikes" (see 2.4) encountered on the total abort delta-V versus days from Earth curves for some RTEs have been smoothed out by noting that in most cases the delta-V for an abort from the same mission point with the next fastest RTE time is lower than the "spike" delta-V, and then replacing the "spike" delta-V with this lower delta-V. In cases where the next fastest abort from the same point is not less expensive, the total delta-V required for an abort with the next fastest RTE time from the point a time step later was, and the "spike" delta-V was replaced with this delta-V. Since the time steps are always less than the 20 days between RTE times, the time to Earth since the decision is made to abort remains less than the original RTE time. The option of using a faster abort, or of waiting a few days before aborting to be able to acquire a faster abort for

Table 4.1: Total ΔV required for RTE to be available over entire duration of phase, km/sec

Mission	Phase	Abort RTE speed to be available during entire phase, in days												
		10	30	50	70	90	110	130	150	170	190	210	230	250
2015 Venus	outbound	767.734	87.791	54.885	40.32	31.382	24.969	20.014	20.014	13.589	10.084	8.048	7.013	6.254
	from Mars	324.531	108.068	64.885	45.482	33.673	25.519	21.876	18.382	11.282	8.581	6.85	6.163	6.163
	inbound before Venus	435.856	139.227	79.291	52.433	37.188	39.693	38.87	15.697	10.657	6.919	4.074	4.897	5.881
	inbound after Venus	69.104	10.331	1.625										
	overall	767.734	139.227	79.291	52.433	37.188	39.693	38.87	20.014	13.589	10.084	8.048	7.013	6.254
2015 DSM	outbound	764.434	84.983	53.347	39.432	30.953	24.812	20.036	18.41	13.398	10.102	8.166	7.151	6.349
	from Mars	314.559	104.654	62.85	44.126	32.734	24.83	20.384	18.238	11.03	8.37	6.674	5.999	6.713
	inbound before DSM	441.953	141.638	80.292	53.019	37.544	27.663	30.584	15.761	10.944	7.341	6.003	7.572	10.264
	inbound after DSM	281.747	76.581	33.982	15.254	5.869	7.033	10.122	6.31	1.539	0.687			
	overall	764.434	141.638	80.292	53.019	37.544	27.663	30.584	18.41	13.398	10.102	8.166	7.572	10.264
2015 2BLO	outbound	864.015	265.547	140.074	85.852	49.515	39.813	32.491	26.351	21.248	17.156	14.612	13.411	12.651
	from Mars	862.592	51.82	25.456	16.908	12.687	10.106	8.167	6.642	5.39	5.457	3.646	3.163	3.47
	inbound	161.422	47.937	25.391	15.808	10.422	7.1	4.462	2.213					
	overall	864.015	265.547	140.074	85.852	49.515	39.813	32.491	26.351	21.248	17.156	14.612	13.411	12.651
2014 ME	outbound	475.31	161.949	97.652	68.435	50.568	39.485	40.817	26.005	20.492	17.411	10.329	9.176	12.23
	from Mars	897.336	278.279	153.515	99.865	75.445	58.605	50.95	50.304	49.253	51.535	53.27	58.559	58.498
	inbound	894.531	276.586	151.863	100.134	46.083	31.397	20.605	12.372	6.038	1.231	0.38	0.21	
	overall	897.336	278.279	153.515	100.134	75.445	58.605	50.95	50.304	49.253	51.535	53.27	58.559	58.498
2015 2BSO	outbound	423.731	146.447	90.38	64.806	49.158	38.302	35.308	26.672	18.846	18.805	11.799	9.769	10.016
	from Mars	495.435	164.421	96.832	65.822	47.311	47.311	30.417	19.555	14.845	11.667	10.103	10.708	14.894
	inbound	570.316	183.058	103.937	69.019	53.262	36.811	25.418	17.958	12.162	7.509			
	overall	570.316	183.058	103.937	69.019	53.262	47.311	35.308	26.672	18.846	18.805	11.799	10.708	14.894
Least expensive total ΔV for RTE and phase, km/sec														
	outbound	423.731	84.983	53.347	39.432	30.953	24.812	20.014	18.41	13.398	10.084	8.048	7.013	6.254
	Mars	314.559	51.82	25.456	16.908	12.687	10.106	8.167	6.642	5.39	5.457	3.646	3.163	3.47
	inbound	161.422	47.937	25.391	15.808	10.422	7.1	4.462	2.213	6.038	1.231	0.38	0.21	5.881
Mission with least expensive total ΔV for RTE and phase														
	outbound	2015 2BSO	2015 DSM	2015 DSM	2015 DSM	2015 DSM	2015 DSM	2015 Venus	2015 DSM	2015 DSM	2015 Venus	2015 Venus	2015 Venus	2015 Venus
	Mars	2015 DSM	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO
	inbound	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2015 2BLO	2014 ME	2014 ME	2014 ME	2015 Venus

less delta-V, was also exercised in cases without "spike" delta-Vs where an abort was seen to have a delta-V lower than that of a slower abort.

The 2 burn long leg outbound (2BLO) mission has the the abort from Mars orbit with the lowest maximum total delta-V in each RTE slot, but the deep space maneuver (DSM) and Venus swingby missions, with nearly identical delta-V requirements, share the honors for outbound aborts. These two missions leave Earth within 2 days of each other, arrive at Mars within 5 days of each other and stay the same amount of time at Mars. The reason aborts from Mars are more expensive for these missions than for the 2BLO mission is that they arrive at Mars later, during a period in which Earth-Mars phasing is worsening (see 2.5.2). Minimum energy missions' aborts from Mars are extremely expensive, because their Mars stays keep the vehicle at Mars throughout the negative phasing period until alignment becomes favorable again, resulting in high total delta-V requirements if a certain speed of return must be available over the entire stay.

In a situation where one mission type has a superior capability for abort in one phase and another mission type has a superior capability for another phase, the best mission for abort capability can be assembled by using each mission type for the phase in which it is superior.

Unfortunately, the delta-V required for an abort from Mars orbit is set not by the type of mission, but by the date the abort occurs, and the 2BLO mission leaves Mars before the Venus swingby or deep space maneuver missions arrive, so these mission types cannot be combined to assemble a mission which has the superior capability while outbound and at Mars.

The differences by which the delta-Vs necessary for aborts from Mars orbit during the 2BLO mission are better than those required for aborts from Mars orbit during the Venus swingby or DSM missions are, for each RTE rate, lower than the differences by which the Venus swingby and DSM missions have the advantage in delta-Vs required for outbound aborts. However, since the cost in IMLEO of a mission is controlled not only by the delta-V required to achieve a desired abort capability, but is also a function of the delta-V already available during each phase of the nominal mission, as well as the nominal mission IMLEO, these delta-V figures alone do not allow any conclusion to be drawn as to which mission type is superior. This would not matter if the mission with the lower abort delta-Vs were also the mission with lower

nominal IMLEOs and higher nominal mission abort delta-Vs available, but this is not the case.

The comparison of inbound abort figures is less straightforward than the comparison of outbound and Mars orbit abort figures. Missions with shorter nominal inbound trips will have lower inbound abort delta-Vs for a given RTE trip than other missions, since they must reduce the remaining trip time by less to acquire the RTE time. This is why the 2BLO mission has the lowest inbound abort delta-Vs for every RTE category; the only reason other missions replace it for the longer inbound aborts is that 190 day aborts make little sense when the nominal inbound leg is 176 days long.

However, the low abort delta-Vs required for high-energy inbound trajectories mask a hidden cost - the high delta-V paid to enter the high-energy nominal inbound trajectory. This makes the mission total delta-V for a high-energy inbound trajectory with an inexpensive abort capability similar to that of lower-energy inbound trajectories which require higher abort delta-Vs to acquire the same abort capability.

4.2 Analysis of abort capability vs mission IMLEOs

It has been shown in chapter 3 that although a mission's abort capability can be characterized by the delta-V required to return to Earth in a given amount of time from each point during the mission, the cost of acquiring such a capability cannot be compared from mission to mission using these delta-Vs as a basis for comparison. The cost in IMLEO of acquiring a certain delta-V is not the same for all missions; which mission offers a certain capability for the least IMLEO may even change when the configuration or architecture assumptions are altered.

The data generated by the mass studies in chapter 3 is not well suited to discussion. For each mission and abort type, the parameters are a function of 4 variables, none of which is varied over more than 3 points. This makes presentation of the data in a two-dimensional media for easy comparison difficult.

The nominal and abort transfer vehicles' masses are what govern the variation in IMLEO once abort capabilities are specified. If the abort capability

specified is large enough, the amount of excess fuel required for the abort burns overwhelms the amount of extra fuel which must be carried to change the sample return mass from 0 to 50 tons, making variation of that parameter irrelevant. The abort delta-Vs available at each mission phase become insensitive to the variation in samples mass at the same point, and are insensitive to variations in the cargo payload in all cases.

Therefore, to provide a clearer picture for study, all the cases examined by the rest of this chapter will have the same cargo payload and samples mass. Both variables are set in the middle of their range: 200 metric tons of cargo and 25 metric tons of samples.

There is no alteration in the abort delta-Vs available during mission phases if the cargo payload is altered. The variation in total IMLEO if the cargo payload is increased or decreased is very simple, adding to the cargo mission the extra payload and an amount of fuel sufficient to send that extra cargo to Mars on a minimum energy trajectory. Although this difference comes to as much as 400 tons between 100 to 300 tons cargo payload, the variation is simple, and the trend of the relative change in IMLEO as the other parameters vary is the same for cases with different cargo masses.

If the mass of the samples to be returned is increased while the abort capability is still low enough that it affects the results, the cargo IMLEO will rise for split fuel missions, and the piloted IMLEO will rise for all fuel piloted missions. The abort delta-Vs available after cargo mission rendezvous will rise (unless none was previously available, indicating no fuel carried through that phase), and for all fuel piloted missions the outbound abort delta-V available will rise. The nominal mission delta-V available from Mars, if higher than the nominal trans-Earth injection delta-V, will fall.

If the samples mass to be returned is reduced, the variations go in the opposite direction.

The results of the mass studies for these selected cases are contained in the following Tables 4.3-4.5.

Table 4.2 contains the performance data for the nominal missions, in the same categories as the data in the mass study tables (see 3.6)

Tables 4.3 to 4.5 present the IMLEOs required to make available specified total abort delta-Vs in each mission phase for the three missions studied in depth (from Tables 3.3-3.11),. They also show the fastest RTE which is available

Table 4.2: Performance data for selected nominal missions

Isp=925 sec Cargo=200 MT Samples= 25 MT

Split fuel missions

Mission	Transfer vehicles nominal	Transfer vehicles abort	piloted	IMLEOs cargo	TOTAL	ΔVs available during each mission phase: Outbound	From Mars before rendezvous	From Mars after rendezvous	Inbound before DSM	Inbound after DSM
2015 Venus	50	50	158.05	610.02	768.07	3014	0	6370	0	0
	50	20	158.05	610.02	768.07	5272	0	9809	0	0
	75	75	223.57	653.59	877.16	3049	0	5937	0	0
	75	20	223.57	653.59	877.16	6791	0	11138	0	0
2015 DSM	50	50	160.17	703.15	863.32	3159	0	8465	3710	0
	50	20	160.17	703.15	863.32	5491	0	12226	6298	0
	75	75	221.79	771.35	993.14	3196	0	7954	3422	0
	75	20	221.79	771.35	993.14	7046	0	13571	7430	0
2014 Min. Energy	50	50	131.75	502.59	634.34	2687	0	2725	0	0
	50	20	131.75	502.59	634.34	4771	0	4830	0	0
	75	75	187.06	516.25	703.31	2719	0	2498	0	0
	75	20	187.06	516.25	703.31	6202	0	5793	0	0
2014 2BSO	50	50	136.75	843.2	979.95	3262	0	11520	5806	5806
	50	20	136.75	843.2	979.95	5645	0	15346	9112	9112
	75	75	194.58	967.05	1161.63	3300	0	11026	5464	5464
	75	20	194.58	967.05	1161.63	7224	0	16655	10507	10507
2015 2BLO	50	50	301.3	617.69	918.99	4292	0	6703	0	0
	50	20	301.3	617.69	918.99	7119	0	10211	0	0
	75	75	428.1	665.9	1094	4339	0	6280	0	0
	75	20	428.1	665.9	1094	8890	0	11579	0	0

All fuel piloted missions

Isp=925 sec Cargo=200 MT Samples= 25 MT

Mission	Transfer vehicles nominal	Transfer vehicles abort	piloted	IMLEOs cargo	TOTAL	ΔVs available during each mission phase: Outbound	From Mars before rendezvous	From Mars after rendezvous	Inbound before DSM	Inbound after DSM
2015 Venus	50	50	356.53	442.47	799	9321	6370	0	0	
	50	20	356.53	442.47	799	13145	9809	0	0	
	75	75	473.67	442.47	916.14	8892	5937	0	0	
	75	20	473.67	442.47	916.14	14583	11138	0	0	
2015 DSM	50	50	474.16	442.47	916.63	11425	8465	3710	0	
	50	20	474.16	442.47	916.63	15255	12226	6298	0	
	75	75	622.93	442.47	1065.4	10927	7954	3422	0	
	75	20	622.93	442.47	1065.4	16566	13571	7430	0	
2014 Min. Energy	50	50	218.31	420.36	638.67	5823	2725	0	0	
	50	20	218.31	420.36	638.67	9132	4830	0	0	
	75	75	287.99	420.36	708.35	5499	2498	0	0	
	75	20	287.99	420.36	708.35	10554	5793	0	0	
2014 2BSO	50	50	602.1	420.36	1022.46	14227	11520	5806	5806	
	50	20	602.1	420.36	1022.46	17779	15346	9112	9112	
	75	75	796.23	420.36	1216.59	13776	11026	5464	5464	
	75	20	796.23	420.36	1216.59	18930	16655	10507	10507	
2015 2BLO	50	50	702.99	442.47	1145.46	10776	6703	0	0	
	50	20	702.99	442.47	1145.46	14626	10211	0	0	
	75	75	940.29	442.47	1382.76	10375	6270	0	0	
	75	20	940.29	442.47	1382.76	16055	11579	0	0	

Table 4.3: 2015 DSM selected mission abort capability mass impacts

Isp=925 sec Cargo=200 MT Samples=25 MT

Total IMLEOs for specified missions with set abort capabilities, in mT

Mission type			SF	SF	SF	SF	AFP	AFP	AFP	AFP	RTE available over entire phas for set ΔV (days)
Nominal transfer vehicle			50	50	75	75	50	50	75	75	
Abort transfer vehicle			50	20	75	20	50	20	75	20	
Abort Type	Abort ΔVs, km/sec insertion	braking									
No aborts (nominal mission)			863.32	863.32	993.14	993.14	916.63	916.63	1065.4	1065.4	
Outbound/Pilote	5	0	879.89	870.08	1021.41	1003.44	nom	nom	nom	nom	none
	2.5	2.5	879.07	869.43	1020.45	1002.79	nom	nom	nom	nom	none
	10	0	1003.02	888.81	1231.57	1022.16	nom	nom	nom	nom	191.054
	5	5	968.51	885.46	1186.75	1018.81	nom	nom	nom	nom	191.054
	15	0	1625.57	1111.26	2120.79	1177.88	1247.13	nom	1581.43	nom	163.607
	7.5	7.5	1425.56	1000.33	1846.54	1066.95	1112.1	nom	1396.29	nom	163.607
	20	0	3649.17	2092.37	5011.65	2157.51	2661.83	1587.15	3602.36	1632.12	130.443
	10	10	2280.16	1396.21	3081.94	1461.36	1716.79	1106.59	2270.26	1151.56	130.443
From Mars	5	0	nom	nom	nom	nom	nom	nom	nom	nom	none
	2.5	2.5	nom	nom	nom	nom	nom	nom	nom	nom	none
	10	0	944.39	nom	1148.25	nom	1018.53	nom	1252.24	nom	177.744
	5	5	915.09	nom	1110.2	nom	983.24	nom	1206.41	nom	177.744
	15	0	1454.56	1027.57	1877.01	1094.19	1628.78	1114.47	2128	1181.09	158.984
	7.5	7.5	1288.51	935.47	1649.32	1002.09	1428.77	1003.54	1849.75	1070.16	158.984
	20	0	3190.87	1869.2	4357.41	1934.35	3724.43	2132.47	5117.69	2199.1	133.579
	10	10	2028.64	1278.19	2719.16	1343.34	2324.52	1420.6	3144.4	1487.22	133.579
Inbound	5	0	1099.1	976.04	1334.99	1109.39	1197.84	1049.62	1470.17	1198.39	none
	2.5	2.5	1088.82	967.91	1322.93	1101.25	1185.47	1039.82	1455.61	1188.59	none
	10	0	1582.7	1210.96	2025.83	1344.3	1780.34	1332.58	2302.25	1481.35	175.24
	5	5	1517.28	1168.99	1940.87	1302.33	1701.54	1282.03	2199.91	1430.8	175.24
	15	0	2717.64	1764.1	3647.08	1898.92	3143.13	1994.58	4249.02	2143.36	153.16
	7.5	7.5	2346.81	1558.44	3138.61	1693.26	2696.46	1746.86	3636.56	1895.64	153.16
	20	0	6599.41	3647.94	9192.32	3781.23	7823	4267.94	10934.32	4416.71	144.281
	10	10	4003.98	2328.14	5533.87	2461.49	4696.79	2678.23	6527.69	2827	144.281

Table 4.4: 2015 Venus swingby selected mission abort capability mass impacts

Isp=925 sec Cargo=200 MT Samples=25 MT

Total IMLEOs for specified missions with set abort capabilities, in mT

Mission type			SF	SF	SF	SF	AFP	AFP	AFP	AFP	RTE available over entire phase for set ΔV (days)
Nominal transfer vehicle			50	50	75	75	50	50	75	75	
Abort transfer vehicle			50	20	75	20	50	20	75	20	
Abort Type	Abort ΔVs, km/sec insertion	braking									
No aborts (nominal mission)			768.07	768.07	877.16	877.16	799	799	916.14	916.14	
Outbound/Piloted	5	0	788.93	818.75	911.51	887.84	nom	nom	nom	nom	none
	2.5	2.5	788.08	778.09	905.51	887.18	nom	nom	nom	nom	none
	10	0	1001.06	803.86	1230.92	907.28	831.56	nom	989.59	nom	190.83
	5	5	966.36	794.71	1185.85	903.77	807.7	nom	nom	nom	190.83
	15	0	1601.25	1095.42	2088.3	1160.94	1244.19	896.43	1579.03	941.48	161.22
	7.5	7.5	1404.54	986.32	1818.57	1051.84	1108.95	821.42	1393.59	nom	161.22
	20	0	3662.34	2096.64	5032.61	2162.16	2661.18	1584.76	3603.23	1629.81	130.0872
	10	10	2662.89	1396.51	3091.87	1462.03	1714.61	1103.43	2286.98	1148.47	130.0872
From Mars	5	0	nom	nom	nom	nom	nom	nom	nom	nom	none
	2.5	2.5	nom	nom	nom	nom	nom	nom	nom	nom	none
	10	0	940.22	773.76	1144.47	nom	1002.94	805.74	1232.79	nom	179.49
	5	5	910.93	nom	1106.42	nom	968.23	nom	1187.72	nom	179.49
	15	0	1446.87	1019.87	1868.22	1085.39	1603.13	1097.29	2090.18	1162.81	159.53
	7.5	7.5	1280.81	927.78	1640.53	993.3	1406.41	988.19	1820.44	1053.72	159.53
	20	0	3186.71	1865.04	4353.62	1930.56	3664.21	2098.51	5034.48	2164.03	140.73
	10	10	2024.47	1274.03	2715.36	1339.55	2287.38	1398.38	3093.74	1463.9	140.74
Inbound	5	0	959.65	861.14	1150.84	970.23	1019.04	902.33	1233.43	1019.47	203.49
	2.5	2.5	951.43	854.63	1141.19	963.72	1009.29	894.61	1221.99	1011.75	203.49
	10	0	1346.81	1049.21	1703.9	1158.3	1477.67	1125.12	1888.61	1242.26	173.52
	5	5	1294.67	1015.61	1635.89	1124.7	1415.63	1085.32	1808.03	1202.46	173.52
	15	0	2252.58	1489.21	2997.82	1598.3	2550.68	1646.36	3421.42	1763.5	152.77
	7.5	7.5	1955.71	1324.56	2590.75	1433.65	2189.99	1451.32	2939.2	1571.45	152.77
	20	0	5363.04	3000.18	7441.18	3109.27	6235.45	3436.62	8685.19	3553.46	146.29
	10	10	3285.21	1943.58	4512.33	2052.68	3773.98	2184.64	5215.57	2301.78	146.29

Table 4.5: 2014 minimum energy selected mission abort capability mass impacts

Isp=925 sec Cargo=200 MT Samples=25 MT

Total IMLEOs for specified missions with set abort capabilities, in mT

Abort Type	Abort ΔVs, km/sec insertion	braking	SF	SF	SF	SF	AFP	AFP	AFP	AFP	RTE available over entire phase for set ΔV (days)
Mission type			SF	SF	SF	SF	AFP	AFP	AFP	AFP	
Nominal transfer vehicle			50	50	75	75	50	50	75	75	
Abort transfer vehicle			50	20	75	20	50	20	75	20	
Outbound/Piloted	5	0	694.62	639.51	795.85	706.19	nom	nom	nom	nom	none
	2.5	2.5	690.02	637.05	790.45	706.01	nom	nom	nom	nom	none
	10	0	911.18	744.71	1105.21	800.02	775.41	656.19	914.37	nom	215.7
	5	5	881.88	725.92	1067.16	781.23	754.42	642.72	887.12	nom	215.7
	15	0	1417.82	990.83	1828.96	1046.13	1138.26	832.45	1432.71	872.06	196.81
	7.5	7.5	1251.76	898.73	1601.27	954.04	1019.33	766.49	1269.64	806.1	196.81
	20	0	3157.66	1835.99	4314.36	1891.3	2384.31	1437.75	3212.73	1477.36	173.2
	10	10	1995.43	1244.98	2676.1	1300.29	1551.93	1014.48	2039.43	1054.09	173.2
From Mars	5	0	688.97	636.62	787.91	nom	696.17	641.07	797.4	nom	none
	2.5	2.5	684.6	nom	782.78	nom	691.57	nom	792	nom	none
	10	0	894.71	736.56	1081.8	791.87	912.73	746.26	1106.76	801.57	none
	5	5	866.87	718.7	1045.66	774.01	883.43	727.47	1068.71	782.78	none
	15	0	1376.03	970.37	1769.38	1025.68	1419.37	992.38	1830.51	1047.69	none
	7.5	7.5	1218.27	882.88	1553.07	938.19	1253.32	900.28	1602.82	955.59	none
	20	0	3028.92	1773.3	4130.57	1828.61	3159.21	1837.54	4315.92	1892.85	none
	10	10	1924.77	1211.83	2574.19	1267.14	1996.98	1246.54	2677.66	1301.84	none
Inbound	5	0	762.6	696.65	886.53	765.61	767.83	698.41	895.37	768.09	174.3
	2.5	2.5	757.09	692.29	880.06	761.25	762.04	693.82	888.56	763.5	174.3
	10	0	1021.79	822.55	1256.78	891.52	1040.66	830.94	1285.1	900.62	157.5
	5	5	986.73	800.06	1211.25	869.02	1003.75	807.26	1237.17	876.94	157.5
	15	0	1628.17	1117.12	2123.02	1186.08	1678.94	1141	2196.91	1210.68	143.6
	7.5	7.5	1429.43	1006.89	1850.5	1075.86	1469.74	1024.98	1910.05	1094.66	143.6
	20	0	3710.53	2128.67	5097.7	2197.63	3870.85	2205.77	5238.09	2275.45	131.5
	10	10	2319.49	1421.31	3136.93	1490.27	2406.63	1461.2	3264.17	1530.88	131.5

interpolation on Table 4.1. Recall that this is the slowest RTE which can be obtained using fuel amounts which allow a single burn the size of the total delta-V in question - if the fuel is used for an insertion and braking burn, a higher total delta-V can be obtained, and with it a faster RTE (see 3.3.2).

For each total delta-V, the IMLEO is shown for both the case of the total delta-V being all insertion burn and the case of the total delta-V being divided into half insertion delta-V and half braking delta-V, giving the maximum and minimum IMLEO, respectively, necessary for that total delta-V to be available during the entire mission phase. As in the mass study tables, an entry of "nom" indicates that a total delta-V equal to or greater than that specified is available to the nominal mission.

The RTE times specified are available over the entire mission phase, so the entries that say "none" do not necessarily mean that at no time in that phase can an abort of any speed be had for that delta-V, but rather that for some range of time in that phase, the specified delta-V is insufficient to enter any Earth-intercept trajectory.

Tables 4.6 and 4.7 combine the results of Tables 4.1-4.5 to show the IMLEOs required to have available certain RTEs over the duration of each mission phase for each mission type. Shown for each mission are the lengths of Earth return time in each phase matching the delta-Vs in those phases specified in the mass studies, and the minimum and maximum IMLEOs required to obtain each RTE length. For Table 4.6, the piloted abort has been separated into its components, outbound abort and abort from Mars orbit before cargo mission rendezvous. Note that the IMLEOs for these two abort types are the same, but the RTE times available in each phase for that IMLEO are different, due to the presence of the MOI fuel while outbound.

The tables show for each case the IMLEO for the nominal mission, and the abort RTEs available to the nominal mission during each mission phase.

For the 2BSO and 2BLO missions only the nominal mission IMLEOs and delta-Vs available are shown, because the high IMLEOs of these missions allow their use to be ruled out based solely on the performance of the nominal missions.

Recall that aborts from Mars orbit consist of braking burns roughly 9

Table 4.6: IMLEO required to offer set RTE speed throughout mission phases, split fuel missions

RTE in days, IMLEO in mT

Split fuel mission: transfer vehicle 50 mT, abort vehicle 50 mT

Mission		2015 DSM			2015 Venus			2014 Min. Energy			2015 2BLO		2015 2BSO
Phase	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	RTE	IMLEO-min
Nominal mission		863.32	863.32		768.07	768.07		634.34	634.34		918.99		979.95
outbound	none			none			none			none		none	
from Mars after	189.29			223.97			none			149.2		191.88	
inbound	none			none			none			none		none	
Outbound	214.67	870.08	879.89	191.8	788.08	818.75	205.59	881.88	911.18				
	176.72	968.51	1003.02	178.11	966.36	1001.06	194.45	1251.76	1417.82				
	158.95	1425.56	1625.57	162.29	1404.54	1601.25	179.05	1995.43	3157.66				
	138.54	2321.3	3721.22	152.32	2662.89	3662.34							
From Mars	177.744	968.51	1003.02	179.49	966.36	1001.06	none	881.88	911.18				
before linkup	158.984	1425.56	1625.57	159.53	1404.54	1601.25	none	1251.76	1417.82				
	133.579	2280.16	3649.17	140.74	2662.89	3662.34	none	1995.43	3157.66				
From Mars	177.744	915.09	944.39	179.49	910.93	940.22	none						
after linkup	158.984	1288.56	1454.56	159.53	1280.81	1446.87	none						
	133.579	2028.64	3190.87	140.74	2024.47	3186.71	none						
Inbound	175.24	1517.28	1582.7	203.49	951.43	959.65	174.3	757.09	762.6				
	153.16	2346.81	2717.64	173.52	1294.67	1346.81	157.5	986.73	1021.79				
	144.281	4003.98	6599.41	152.77	1955.71	2252.58	143.6	1429.43	1628.17				
				146.29	3285.21	5363.04	131.5	2319.49	3710.53				

Split fuel mission: transfer vehicle 50 mT, abort vehicle 20 mT

Mission		2015 DSM			2015 Venus			2014 Min. Energy			2015 2BLO		2015 2BSO
	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	RTE	IMLEO-min
Nominal mission		863.32	863.32		768.07	768.07		634.34	634.34		918.99		979.95
outbound	none			none			none			none		none	
from Mars after	166.68			180.91			none			109.19		167.87	
inbound	205.59	(before DSM only)		none			none			none		183.11	
Outbound	199.61	869.93	870.08	200.75	778.09	818.75	204.31	725.92	744.71				
	173.49	885.46	888.81	175.2	794.71	803.86	194.15	898.73	990.83				
	158.38	1000.3	1111.3	161.88	986.32	1095.42	179.33	1244.98	1835.99				
	138.87	1396.2	2092.4	152.42	1396.51	2096.64							
From Mars	177.744	885.46	888.81	179.49	794.71	803.86	none						
before linkup	158.984	1000.3	1111.3	159.53	986.32	1095.42	none						
	133.579	1396.2	2092.4	140.74	1396.51	2096.64	none						
From Mars	177.744	nom	nom	179.49	nom	773.76	none						
after linkup	158.984	935.47	1027.6	159.53	927.78	1019.87	none						
	133.579	1278.2	1869.2	140.74	1274.03	1865.04	none						
Inbound	175.24	1169	1211	203.49	854.63	861.14	174.3	692.29	696.65				
	153.16	1558.4	1764.1	173.52	1015.61	1049.21	157.5	800.06	822.55				
	144.281	2328.1	3647.9	152.77	1324.56	1489.21	143.6	1006.89	1117.12				
				146.29	1943.58	3000.18	131.5	1421.31	2128.67				

Table 4.6: IMLEO required to offer set RTE speed throughout mission phases, split fuel missions

Split fuel mission: transfer vehicle 75 mT, abort vehicle 75 mT

Mission	2015 DSM			2015 Venus			2014 Min. Energy			2015 2BLO		2015 2BSO	
	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	RTE	IMLEO-min
Nominal mission		993.14	993.14		877.16	877.16		703.31	703.31		1094		1161.63
outbound	none			none			none			none		none	
from Mars after	194.91			none			none			109.19		167.87	
inbound	none			none			none			none		183.11	
Outbound	214.14	1020.45	1021.41	214.46	905.51	911.51	205.47	1067.16	1105.21				
	176.46	1186.8	1231.6	177.86	1185.85	1230.92	194.32	1601.27	1828.96				
	158.77	1846.5	2120.8	162.15	1818.57	2088.3	178.78	2676.1	4314.36				
	138.04	3081.9	5011.7	152.2	3091.87	5032.61							
From Mars	177.744	1186.8	1231.6	179.49	1185.85	1230.92	none						
before linkup	158.984	1846.5	2120.8	159.53	1818.57	2088.3	none						
	133.579	3081.9	5011.7	140.74	3091.87	5032.61	none						
From Mars	177.744	1110.2	1148.3	179.49	1106.42	1144.47	none						
after linkup	158.984	1649.3	1877	159.53	1640.53	1868.22	none						
	133.579	2719.2	4357.4	140.74	2715.36	4353.62	none						
Inbound	175.24	1940.9	2025.8	203.49	1141.19	1150.84	174.3	880.06	886.53				
	153.16	3138.6	3647.1	173.52	1635.89	1703.9	157.5	1211.25	1256.78				
	144.281	5533.9	9192.3	152.77	2590.75	2997.82	143.6	1850.5	2123.02				
				146.29	4512.33	7441.18	131.5	3136.93	5097.7				

Split fuel mission, transfer vehicle 75 mT, abort vehicle 20 mT

Mission	2015 DSM			2015 Venus			2014 Min. Energy			2015 2BLO		2015 2BSO	
	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO	RTE	IMLEO
Nominal mission		993.14	993.14		877.16	877.16		703.31	703.31		1094		1161.63
outbound	232.62			235.85			none			none		none	
from Mars after	162.95			171.07			none			98.59		162.31	
inbound	189.51	(before DSM only)		none			none			none		183.11	
Outbound	189.98	1002.79	1003.44	191.82	877.16	887.84	225.68	706.01	706.19				
	170.4	1018.8	1022.2	172.38	903.77	907.28	203	781.23	800.02				
	157.42	1067	1177.9	161.15	1051.84	1160.94	193.53	954.04	1046.13				
	138.68	1461.4	2157.5	152.13	1462.03	2162.16	178.76	1300.29	1891.3				
From Mars	177.744	1018.8	1022.2	179.49	903.77	907.28	none						
before linkup	158.984	1067	1177.9	159.53	1051.84	1160.94	none						
	133.579	1461.4	2157.5	140.74	1462.03	2162.16	none						
From Mars	177.744	nom	nom	179.49	nom	nom	none						
after linkup	158.984	1002.1	1094.2	159.53	993.3	1085.39	none						
	133.579	1343.3	1934.4	140.74	1339.55	1930.56	none						
Inbound	175.24	1302.3	1344.3	203.49	963.72	970.23	174.3	761.25	765.61				
	153.16	1693.3	1898.9	173.52	1124.7	1158.3	157.5	869.02	891.52				
	144.281	2461.5	3781.2	152.77	1433.65	1598.3	143.6	1075.86	1186.08				
				146.29	2052.68	3109.27	131.5	1490.27	2197.63				

Table 4.7: IMLEO required to offer set RTE speed throughout mission phases, all fuel piloted missions

RTE in days, IMLEO in mT

All fuel piloted mission: transfer vehicle 50 mT, abort vehicle 50 mT

Mission		2015 DSM			2015 Venus			2014 Min. Energy			2015 2BLO		2015 2BSO
Phase	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	RTE	IMLEO-min
Nominal mission		916.63	916.63		799	799		638.67	638.67		918.99		979.95
outbound	181.97			197.5			none			none		none	
from Mars	189.29			223.97			none			149.2		191.88	
Inbound	none			none			none			none		none	
Outbound	191.054	nom	nom	190.83	807.7	831.56	215.7	754.42	775.41				
	163.607	1112.1	1247.1	161.22	1108.95	1244.19	196.81	1019.33	1138.26				
	130.433	1716.8	2661.8	130.09	1714.61	2661.18	173.2	1551.93	2384.31				
From Mars	177.744	983.24	1018.5	179.49	968.23	1002.94	none						
	158.984	1428.8	1628.8	159.53	1406.41	1603.13	none						
	133.579	2324.5	3724.4	140.74	2287.38	3664.21	none						
Inbound	175.24	1701.5	1780.3	203.49	1009.29	1019.04	174.3	762.04	767.83				
	153.16	2696.5	3143.1	173.52	1415.63	1477.67	157.5	1003.75	1040.66				
	144.281	4696.8	7823	152.77	2189.99	2550.68	143.6	1469.74	1678.94				
				146.29	3773.98	6235.45	131.5	2406.63	3870.85				

All fuel piloted mission: transfer vehicle 50 mT, abort vehicle 20 mT

Mission		2015 DSM			2015 Venus			2014 Min. Energy			2015 2BLO		2015 2BSO
	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	RTE	IMLEO-min
Nominal mission		916.63	916.63		799	799		638.67	638.67		918.99		979.95
outbound	162.59			172.53			230.76			none		none	
from Mars	166.68			180.91			none			109.19		167.87	
Inbound	205.59	(before DSM only)		none			none			none		183.11	
Outbound	191.054	nom	nom	190.83	nom	nom	215.7	642.72	656.19				
	163.607	nom	nom	161.22	821.42	896.43	196.81	766.49	832.45				
	130.433	1106.59	1587.15	130.09	1103.43	1584.76	173.2	1014.48	1437.75				
From Mars	177.744	nom	nom	179.49	nom	805.74	none						
	158.984	1003.54	1114.47	159.53	988.19	1097.29	none						
	133.579	1420.6	2132.47	140.74	1398.38	2098.51	none						
Inbound	175.24	1282.03	1332.58	203.49	894.61	902.33	174.3	693.82	698.41				
	153.16	1746.86	1994.58	173.52	1085.32	1125.12	157.5	807.26	830.94				
	144.281	2678.23	4267.94	152.77	1451.32	1646.36	143.6	1024.98	1141				
				146.29	2184.64	3436.62	131.5	1461.2	2205.77				

Table 4.7: IMLEO required to offer set RTE speed throughout mission phases, all fuel piloted missions

All fuel piloted mission: transfer vehicle 75 mT, abort vehicle 75 mT

Mission	2015 DSM			2015 Venus			2014 Min. Energy			2015 2BLO		2015 2BSO	
	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	RTE	IMLEO-min
Nominal mission		1065.4	1065.4		916.14	916.14		708.35	708.35		1094		1161.63
outbound	184.99			201.71			none			none		none	
from Mars	194.91			none			none			109.19		167.87	
Inbound	none			none			none			none		183.11	
Outbound	191.054	nom	nom	190.83	nom	989.59	215.7	887.12	914.37				
	163.607	1396.29	1581.43	161.22	1393.59	1579.03	196.81	1269.64	1432.71				
	130.433	2270.26	3602.36	130.09	2286.98	3603.23	173.2	2039.43	3212.73				
From Mars	177.744	1206.41	1252.24	179.49	1187.72	1232.79	none						
	158.984	1849.75	2128	159.53	1820.44	2090.18	none						
	133.579	3144.4	5117.69	140.74	3093.74	5034.48	none						
Inbound	175.24	2199.91	2302.25	203.49	1221.99	1233.43	174.3	888.56	895.37				
	153.16	3636.56	4249.02	173.52	1808.03	1888.61	157.5	1237.17	1285.1				
	144.281	6527.69	10934.32	152.77	2939.2	3421.42	143.6	1910.05	2196.91				
				146.29	5215.57	8685.19	131.5	3264.17	5328.09				

All fuel piloted mission: transfer vehicle 75 mT, abort vehicle 20 mT

Mission	2015 DSM			2015 Venus			2014 Min. Energy			2015 2BLO		2015 2BSO	
	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO-min	IMLEO-max	RTE	IMLEO	RTE	IMLEO
Nominal mission		1065.4	1065.4		916.14	916.14		708.35	708.35		1094		1161.63
outbound	157.36			166.91			209.36			none		none	
from Mars	162.95			171.07			none			98.59		162.31	
Inbound	189.51	(before DSM only)		none			none			none		183.11	
Outbound	191.054	nom	nom	190.83	nom	nom	215.7	nom	nom				
	163.607	nom	nom	161.22	nom	941.48	196.81	806.1	872.06				
	130.433	1151.56	1632.12	130.09	1148.47	1629.81	173.2	1054.09	1477.36				
From Mars	177.744	nom	nom	179.49	nom	nom	none						
	158.984	1070.16	1181.09	159.53	1053.72	1162.81	none						
	133.579	1487.22	2199.1	140.74	1463.9	2164.03	none						
Inbound	175.24	1430.8	1481.35	203.49	1011.75	1019.47	174.3	763.5	768.09				
	153.16	1895.64	2143.36	173.52	1202.46	1242.26	157.5	876.94	900.62				
	144.281	2827	4416.71	152.77	1571.45	1763.5	143.6	1094.66	1210.68				
				146.29	2301.78	3553.46	131.5	1530.88	2275.45				

portion of the phase near Mars. For a total delta-V to which 9 km/sec is a small variation, the insertion and braking burns will be nearly equal, and the IMLEO required to acquire the capability for these aborts will be closer to the minimum IMLEO for such a total delta-V than the maximum IMLEO.

Unfortunately, for a total delta-V of 20 km/sec, this rule of thumb gives an insertion burn/braking burn split of 14.5/5.5 km/sec, the insertion burn is substantially more expensive than the braking burn, and the IMLEO for such an abort will be closer to the maximum than the minimum IMLEO for that total delta-V. As can be seen from the tables, the maximum IMLEOs increase by at least half from the nominal IMLEO for all mission types when aborts requiring total delta-Vs of 20 km/sec are required, so aborts more energetic than that were not considered.

For total delta-Vs lower than 20 km/sec, the insertion/braking delta-V division will be slanted even more sharply toward the all insertion delta-V case, and the IMLEO will be closer to the maximum IMLEO.

Therefore, the maximum IMLEOs are used as the basis for comparison between abort capabilities.

4.2.1 Outbound Aborts

The fastest nominal mission outbound aborts are for the deep space maneuver mission, but these aborts are available only for all fuel piloted missions and for split fuel missions with the 75 ton nominal transfer vehicle (NTV) and the 20 ton abort transfer vehicle (ATV). The all fuel piloted nominal DSM missions offer RTE lengths from 157-185 days with IMLEO of 917-1065 metric tons, and the split fuel 75/20[35] nominal mission has 233 day RTE for 933 metric tons.

To improve the RTE time available to nominal transfer vehicle aborts from 180-190 days to 164 days requires 1200-1500 metric tons IMLEO for all fuel piloted missions, and for split fuel missions 1600-2100 metric tons IMLEO is required to lower the outbound abort RTE available to 160 days If the split transfer vehicle is used,

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35 This notation specifies the nominal transfer vehicle and abort transfer vehicle masses, here 75 metric tons for the nominal vehicle and 20 metric tons for the abort vehicle.

the cost is 1100 mT IMLEO to lower the RTE to 160 days for the split fuel mission, and all fuel piloted deep space maneuver missions with the split transfer vehicle have 160 day outbound abort RTE available for the nominal missions.

The nominal mission outbound abort capability for Venus swingby missions is 167-173 day RTE for split transfer vehicle all fuel piloted cases; 200 day RTE for nominal transfer vehicle aborts from the all fuel piloted missions; and 236 day RTE for the split fuel 75/20 mission. The IMLEOs of these missions are 800-900 mT. The same cases which did not have enough delta-V for an outbound abort for the nominal DSM missions lack outbound abort capability for nominal Venus swingby missions.

The outbound abort RTEs available to nominal Venus swingby missions are longer than those available to the nominal deep space maneuver missions. However, the nominal mission IMLEOs of the Venus swingby missions are lower than the IMLEOs of the nominal DSM missions by 100 or more tons, and the increased IMLEOs required for the Venus swingby missions to achieve the same outbound abort RTE times as the corresponding deep space maneuver mission are less than the nominal DSM missions' IMLEOs.

Minimum energy missions require at least 1400 mT to achieve 173 day RTE for outbound aborts in all cases. For all fuel piloted missions, 197 day outbound abort RTE can be had with 832-872 mT IMLEO for split transfer vehicle cases and 1100-1400 mT IMLEO for nominal transfer vehicle aborts. For split fuel missions the costs are 991-1046 mT IMLEO for split transfer vehicle aborts and 1400-1800 mT IMLEO for nominal transfer vehicle aborts.

The nominal 2BLO missions have an outbound abort capability of 200-210 day RTE only for all fuel piloted missions with split transfer vehicles. These missions have 1145-1383 mT IMLEO, which suggests this mission is not the one to choose to acquire outbound abort capability, as the DSM and Venus swingby missions can acquire RTE times less than 160 days for this much IMLEO.

The nominal 2BSO missions have an outbound abort capability of 200 day RTE for all fuel piloted missions with split transfer vehicles and 170-190 day

RTE for all fuel piloted mission nominal transfer vehicle aborts. These missions have 1022-1217 mT IMLEO, which removes this mission from consideration for outbound aborts, for the same reason the 2BLO mission was eliminated.

The nominal Venus swingby mission is the lightest non-minimum energy mission, and has the second-best nominal mission outbound abort capability. For all fuel piloted missions, the Venus swingby mission can match the best nominal mission outbound abort capability for less IMLEO than that mission's nominal IMLEO. For split fuel missions, acquiring an outbound abort capability requires less IMLEO for the Venus swingby mission than any other non-minimum energy mission.

Since a non-minimum energy mission is specified for the first Mars trip, this makes the Venus swingby mission the best for outbound abort capability.

The all fuel piloted architecture was chosen over the split fuel architecture even though the nominal mission IMLEOs were heavier because adding an outbound abort capability to the split fuel mission to equal that of the nominal all fuel piloted mission required a higher IMLEO than that of the nominal all fuel piloted mission in every transfer vehicle mass case. This choice also eliminates the need to transfer fuel between piloted and cargo missions in Mars orbit, and allows abort from Mars orbit before cargo mission rendezvous.

Lowering the outbound abort RTE time available below that available to the nominal mission is not cost effective. Even for the all fuel piloted mission, the heaviest nominal transfer vehicle and the split transfer vehicle, doubling the IMLEO only reduces the outbound abort RTE time by 37 days (from 167 days for the nominal mission).

In all cases, outbound aborts are cheaper for the all fuel piloted mission than for the split fuel mission.

4.2.2 Aborts from Mars orbit

The deep space maneuver nominal missions offer 190-195 day RTE for abort from Mars orbit for nominal transfer vehicle aborts and 163-167 day RTE from Mars orbit for split transfer vehicle aborts.

The Venus swingby nominal missions offer 224 day RTE for abort from Mars orbit for nominal transfer vehicle aborts and 171-181 day RTE from Mars orbit for split transfer vehicle aborts.

The 2BLO nominal mission has 149-156 and 99-109 day abort from Mars RTE times available. The 2BSO mission offers 192-198 and 162-168 day Mars orbit abort RTE times. Minimum energy missions, of course, cannot afford aborts of any speed from Mars during their entire stay without an enormous increase in IMLEO.

These RTE times are available to both all fuel piloted and split fuel missions, but for split fuel missions the ability to perform the abort is not acquired until after cargo mission rendezvous.

The nominal mission with the fastest RTE for abort from Mars orbit is the 2BLO mission, with 150 day RTE for nominal transfer vehicle aborts and 99-109 day RTE for split transfer vehicle aborts. This mission has an IMLEO of 1145-1383 mT for all fuel piloted missions and 919-1094 mT for split fuel missions.

For the same IMLEO and transfer vehicle masses as a nominal 2BSO mission, an all fuel piloted Venus swingby mission can have available RTE times of 170 days for nominal transfer vehicle aborts and 155 days for split transfer vehicle aborts, and an all fuel piloted deep space maneuver mission can acquire 175 and 159 day RTEs.

The split fuel Venus swingby mission can obtain 180 and 160 day RTE from Mars orbit after cargo mission rendezvous for the same IMLEO as the nominal 2BLO mission. The split fuel deep space maneuver missions offer 180 and 155 day RTE from Mars orbit after cargo rendezvous for the same IMLEO as the 2BLO nominal mission. For split fuel mission aborts from Mars orbit before cargo mission rendezvous, the RTEs available for the same IMLEO as the nominal 2BLO mission will be even lower.

The 2BSO missions also cannot match the Mars orbit abort performance of the nominal 2BLO missions without increasing their IMLEOs above those of the nominal 2BSO missions.

The 2015 2BLO mission is clearly the superior mission for aborts from Mars orbit, particularly if the split transfer vehicle is used, in which case it offers 100 day RTE rather than the 160 day RTE the Venus swingby and DSM missions can achieve for the same IMLEO.

To acquire an abort capability from Mars orbit beyond that offered by a nominal mission requires less IMLEO for split fuel missions than for all fuel piloted missions, even if the abort is specified to be available before cargo mission rendezvous. If the capability is to be available only after rendezvous, the IMLEO for split fuel missions is substantially lower than the IMLEO for the all fuel piloted missions. If the capability must be available before the cargo mission rendezvous, the split fuel mission IMLEO is only trivially lower than the all fuel piloted IMLEO, because the only difference between the two architectures now is whether the Mars stay and inbound consumables are on the cargo or piloted mission.

However, improving the Mars orbit abort capability beyond that of the nominal mission is not recommended, as increasing the IMLEO by 50% of the nominal mission IMLEO allows at best a 20 day decrease in RTE time available from Mars orbit for all fuel piloted missions, and a decrease of at most 50 days for split fuel missions with nominal transfer vehicle aborts. These decreases are not significant compared to a base of 170 to 200 day RTE available to the nominal missions, and do not justify a 300-400 mT increase in IMLEO.

The all fuel piloted architecture is superior if a nominal mission will be used. Although the IMLEO could be reduced from that of the all fuel piloted mission while still having an abort from Mars orbit available before cargo mission rendezvous by using a split fuel mission with an IMLEO between that of the nominal split fuel and nominal all fuel piloted IMLEOs, the lack of the Earth return fuel on the piloted vehicle would cause this mission to lack the outbound abort capability present in the all fuel piloted mission until the IMLEO approached that of the all fuel piloted mission.

Thus, the all fuel piloted mission maximizes the outbound abort and abort from Mars orbit before cargo mission rendezvous capabilities available without carrying any more fuel than required for the nominal mission, at the cost of a slight increase in IMLEO.

Since the difference between all fuel piloted mission and split fuel mission nominal IMLEOs is slight, and the use of the all fuel piloted architecture also eliminates the need for the transfer of fuel between vehicles, the optimization of abort capability before cargo mission rendezvous makes the all fuel piloted mission the better choice for nominal missions.

4.2.3 Inbound aborts

Inbound aborts require more consideration than outbound aborts or aborts from Mars. An abort capability is required to allow the option of returning to Earth before initially planned if a failure should occur while outbound or in Mars orbit. During the inbound leg of the mission, the spacecraft is already headed for Earth, and any fuel held in reserve for an inbound abort is fuel that could have been used in the initial insertion burn to speed the trip home for the nominal mission.

Although the abort fuel carried by a mission with inbound abort capability could be used, once close enough to Earth, to perform a deep space maneuver to shorten the nominal inbound time, the decrease in trip time would not be as great as it would be if that fuel had been used in the insertion burn. But, if only the abort configuration is being accelerated by the abort fuel, the decrease in payload mass may allow a sufficient decrease in RTE trip length available to justify the increase of nominal mission RTE suffered by not using the abort fuel in the insertion burn.

Examining the data for the 2BSO mission in Table 3.1 and Appendix A.4 shows how much of a gain is possible. This mission carries enough fuel for a 4596 m/sec braking burn at Earth arrival. With this fuel, for a 50 mT nominal and abort transfer vehicle, the inbound abort delta-V available is 5806 m/sec if 25 mT of samples were carried from Mars and 4439 m/sec if no samples were

taken[36]. If the split transfer vehicle is used, the delta-Vs become 9112 and 7320 m/sec.

Using a split transfer vehicle creates a substantial increase in the abort delta-V available for a certain amount of fuel, but the loss of efficiency caused by separating the abort delta-V and the TEI delta-V overcomes this gain. For missions with nominal transfer vehicles as abort transfer vehicles, a certain amount of fuel will propel the nominal mission configuration to Earth from Mars with a shorter RTE time than the fastest RTE that fuel will be able to provide to the abort configuration after trans-Earth injection. For configurations with low-mass abort transfer vehicles the fastest abort RTE becomes faster than the RTE available to the nominal configuration at Mars, but unless the abort delta-V is high enough to allow a fast abort from near-Earth orbit, or the samples mass is huge,[37] the difference in RTE time between the abort RTE time and the new nominal mission RTE time is insignificant compared to the new nominal RTE trip length.

For the 2015 Venus swingby mission with 25 tons of samples, 10 km/sec available while inbound allows a 174 day abort RTE (Table 4.4), a savings of 87 days from the nominal inbound transfer time of 261 days. However, for the same amount of fuel required for that abort, the nominal mission configuration can leave Mars with a delta-V of 8300-12700 m/sec (Tables 3.4 and 3.5), allowing the nominal configuration to return home in 194-166 days.

For cases where the nominal transfer vehicle is the abort transfer vehicle an inbound abort specification is obviously unwise, as the nominal configuration can be sent on an inbound transfer from Mars shorter than the fastest abort available immediately after TEI for the same amount of fuel in Mars orbit.

For the above cases with lower-mass ATVs, the choice is between having the ability to shorten the RTE time by at most 90 days for the crew only, or sending the entire nominal configuration, living quarters, samples and all, on a trajectory 70 days shorter than the nominal mission's. The potential to

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36 This is less than the braking burn delta-V because a burn to place the nominal mission configuration (NTV abort, no samples to drop) on an abort trajectory is also propelling trip consumables which would be gone by the time of Earth arrival and the nominal braking burn.

37 An increase in the mass of samples carried by the nominal configuration during the inbound leg lengthens the fastest RTE available to the nominal mission for the amount of fuel required for a specified inbound abort.

decrease the trip time of the abort transfer configuration by 90 days is not worth sacrificing the ability to send the nominal configuration home in 70 less days, so the use of extra fuel in Mars orbit for an inbound abort rather than an accelerated nominal inbound leg is still unwise if a split transfer vehicle is used.

These figures were predicated on the nominal configuration carrying 25 mT of samples, which is a lot of Martian material. As the samples mass is reduced, the difference between the best abort RTE available over the entire inbound mission for split transfer vehicles and the RTE available to the nominal mission from Mars orbit will shrink, and the use of extra fuel in available in Mars orbit to create an inbound abort capability makes even less sense.

Acquiring an inbound abort capability fast enough for the difference between inbound abort and revised nominal mission RTEs to be significant would require a prohibitive increase in IMLEO. Acquiring the 174 day abort RTE discussed above required doubling the IMLEO for nominal transfer vehicle aborts, and IMLEO increases by half to obtain this capability for split transfer vehicle cases.

As a further illustration, again consider the 2015 Venus swingby mission. From Table 3.4, the first 8 rows show that for the same amount of fuel required to provide a 5 km/sec inbound abort to a split fuel mission with 50 mT nominal transfer vehicle and 50 mT abort transfer vehicle, the nominal mission configuration can leave Mars with 9 km/sec for 0 mT samples aboard, and 8 km/sec for 25 mT samplescarried. If the abort is to be available for a split transfer vehicle, 6.3-7.4 km/sec are available to the nominal configuration in Mars orbit with 25-0 mT samples on board.

From Table 4.4, it can be seen that 5 km/sec allows a 203 day RTE from the entire inbound leg. The largest gap between the abort RTE time available and the time remaining in the nominal inbound leg occurs when both are largest, so 5 km/sec inbound abort will allow a reduction in RTE time of no more than 60 days from the time remaining in the nominal transfer.

Table 4.1 shows that a 210 day RTE from Mars costs no more than 6.85 km/sec over the entire length of the stay at Mars. Therefore, for the same IMLEO required to provide a 203 day abort option over the inbound leg, the nominal Earth return configuration could return from Mars in 210 days from

the nominal trans-Earth launch date, providing a 60 day reduction from the original nominal RTE time and allowing the crew to travel in the nominal transfer vehicle and return samples to Earth.

The rise in IMLEO caused by specifying an inbound abort capability is caused as much by the fuel required to transport the abort fuel to Mars and into the Earthbound trajectory as it is by the fuel for the abort maneuver itself. Therefore, split fuel missions offer inbound aborts for less IMLEO than all fuel piloted missions, since the extra fuel can be carried on the cargo mission on a minimum energy trajectory.

Still, the specification of inbound abort capability is not recommended, since the fuel required to place inbound abort fuel into the nominal inbound trajectory can be added to the abort fuel while still in Mars orbit, and this combined fuel supply can be used to reduce the nominal mission trip time from Mars to Earth by almost as much as the difference between the original nominal mission inbound RTE and the fastest abort RTE available over the entire inbound trip. For cases where the nominal transfer vehicle will be used as the abort transfer vehicle, using the abort fuel and TEI fuel from Mars orbit will actually provide a faster RTE to the nominal mission than the fastest RTE available to the abort configuration for aborts performed in near-Mars space.

4.3 Architecture analysis

The difference between split fuel and all fuel piloted architectures is that the split fuel architecture allows some of the fuel and consumables required once in Mars orbit to be carried on a minimum energy trajectory by the cargo mission rather than by the piloted mission.

For split fuel missions, the amount of fuel carried to Mars orbit on the piloted mission is set by the specified capability for outbound abort or abort from Mars orbit before cargo mission rendezvous. If this is less than the amount of fuel required for the specified inbound abort, nominal mission, or specified abort from Mars orbit after cargo mission rendezvous, the rest of the fuel will be carried on the cargo mission.

For an all fuel piloted mission, the amount of fuel carried to Mars orbit on the piloted mission is the all the fuel required for every scenario specified after Mars arrival.

If the amount of fuel the split fuel mission requires sent to Mars orbit is set by the specified capability for abort from Mars orbit before cargo mission rendezvous, the amount of fuel carried by the split fuel mission's piloted vehicle will be exactly the same as that carried by the all fuel piloted mission's piloted vehicle for the same abort capability. The only difference between the two will be that the split fuel piloted mission carries only enough consumables for the outbound leg and the abort from Mars, while the all fuel piloted mission's manned vehicle carries sufficient consumables for the entire nominal mission. For these cases, the split fuel mission will have a marginal advantage obtained by shifting the inbound and stay consumables to the cargo mission. If these consumables were also carried by the split fuel manned vehicle, there would be no difference between the two types of mission's IMLEOs.

This is why, for the 2015 Venus swingby mission with 50 mT nominal and abort transfer vehicles, 160 day RTE from Mars orbit before cargo rendezvous requires 1603 mT IMLEO for the all fuel piloted mission and 1601 mT IMLEO for the split fuel mission.

To improve the abort capability available at Mars after cargo mission rendezvous is much less expensive for split fuel missions than for all fuel piloted missions, because the fuel required to create the abort capability is sent on the minimum energy cargo mission rather than the high-energy manned mission. The same is true for providing an inbound abort capability, which is not recommended under any circumstances (see 4.2.3).

Improving the outbound abort capability beyond that of the nominal mission requires less IMLEO to make any given RTE available to the all fuel piloted mission than it does to make that RTE available to the split fuel mission.

Nominal all fuel piloted missions also offer superior outbound abort and abort from Mars before rendezvous capabilities when compared to nominal split fuel missions, and both architectures have the same capability for inbound aborts or aborts from Mars after cargo mission rendezvous.

All fuel piloted missions are recommended as superior to split fuel missions for this reason. Although the IMLEO could be reduced from that of the nominal all fuel piloted mission while still having an abort from Mars orbit available before cargo mission rendezvous by using a split fuel mission with an IMLEO between that of the nominal split fuel and nominal all fuel piloted IMLEOs, the lack of the Earth return fuel on the piloted vehicle would cause this mission to lack the outbound abort capability present in the all fuel piloted mission, until the IMLEO approached that of the all fuel piloted mission.

Thus, the all fuel piloted mission maximizes the outbound abort and abort from Mars orbit before cargo mission rendezvous capabilities available while carrying only the fuel required for the nominal mission, at the cost of a slight increase in IMLEO. The difference in IMLEO between nominal missions is never more than 70 mT for the DSM, Venus swingby, 2BSO and minimum energy missions.

Since the difference between all fuel piloted and split fuel nominal IMLEOs is slight, and the use of the all fuel piloted architecture also eliminates the need for the transfer of fuel between vehicles, the optimization of abort capability before cargo mission rendezvous makes the all fuel piloted mission the better choice for nominal missions.

If an an abort capability beyond those of the nominal missions is desired in any mission phase other than outbound, then split fuel missions are superior.

4.4 Configuration analysis

The configuration where the nominal transfer vehicle is divided into an abort transfer vehicle and main transfer vehicle to allow reduction of the spacecraft mass before an abort is superior to the configuration where the full nominal transfer vehicle is used in an abort scenario.

The benefit of the split transfer vehicle configuration is to increase the delta-V available for a set fuel mass, and thus to reduce the trip time available for that situation. The use of the split transfer vehicle reduces the RTE times available to aborts from nominal mission phases by 20-30 days, and in some cases where the delta-V available to the nominal mission using the nominal

transfer vehicle was insufficient to allow any abort capability over the phase, the use of the split transfer vehicle creates an abort capability for the phase.

The use of the split transfer vehicle does not allow substantial reduction of the RTE time for aborts beyond the RTE time for the nominal mission capability. Reduction of the RTE time by more than 30 or 40 days still causes the IMLEO required to double, but the time the nominal RTE time being reduced has been lowered without any increase in IMLEO.

4.5 Choice of optimal trajectory for 2014/2015 manned Mars mission

This section details the choice of an optimal high-energy mission for the 2014/2015 manned Mars mission, based on the IMLEO cost and abort capability available. Minimum energy missions, besides allowing no abort capability over the mission duration at Mars, are not considered for the first manned Mars mission due to concerns about the effects of long-term exposure causing high-energy transfers to be specified for the first manned Mars mission.

The nominal 2015 Venus swingby mission using the all fuel piloted architecture is chosen. This mission requires 799 mT IMLEO for the 50 mT nominal transfer vehicle and 916 mT IMLEO for the 75 mT nominal transfer vehicle. This mission requires 12815 m/sec total delta-V and takes 580 days from Earth departure to Earth return, consisting of 279 days outbound, 40 days at Mars, and 261 days inbound, including the Venus swingby. This mission is the cheapest non-minimum energy mission in terms of total delta-V and IMLEO, and allows an abort capability comparable to those of the more expensive nominal missions.

The nominal all fuel piloted 2015 Venus swingby mission allows a 200 day RTE from all points of the nominal outbound mission for nominal transfer vehicle aborts, and 167-172 day RTE for split transfer vehicles. The fastest abort from Mars orbit RTE available over the entire Mars stay is 171-224 days.

Although these aborts are not as fast as those available to the nominal 2015 deep space maneuver mission, they are only 10-20 days slower, and the nominal DSM mission costs 100-200 mT more IMLEO than the nominal Venus swingby mission, and is 100 days longer if no abort is performed. The decrease

in abort trip time allowed by using the DSM mission is not worth another 100 mT IMLEO.

If this decrease in available abort RTE times of 10-20 days from 170 plus days is considered important enough to increase the IMLEO by 100 or more mT, the Venus swingby mission is still superior, as the IMLEO required for the 2015 Venus swingby mission to match the abort capability of the nominal 2015 DSM mission is less than the IMLEO of the DSM mission. If this excess capability is purchased, the total mission length for the Venus swingby mission if no abort is performed becomes faster as well, widening the gap in nominal mission trip time between the missions even futher.

The aborts from Mars orbit available to the nominal 2015 Venus swingby mission are also not as swift as those available to the nominal 2015 2BLO mission, which has available 149-156 day and 99-109 day abort from Mars orbit RTEs. The nominal 2BLO mission has no outbound abort capability for nominal transfer vehicle aborts, and offers 200-210 day RTE for the split transfer vehicle cases. The nominal 2BLO missions have IMLEOs of 1145-1382 mT, half again the IMLEO of the nominal 2015 Venus swingby mission.

For the same IMLEO as the nominal 2BSO mission with the same transfer vehicle masses, the all fuel piloted Venus swingby mission can acquire 179 and 160 day RTE for aborts from Mars orbit, but for the 2BSO mission to match the outbound aborts available to the nominal Venus swingby mission would require increasing its IMLEO even further beyond that of the nominal Venus swingby mission.

Choosing the nominal 2015 2BLO mission over the nominal 2015 Venus swingby mission would increase IMLEO by half, and eliminate the capability for outbound aborts if the abort transfer vehicle is not substantially lighter than the nominal transfer vehicle. The 2015 2BLO mission is also not superior to a 2015 Venus mission with the same IMLEO, which offers Mars aborts 30-60 days slower, but also allows 140-160 day outbound aborts.

Therefore the Venus swingby mission was chosen. The nominal mission was chosen over increasing IMLEO to match the 2BLO Mars abort capability because a decrease in Mars abort RTE time of 10-30 days is not worth an IMLEO increase of 350-470 mT.

The nominal all fuel piloted mission was chosen despite the slight increase in IMLEO from the nominal split fuel mission because the delta-Vs available to the nominal split fuel missions are insufficient to allow any outbound abort except for the case of the 75 mT nominal transfer vehicle and the split transfer vehicle, which is 70 days slower than the corresponding all fuel piloted mission and only 40 mT lighter. Also, the all fuel piloted architecture allows an abort from Mars orbit before cargo mission rendezvous, which the nominal split fuel mission does not, and purchasing abort capability for the split fuel mission to match that of the nominal all fuel piloted mission will raise the IMLEO above that of the nominal all fuel piloted mission.

Inbound abort capability is not specified. To assure a 200 day RTE will be available over the entire inbound leg increases the IMLEO by 100-300 mT, and the nominal inbound trip time is 261 days. Furthermore, as explained above, any extra fuel carried to Mars can be used more efficiently in decreasing the nominal mission inbound trip time than it would be in creating an inbound abort capability.

4.6 Abort capability of minimum energy missions

Minimum energy transfers may be used for the piloted vehicles of followup missions to Mars, so their abort capabilities are explored.

For inbound and outbound aborts the abort characteristics of minimum energy missions are the same as those of the high energy missions discussed above, except the IMLEOs are lower and the RTE times are longer: the nominal all fuel piloted missions have better abort capabilities than the nominal split fuel missions; decreasing the outbound abort RTE times from the times available to the nominal mission requires less IMLEO for all fuel piloted missions than split fuel missions; reducing the RTE times of inbound aborts and aborts from Mars is less expensive for split fuel missions; and decreasing RTE times available for aborts is not cost-effective, requiring 30-40% increases in the IMLEO to shorten the RTE by only 30-40 days.

Specifying an abort from Mars orbit capability for the entire Mars stay of minimum energy missions is not practical, due to the huge total delta-Vs

required for return to Earth from the portion of the Mars stay during which Earth-Mars phasing is at its worst.

However, the ability to return to Earth from Mars orbit before the nominal TEI date if cargo mission rendezvous fails is necessary. As this is not available for nominal missions, an increase in IMLEO must be specified to increase the delta-V available in Mars orbit to a level which will allow return to Earth from the first few days in Mars orbit. The split fuel architecture will be used for minimum energy missions, since this allows the acquisition of aborts from Mars before rendezvous for slightly less IMLEO than for the all fuel piloted architecture.

For minimum energy missions, the total delta-V required to return to Earth from the day of Mars arrival at any speed has a minimum for 210-230 day RTE trips, requiring 10 km/sec. The total delta-V required for any length of RTE increases from this day on.

Minimum energy missions have only 2-3 km/sec available while in Mars orbit for nominal transfer vehicle aborts, and 5-6 km/sec for split transfer vehicle aborts.

Specifying a 10 km/sec delta-V capability from Mars orbit for the day of arrival increases mission IMLEO from 640-710 mT to 746-1107 mT. For minimum energy missions, the use of the split transfer vehicle will be vital.

If a light enough abort transfer vehicle is not available, the requirement for abort capability before cargo mission rendezvous will raise the IMLEO to the level of the IMLEOs of nominal high-energy missions, which have lower transfer times and can be configured to allow Mars stays as long as those of the minimum energy mission. If such a light transfer vehicle is not available, the minimum energy mission will offer no advantage over the high-energy missions unless the requirement for abort capability from Mars before rendezvous is removed, and this criterion is much more important for missions with long Mars stay times than for those with short stay times.

5.0 RECOMMENDATIONS

5.1 Fast vs slow aborts

The delta-Vs required to return to Earth with trip times of 10 to 250 days from mission points covering the entire duration of the manned Mars mission have been calculated for a range of mission profiles under consideration for the manned Mars mission. Both minimum energy and more rapid transfer profiles were considered. In addition to traditional two-impulse high-energy transfers, Venus swingby missions and missions taking advantage of Earth-Mars opposition by performing a deep space maneuver opposite the Sun from Earth and Mars were also considered.

Almost all abort trajectories requiring an insertion delta-V larger than the hyperbolic excess velocity at Earth arrival corresponding to maximum safe entry velocity were found to require a braking burn at Earth arrival to lower the entry velocity to within safe limits.

It was found that "fast" abort trajectories which return to Earth in less than 100 days from the point of abort were prohibitively expensive, requiring a total delta-V higher than the nominal mission total delta-V unless performed when the spacecraft was in near-Earth space.

Requiring that a manned Mars mission have the ability to return the crew to Earth in a brief time during the entire mission length would be prohibitively expensive, and is not recommended.

The costs of slower aborts are more reasonable, and these aborts may be specified if mission elements are arranged so as to optimize their performance and availability. Also, the amount of delta-V required to allow a slow abort over the entire mission duration will allow a fast abort during the beginning of the outbound leg and the final portion of the inbound leg.

5.2 Split transfer vehicle configuration

Separating the systems and crew facilities in the Mars transfer vehicle into two separate vehicles is considered. One vehicle would contain only those systems absolutely vital for minimum comfort crew survival and control of an abort maneuver, while the other would contain all other facilities required in

the nominal mission transfer vehicle, such as crew living quarters and work areas.

In the case of an abort, the main transfer vehicle module would be detached, to reduce the mass of the spacecraft being accelerated into an abort trajectory to the absolute minimum. This configuration would consist of the abort transfer vehicle, the crew Earth entry vehicle and the engine.

This configuration was compared to a configuration in which aborts are made in the nominal transfer vehicle, with only excess consumables being discarded before the abort.

The use of the split transfer vehicle configuration is found to offer substantial advantages over the use of the nominal transfer vehicle for aborts. The return to Earth time available from Mars orbit during the 2015 Venus swingby mission's stay is improved from 224 days to 181 days by reducing the mass of the abort transfer vehicle to 20 mT from the nominal transfer vehicle's 50 metric tons. Reducing to 20 mT from a nominal transfer vehicle of 75 mT changes the situation from one in which the nominal mission fuel cannot produce an abort return to Earth faster than 250 days to one where a 171 day return is possible during the entire length of the stay.

The use of a split transfer vehicle configuration is recommended, and the mass of the abort transfer vehicle should be reduced as far as is possible.

5.3 Carrying return fuel on piloted or cargo mission

The Synthesis Group suggests a mission architecture in which the fuel required for the return from Mars is carried to Mars by an unmanned precursor mission flying a minimum energy transfer. In this architecture, the piloted mission, using a high-energy transfer, carries only enough fuel and consumables to reach Mars orbit, then links up with the cargo mission to acquire the Mars exploration packages and the return fuel.

This architecture, referred to as the "split fuel" architecture, was contrasted with another architecture in which all fuel and consumables necessary to complete the nominal mission are carried by the manned mission. Although this increases the initial mass to low Earth orbit (IMLEO), shifting the return to Earth fuel to the piloted mission increases the speed of Earth return possible during the outbound leg and creates the possibility of an abort from Mars orbit before cargo mission rendezvous without requiring the

addition of extra fuel. The increases in IMLEO are slight when compared to the nominal split fuel mission IMLEO for all mission types except the 2BLO mission, which was not specified by the Synthesis Group as one of the high-energy missions to be used or found by this study to have abort qualities to commend its use before the missions specified by the Synthesis Group.

For nominal missions, the all fuel piloted architecture offers optimization of the speed of outbound abort available using only the fuel necessary for the nominal mission. The nominal all fuel piloted mission offers the same abort from Mars orbit capability as available to the nominal split fuel mission, but offers it before cargo mission rendezvous as well.

If an outbound abort capability beyond the nominal all fuel piloted mission capability is desired, the cost will be less for an all fuel piloted mission.

If an increase in abort capability available at Mars before cargo mission rendezvous is desired, the cost for split fuel missions and all fuel piloted missions is nearly identical, with the split fuel missions having a slight advantage. If an increase in the abort capability from Mars orbit after cargo rendezvous is desired, the split fuel mission will require a substantially lower IMLEO.

Finally, the all fuel piloted architecture eliminates the need to transfer large quantities of fuel between the two missions, which is another safety advantage.

For these reasons, the all fuel piloted architecture is recommended over the split fuel architecture.

5.4 Inbound abort capability

Inbound abort capability is found to cost more than it is worth. The fuel required to create an inbound abort capability must be transported as cargo until the spacecraft enters the return to Earth trajectory, and this creates a substantial increase in IMLEO. Even with the low-mass abort transfer vehicle, it costs 100 metric tons to create the possibility of a 203 day abort to Earth over the length of the inbound leg of the Venus swingby mission, which has a nominal inbound length of 261 days. This amount of fuel will allow faster aborts when further inbound, but the trip to Earth is never shortened by more than 50 days.

Furthermore, it is found that the use of the fuel required for a specified inbound abort capability, combined with the fuel used to accelerate that extra mass for TEI, can reduce the RTE time of the nominal inbound leg almost as much, or more, than the reduction in RTE time accomplished by the fastest abort available for that inbound abort capability.

The specification of an inbound abort capability is not recommended. However, if a mission requiring a braking burn at Earth arrival is chosen as optimal for reasons beyond those considered in this study, the use of a split transfer vehicle is recommended, to allow the option of using the fuel carried for the braking burn to accelerate the abort transfer vehicle into a higher-energy return trajectory while still retaining the ability to brake to a safe entry speed on arrival.

5.5 Nominal missions vs additional abort capability

The carrying of contingency fuel to create the capability of rapid aborts to Earth is found to be not cost-effective. Improving the speed of Earth return available until Mars departure for the 2015 Venus swingby mission from 180-220 days to 160 days requires at least 200 additional metric tons to LEO, and the time difference of 20-60 days does not seem significant when the trip time remains so long. If there is room in the mass budget for such an increase, it would be better spent adding layers of redundancy to critical systems and carrying spare parts for other systems. Even for an equal cost, these measures are superior to an abort capability, as they prevent failures and allow mission completion after a failure, rather than cancelling the rest of the mission.

The use of nominal all fuel piloted missions, with no contingency fuel carried to increase abort capability, is recommended. These missions offer a slow (170-200 day) abort capability while outbound and from Mars orbit, including the abort capability before cargo mission rendezvous specified by the Synthesis Group. The time required for return to Earth for aborts cannot be increased by a significant amount without at least doubling the IMLEO, so the carrying of additional contingency fuel beyond that required for the planned maneuvers is not recommended.

5.6 Optimal mission for 2014/2015 manned Mars mission

The nominal 2015 Venus swingby all fuel piloted mission is found to offer the best abort capability for the least IMLEO among the high-energy mission types.

Although this mission does not have the best nominal mission abort capability in each category, it is the least expensive in terms of total delta-V and IMLEO, and its low nominal IMLEO allows it to match the abort capability of the other missions while remaining less expensive in terms of IMLEO. This capability matching is not recommended, however, beacuse reductions of 10-30 days of 160-200 day trip times do not seem to justify a 100 mT increase in IMLEO.

The 2015 Venus swingby mission requires 799 mT IMLEO for the 50 mT nominal transfer vehicle and 916 mT IMLEO for the 75 mT nominal transfer vehicle. This mission requires 12815 m/sec total delta-V and takes 580 days from Earth departure to Earth return, consisting of 279 days outbound, 40 days at Mars, and 261 days inbound. The Venus swingby occurs during the inbound leg.

The nominal all fuel piloted 2015 Venus swingby mission allows a 200 day RTE from all points of the nominal outbound mission for nominal transfer vehicle aborts, and 167-172 day RTE for split transfer vehicle aborts. The fastest abort from Mars orbit RTE available over the entire Mars stay is 171-224 days.

5.7 Minimum energy mission abort profiles

The mission configurations and architectures which are superior for each case for high energy missions are also superior for minimum energy missions.

However, due to the low delta-Vs required for the minimum energy trajectory maneuvers, nominal minimum energy missions do not share the abort capabilities of high-energy nominal missions. Furthermore, the minimum energy Mars visit takes place during a period of poor Earth-Mars phasing, resulting in high total delta-Vs being necessary for aborts from Mars from the day of arrival well into the stay.

The high delta-Vs required for even very long aborts from Mars makes the IMLEO required to allow the abort from Mars before cargo rendezvous specified by the Synthesis Group equal to the IMLEOs of the nominal high-energy missions unless an abort transfer vehicle much lighter than the nominal transfer vehicle is available. If such a transfer vehicle is not available, the use of a minimum energy mission is not recommended, since the use of nominal high energy missions will allow shorter nominal and abort trip times for the same IMLEO.

5.8 Comparison to Synthesis Group baseline

This more detailed analysis calls into question some of the conclusions of the Synthesis Group.

Rapid aborts are found to be prohibitively expensive unless performed in near-Earth space, and rapid aborts from Mars orbit are found to be prohibitvely expensive at all times.

Slow aborts are found to be available for more reasonable delta-Vs, including the delta-Vs available if the nominal mission fuel availble while outbound or in Mars orbit is used. Accelerating the abort trajectories available to nominal missions is found not to be cost-effecxtive; the reductions in abort trip time made by 50-100% increases in IMLEO are insignificant compared to the original trip lengths.

The Synthesis Group recommends that the fuel be divided between the cargo and piloted missions to allow transport of some of the fuel on a minimum-energy trajectory to lower IMLEO. This study finds that the requirement for an abort capability in Mars orbit before cargo mission rendezvous requires that almost all the total mission fuel be carried on the piloted vehicle, and that carrying all the mission fuel on the piloted vehicle optimizes the outbound abort capability at a cost of an increase in IMLEO of less than 5% from the IMLEO required for a split fuel mission with a substantially slower outbound abort and abort from Mars before cargo mission rendezvous capability.

The Venus swingby and deep space maneuver classes of high-energy mission are found to be the mission types offering abort capabilities for the least IMLEO, as suggested by the Syntheis Group.

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APPENDIX A Abort trajectory data

This chapter contains the raw data for the abort trajectories discussed in chapter 2. There is a section for each mission examined, consisting of the data in table form.

The table lists the injection burn and hyperbolic excess velocity at Earth arrival for each abort for that mission, as well as the derived braking burn and total delta-V (insertion + braking) for each abort. The rows are organized chronologically, with the mission phase/abort type (outbound, at/from Mars, inbound), number of days from Earth, and the number of days in the mission phase (number days from Earth, at Mars, from Mars) shown for each row. The horizontal organization is by the number of days the aborts in that column take to return to Earth (RTE). The data in the cells are in units of kilometers per second for both delta-Vs and hyperbolic excess velocities. Also, the tables list the maximum total delta-V for each mission phase for each RTE.

The entires which read "xxx" represent missions which were not considered, either very short aborts or long inbound aborts. Long inbound aborts cease to be considered when enough of the inbound leg has been completed that using an abort of the length would delay return to Earth compared to completing the nominal inbound transfer. Short aborts, such as 5 and 20 days, were only considered for inbound mission points near Earth, so that more than one or two data points might be had for that date.

Appendix A.1: 2014 minimum energy mission aborts

Mission Phase	Days From Earth	Days in Phase	ΔV in space	10 day RTE arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	30 day RTE arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space
Outbound	11.2	11.2	5.92	4.289	0	5.92	4.403	1.362	0	4.403	4.19
Outbound	22.4	22.4	9.32	8.718	0	9.32	5.434	2.752	0	5.434	4.903
Outbound	33.6	33.6	18.566	13.581	4.281	22.847	9.477	3.873	0	9.477	8.2
Outbound	44.8	44.8	25.12	19.206	9.906	35.026	12.727	6.148	0	12.727	10.494
Outbound	56	56	32.958	25.929	16.629	49.587	16.122	8.418	0	16.122	12.892
Outbound	67.2	67.2	42.039	33.845	24.545	66.584	19.927	11.144	1.844	21.771	15.68
Outbound	78.4	78.4	52.498	43.142	33.842	86.34	24.164	14.377	5.077	29.241	18.597
Outbound	89.6	89.6	64.296	53.837	44.537	108.833	28.793	18.112	8.812	37.605	21.698
Outbound	100.8	100.8	77.3	65.846	56.546	133.846	33.742	22.31	13.01	46.752	24.929
Outbound	112	112	91.323	79.014	69.714	161.037	38.928	26.913	17.613	56.541	28.229
Outbound	123.2	123.2	105.594	92.181	82.881	188.475	44.183	31.792	22.492	66.675	31.48
Outbound	134.4	134.4	121.536	108.023	98.723	220.259	49.669	37.034	27.734	77.403	34.81
Outbound	145.6	145.6	137.514	123.648	114.348	251.862	55.156	42.471	33.171	88.327	38.054
Outbound	156.8	156.8	153.823	139.759	130.459	284.282	60.646	48.063	38.763	99.409	41.227
Outbound	168	168	170.252	156.164	146.864	317.116	66.053	53.745	44.445	110.498	44.269
Outbound	179.2	179.2	186.664	172.707	163.407	350.071	71.345	59.459	50.159	121.504	47.17
Outbound	190.4	190.4	202.829	189.17	179.87	382.699	76.436	65.127	55.827	132.263	49.871
Outbound	201.6	201.6	218.625	205.414	196.114	414.739	81.294	70.699	61.399	142.693	52.361
Outbound	212.8	212.8	233.753	221.161	211.861	445.614	85.808	76.074	66.774	152.582	54.565
Outbound	224	224	248.23	236.38	227.08	475.31	90.011	81.238	71.938	161.949	56.253
Mars	224	0	241.781	236.396	227.096	468.877	83.798	81.243	71.943	155.741	50.925
Mars	234	10	251.139	246.137	236.837	487.976	86.828	84.511	75.211	162.039	52.366
Mars	254	30	268.981	264.649	255.349	524.33	92.261	90.648	81.348	173.609	55.092
Mars	274	50	285.896	282.078	272.778	558.674	97.419	96.321	87.021	184.44	57.663
Mars	294	70	302.188	298.725	289.425	591.613	102.391	101.628	92.328	194.719	60.137
Mars	314	90	318.131	314.885	305.585	623.716	107.238	106.662	97.362	204.6	62.553
Mars	334	110	333.911	330.793	321.493	655.404	111.983	111.499	102.199	214.182	64.929
Mars	354	130	349.592	346.575	337.275	686.867	116.605	116.176	106.876	223.481	67.258
Mars	374	150	365.098	362.221	352.921	718.019	121.041	120.69	111.39	232.431	69.548
Mars	394	170	380.21	377.578	368.278	748.488	125.197	124.995	115.695	240.892	75.051
Mars	414	190	394.586	392.354	383.054	777.64	128.964	129.011	119.711	248.675	73.379
Mars	434	210	407.786	406.137	396.837	804.623	132.245	132.655	123.355	255.6	74.996
Mars	454	230	419.291	418.41	409.11	828.401	134.963	135.839	126.539	261.502	76.348
Mars	474	250	428.555	428.573	419.273	847.828	137.134	138.56	129.26	266.394	77.391
Mars	494	270	435.503	436.556	427.256	862.759	138.776	140.812	131.512	270.288	78.12
Mars	514	290	439.986	441.538	432.238	872.224	139.953	142.635	133.335	273.288	78.545
Mars	534	310	443.664	445.747	436.447	880.111	140.729	144.071	134.771	275.5	78.69
Mars	554	330	446.606	449.175	439.875	886.481	141.16	145.158	135.858	277.018	78.59
Mars	574	350	448.819	451.854	442.554	891.373	1410296	145.925	136.625	1410432.63	78.287
Mars	594	370	450.296	453.774	444.474	894.77	141.18	146.399	137.099	278.279	77.828
Mars	614	390	451.067	454.952	445.652	896.719	140.858	146.612	137.312	278.17	77.263
Mars	634	410	451.195	455.441	446.141	897.336	140.374	146.596	137.296	277.67	76.64
Mars	654	430	450.769	455.319	446.019	896.788	139.771	146.391	137.091	276.862	76.003
Mars	674	450	449.882	454.683	445.383	895.265	139.086	146.033	136.733	275.819	75.388
Mars	682	458	449.417	454.305	445.005	894.422	138.795	145.856	136.556	275.351	75.153
Inbound	682	0									
Inbound	693.9	11.9	450.71	453.121	443.821	894.531	140.509	145.377	136.077	276.586	76.76
Inbound	705.7	23.7	448.247	451.193	441.893	890.14	139.219	144.648	135.348	274.567	75.78
Inbound	717.5	35.5	445.506	448.878	439.578	885.084	137.918	143.793	134.493	272.411	74.861
Inbound	729.4	47.4	442.067	445.906	436.606	878.673	136.356	142.715	133.415	269.771	73.794
Inbound	741.2	59.2	438.272	442.527	433.227	871.499	134.726	141.504	132.204	266.93	72.749
Inbound	753.1	71.1	433.751	438.459	429.159	862.91	132.833	140.056	130.756	263.589	22.865
Inbound	765	83	428.798	433.937	424.637	853.435	130.824	138.456	129.156	259.98	18.87
Inbound	776.8	94.8	423.273	428.827	419.527	842.8	128.648	136.651	127.351	255.999	15.291
Inbound	788.6	106.6	417.215	423.17	413.87	831.085	126.318	134.657	125.357	251.675	12.087
Inbound	800.5	118.5	410.816	417.147	407.847	818.663	23.739	38.654	29.354	53.093	9.245
Inbound	812.4	130.4	403.759	410.445	401.145	804.904	18.643	31.904	22.604	41.247	6.829
Inbound	824.2	142.2	396.312	403.285	393.985	790.297	14.314	25.885	16.585	30.899	4.876
Inbound	836	154	388.529	395.716	386.416	774.945	10.646	20.556	11.256	21.902	3.282
Inbound	847.9	165.9	40.216	50.39	41.09	81.306	7.591	15.922	6.622	14.213	1.981
Inbound	859.8	177.8	29.85	38.392	29.092	58.942	5.103	12.067	2.767	7.87	0.881
Inbound	871.6	189.6	21.052	28.233	18.933	39.985	2.888	8.879	0	2.888	xxx
Inbound	883.5	201.5	13.819	19.916	10.616	24.435	0.971	6.32	0	0.971	xxx
Inbound	895.3	213.3	7.263	12.743	3.443	10.706	xxx	xxx	xxx	xxx	xxx
Inbound	907.1	225.1	0.881	6.133	0	0.881	xxx	xxx	xxx	xxx	xxx
Inbound	919	237									

	10 day RTE	30 day RTE
Max. total ΔV, outbound	475.31	161.949
Max. total ΔV, from Mars	897.336	1410432.63
Max. total ΔV, inbound	894.531	276.586

50 day RTE arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	70 day RTE arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	90 day RTE arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space
0.75	0	4 19	4.118	0.506	0	4.118	4.08	0.417	0	4.08	4.052
1.53	0	4.903	4.721	1.075	0	4.721	4.621	0.925	0	4.621	4.543
2.309	0	8.2	7 66	1.752	0	7.66	7.314	1.582	0	7.314	7.023
3.619	0	10.494	9.563	2.754	0	9.563	8.973	2.459	0	8.973	8.493
5.1	0	12.892	11.611	3.966	0	11.611	10.721	3.538	0	10.721	10.003
6.901	0	15.68	13.766	5.424	0	13.766	12.51	4.807	0	12.51	11.507
9.035	0	18.597	16.037	7.126	0	16.037	14.351	6.261	0	14.351	13.019
11.487	2.187	23.885	18.393	9.053	0	18.393	16.216	7.879	0	16.216	14.516
14.225	4.925	29.854	20.789	11.177	1.877	22.666	18.068	9.635	0.335	18.403	15.965
17.205	7.905	36.134	23.175	13.46	4.16	27.335	19.865	11.496	2.196	22.061	17.332
20.342	11.042	42.522	25.458	15.834	6.534	31.992	21.529	13.402	4.102	25.631	18.551
23.688	14.388	49.198	27.748	18.336	9.036	36.784	23.16	15.384	6.084	29.244	19.716
27.132	17.832	55.886	29.912	20.878	11.578	41.49	24.645	17.366	8.066	32.711	20.731
30.647	21.347	62.574	31.972	23.438	14.138	46.11	26.012	19.332	10.032	36.044	21.627
34.187	24.887	69.156	33.879	25.979	16.679	50.558	27.221	21.248	11.948	39.169	22.373
37.712	28.412	75.582	35.633	28.469	19.169	54.802	28.28	23.092	13.792	42.072	22.986
41.17	31.87	81.741	37.192	30.864	21.564	58.756	29.159	24.829	15.529	44.688	23.446
44.524	35.224	87.585	38.555	33.138	23.838	62.393	29.864	26.442	17.142	47.006	23.775
47.704	38.404	92.969	39.667	35.238	25.938	65.605	30.537	27.89	18.59	49.127	23.971
50.699	41.399	97.652	40.575	37.16	27.86	68.435	30.687	29.181	19.881	50.568	24.241
50.703	41.403	92.328	35.377	37.164	27.864	63.241	25.85	29.184	19.884	45.734	19.639
52.512	43.212	95.578	36.174	38.234	28.934	65.108	26.321	29.848	20.548	46.869	23.088
55.811	46.511	101.603	37.69	40.131	30.831	68.521	27.301	31.098	21.798	49.099	20.995
58.742	49.442	107.105	39.155	41.776	32.476	71.631	28.89	33.153	23.853	52.743	21.021
61.387	52.087	112.224	40.632	43.275	33.975	74.607	33.382	39.298	29.998	63.38	21.607
63.831	54.531	117.084	42.223	44.825	35.525	77.748	30.387	33.993	24.693	55.08	22.323
66.148	56.848	121.777	45.301	48.609	39.309	84.61	31.198	34.48	25.18	56.378	23.099
68.401	59.101	126.359	45.59	48.282	38.982	84.572	32.192	35.288	25.988	58.18	23.887
70.673	61.373	130.921	46.391	48.565	39.265	85.656	33.189	36.214	26.914	60.103	24.637
78.183	68.883	143.934	47.67	49.827	40.527	88.197	34.115	37.213	27.913	62.028	25.302
74.71	65.41	138.789	48.851	51.167	41.867	90.718	34.918	38.253	28.953	63.871	25.839
76.581	67.281	142.277	49.854	52.491	43.191	93.045	35.556	39.301	30.001	65.557	26 216
78.352	69.052	145.4	50.64	53.753	44.453	95.093	35.999	40.325	31.025	67.024	26.409
79.939	70.639	148.03	51.184	54.915	45.615	96.799	36.23	41.296	31.996	68.226	26.412
81.312	72.012	150.132	51.48	55.95	46.65	98.13	36.247	42.192	32.892	69.139	26.231
82.457	73.157	151.702	51.534	56.837	47.537	99.071	36.062	43.002	33.702	69.764	25.891
83.37	74.07	152.76	51.367	57.751	48.451	99.818	35.899	43.728	34.428	70.327	25.436
84.055	74.755	153.345	51.011	58.154	48.854	99.865	35.2	44.382	35.082	70.282	24.939
84.528	75.228	153.515	50.509	58.602	49.302	99.811	34.621	44.995	35.695	70.316	24.507
84.812	75.512	153.34	49.912	58.94	49.64	99.552	33.97	46.005	36.705	70.675	24.293
84.936	75.636	152.899	49.282	59.202	49.902	99.184	33.539	46.284	36.984	70.523	24.48
84.933	75.633	152.273	48.678	59.43	50.13	98.808	33.233	47.078	37.778	71.011	25.22
84.84	75.54	151.543	48.162	59.667	50.367	98.529	33.217	48.042	38.742	71.959	18.22
84.69	75.39	150.778	47.782	59.949	50.649	98.431	35.556	49.189	39.889	75.445	14.56
84.622	75.322	150.475	47.677	60.081	50.781	98.458	33.792	49.695	40.395	74.187	13.159
84.403	75.103	151.863	49.19	60.244	50.944	100.134	17.67	37.713	28.413	46.083	11.468
84.043	74.743	150.523	48.602	60.336	51.036	99.638	15.118	34.077	24.777	39.895	9.532
83.624	74.324	149.185	20.941	40.966	31.666	52.607	12.69	30.453	21.153	33.843	7.716
83.086	73.786	147.58	17.961	36.626	27.326	45.287	10.345	26.827	17.527	27.872	6.005
82.485	73.185	145.934	14.743	32.401	23.101	37.844	8.288	23.36	14.06	22.348	4.562
41.476	32.176	55.041	11.948	28.219	18.919	30.867	6.392	19.994	10.694	17.086	3.279
36.136	26.836	45.706	9.437	24.213	14.913	24.35	4.751	16.836	7.536	12.287	2.22
31.073	21.773	37.064	7.276	20.485	11.185	18.461	3.41	13.968	4.668	8.078	1.41
26.292	16.992	29.079	5.418	17.035	7.735	13.153	2.312	11.388	2.088	4.4	0.784
21.805	12.505	21.75	3.838	13.867	4.567	8.405	1.427	9.103	0	1.427	0.296
17.729	8.429	15.258	2.583	11.078	1.778	4.341	0.743	7.198	0	0.743	xxx
14.178	4.878	9.754	1.581	8.745	0	1.581	0.203	5.718	0	0.203	xxx
11.12	1.82	5.102	0.774	6.838	0	0.774	xxx	xxx	xxx	xxx	xxx
8.556	0	1.981	0.067	5.346	0	0.067	xxx	xxx	xxx	xxx	xxx
6.519	0	0.881	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

50 day RTE	70 day RTE	90 day RTE
97.652	68.435	50.568
153.515	99.865	75.445
151.863	100.134	46.083

110 day RTE				130 day RTE				150 day RTE			
arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space
0.413	0	4.052	4.022	0.469	0	4.022	3.983	0.627	0	3.983	3.923
0.921	0	4.543	4.466	1.013	0	4.466	4.385	1.276	0	4.385	4.35
1.58	0	7.023	6.745	1.697	0	6.745	6.488	2.08	0	6.488	6.761
2.389	0	8.493	8.056	2.455	0	8.056	7.671	2.785	0	7.671	7.797
3.377	0	10.003	9.369	3.376	0	9.369	8.833	3.687	0	8.833	9.095
4.513	0	11.507	10.641	4.412	0	10.641	9.933	4.683	0	9.933	10.478
5.789	0	13.019	11.889	5.556	0	11.889	10.993	5.776	0	10.993	12.218
7.188	0	14.516	13.097	6.793	0	13.097	12.006	6.966	0	12.006	15.166
8.684	0	15.965	14.236	8.1	0	14.236	12.963	8.258	0	12.963	23.328
10.246	0.946	18.278	15.28	9.452	0.152	15.432	13.873	9.684	0.384	14.257	28.356
11.821	2.521	21.072	16.176	10.804	1.504	17.68	14.767	11.346	2.046	16.813	16.134
13.439	4.139	23.855	17.015	12.19	2.89	19.905	16.009	13.783	4.483	20.492	13.614
15.033	5.733	26.464	17.27	13.563	4.263	21.533	19.195	19.729	10.429	29.624	12.991
16.593	7.293	28.92	18.344	14.945	5.645	23.989	32.769	42.362	33.062	65.831	12.78
18 091	8.791	31.164	18.907	16.398	7.098	26.005	17.22	18.332	9.032	26.252	12.622
19.515	10.215	33.201	19.636	18.279	8.979	28.615	15.678	15.896	6.596	22.274	12.44
20.842	11.542	34.988	22.528	24.105	14.805	37.333	15.309	15.977	6.677	21.986	12.186
22.074	12.774	36.549	22.935	27.182	17.882	40.817	15.054	16.459	7.159	22.213	11.862
23.222	13.922	37.893	18.594	20.241	10.941	29.535	14.737	16.97	7.67	22.407	11.449
24.544	15.244	39.485	18.498	20.267	10.967	29.465	14.365	17.439	8.139	22.504	10.987
24.547	15.247	34.886	14.741	20.269	10.969	25.71	11.037	17.441	8.141	19.178	8.322
30.162	20.862	43.95	14.874	20.446	11.146	26.02	11.165	17.582	8.282	19.447	8.43
26.014	16.714	37.709	15.236	20.793	11.493	26.729	11.473	17.823	8.523	19.996	8.695
25.704	16.404	37.425	15.69	21.119	11 819	27.509	11.853	18.049	8.749	20.602	9.021
26.085	16.785	38.392	16.223	21.459	12.159	28.382	12.295	18.305	9.005	21.3	9.393
26.579	17.279	39.602	16.816	21.85	12.55	29.366	12.779	18.627	9.327	22.106	9.788
27.155	17.855	40.954	17.438	22.319	13.019	30.457	13.272	19.044	9.744	23 016	10.176
27.821	18.521	42.408	18.049	22.883	13.583	31.632	13.736	19.571	10.271	24.007	10.524
28.574	19.274	43.911	18.606	23.545	14.245	32.851	14.132	20.217	10.917	25.049	10.803
29.404	20.104	45.406	19.066	24.298	14.998	34.064	14.426	20.983	11.683	26.109	10.998
30.29	20.99	46.829	19.394	25.13	15.83	35.224	14.593	21.871	12.571	27.164	11.118
31.207	21.907	48.123	19.566	26.028	16.728	36.294	14.626	22.887	13.587	28.213	11.213
32.134	22.834	49.243	19.571	26.982	17.682	37.253	14.545	24.054	14.754	29.299	11.408
33.053	23.753	50.165	19.418	27.996	18.696	38.114	14.407	25.421	16.121	30.528	11.941
33.954	24.654	50.885	19.139	29.089	19.789	38.928	14.33	27.079	17.779	32.109	13.198
34.845	25.545	51.436	18.797	30.307	21.007	39.804	14.53	29.181	19.881	34.411	15.591
35.747	26.447	51.883	18.507	31.731	22.431	40.938	15.34	31.941	22.641	37.981	19.083
36.708	27.408	52.347	18.457	33.487	24.187	42.644	17.112	35.53	26.23	43.342	19.534
37.796	28.496	53.003	18.911	35.724	26.424	45.335	19.849	39.755	30.455	50.304	16.582
39.104	29.804	54.097	20.127	38.53	29.23	49.357	17.816	37.963	28.663	46.479	13.701
40.723	31.423	55.903	19.515	40.735	31.435	50.95	14.719	34.001	24.701	39.42	10.961
42.685	33.385	58.605	16.134	36.444	27.144	43.278	11.757	29.85	20.55	32.307	8.44
39.468	30.168	48.388	12.88	31.936	22.636	35.516	9.017	25.618	16.318	25.335	6.224
34.509	25.209	39.769	9.857	27.333	18.033	27.89	6.605	21.416	12.116	18.721	4.417
32.487	23.187	36.346	8.741	25.493	16.193	24.934	5.761	19.767	10.467	16.228	3.836
29.229	19.929	31.397	7.327	22.578	13.278	20.605	4.473	17.199	7.899	12.372	2.508
26.027	16.727	26.259	5.876	19.772	10.472	16.348	3.422	14.78	5.48	8.902	1.79
22.893	13.593	21.309	4.533	17.078	7.778	12.311	2.463	12.508	3.208	5.671	1.146
19.82	10.52	16.525	3.306	14.494	5.194	8.5	1.62	10.388	1.088	2.708	0.603
16.939	7.639	12.201	2.322	12.131	2.831	5.153	0.988	8.518	0	0.988	0.221
14.208	4.908	8.187	1.486	9.959	0.659	2.145	0.477	6.889	0	0.477	xxx
11.712	2.412	4.632	0.837	8.054	0	0.837	0.096	5.582	0	0.096	xxx
9.524	0.224	1.634	0.375	6.486	0	0.375	xxx	xxx	xxx	xxx	xxx
7.646	0	0.784	0.029	5.267	0	0.029	xxx	xxx	xxx	xxx	xxx
6.094	0	0.296	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

110 day RTE	130 day RTE	150 day RTE
39.485	40.817	65.831
58.605	50.95	50.304
31.397	20.605	12.372

170 day RTE				190 day RTE				210 day RTE				
arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	
1.29	0	3.923	5.111	3.684	0	5.111	4.108	0.833	0	4.108	4.018	
2.405	0	4.35	7.72	8.129	0	7.72	4.539	1.704	0	4.539	4.322	
4 169	0	6.761	9.978	7.012	0	9.978	6.455	2.366	0	6.455	5.851	
4.632	0	7.797	14.364	12.347	3.047	17.411	7 29	3.315	0	7.29	6.446	
5.97	0	9.095	13.474	11.529	2.229	15.703	7.826	4.018	0	7.826	6.865	
7.664	0	10.478	12.285	10.173	0.873	13.158	8.205	4.68	0	8.205	7.153	
10.103	0.803	13.021	11.401	9.034	0	11.401	8.489	5.346	0	8.489	7.35	
14.511	5.211	20.377	10.918	8.399	0	10.918	8.702	6.046	0	8.702	7.467	
26.178	16.878	40.206	10.722	8.275	0	10.722	8.844	6.785	0	8.844	7.499	
33.64	24.34	52.696	10.672	8.541	0	10.672	8.906	7.549	0	8.906	7.441	
16.706	7.406	23.54	10.635	9.038	0	10.635	8.861	8.305	0	8.861	7.271	
12.727	3.427	17 041	10.619	9.685	0.385	11.004	8.769	9.077	0	8.769	7.054	
12.052	2.752	15.743	10.536	10.38	1.08	11.616	8.582	9.82	0.52	9.102	6.748	
12.317	3.017	15.797	10.4	11.087	1.787	12.187	8.331	10.534	1.234	9.565	6.393	
12.865	3.565	16.187	10.182	11.767	2.467	12.649	8.002	11.204	1.904	9.906	5.984	
13.49	4.19	16.63	9.9	12.408	3.108	13.008	7.62	11.831	2.531	10.151	5.558	
14.098	4.798	16.984	9.54	12.989	3.689	13.229	7.161	12.402	3.102	10.283	5.133	
14.658	5.358	17.22	9.121	13.509	4.209	13.33	6.71	12.919	3.619	10.329	4.764	
15.136	5.836	17.285	8.633	13.948	4.648	13.281	6.212	13.366	4.066	10.278	4.502	
15.542	6.242	17 229	8.12	14.322	5.022	13.142	5.746	13.763	4.463	10.209	4.444	
15.545	6.245	14 567	6.387	14.325	5.025	11.412	5.299	13.766	4.466	9.765	5.343	
15.635	6.335	14.765	6.497	14.394	5.094	11.591	5.448	13.854	4.554	10.002	5.604	
15.795	6.495	15.19	6.759	14.534	5.234	11.993	5.779	14.06	4.76	10.539	6.171	
15.966	6.666	15.687	7.066	14.712	5.412	12.478	6.144	14.343	5.043	11.187	6.817	
16.189	6.889	16.282	7.402	14.969	5.669	13.071	6.54	14.761	5.461	12.001	7.591	
16.5	7.2	16.988	7.748	15.349	6.049	13.797	6.973	15.379	6.079	13.052	8.589	
16.928	7.628	17.804	8.085	15.892	6.592	14.677	7.469	16.277	6.977	14.446	9.996	
17.497	8.197	18.721	8.402	16.642	7.342	15.744	8.097	17.572	8.272	16.369	12.124	
18.227	8.927	19.73	8.71	17 657	8.357	17.067	9.005	19.435	10.135	19.14	15.404	
19.14	9.84	20.838	9.059	19.016	9.716	18.775	10.468	22.141	12.841	23.309	20.073	
20.271	10.971	22.089	9.581	20.85	11.55	21.131	12.911	15.534	6.234	19.145	26.751	
21.677	12.377	23.59	10.533	23.374	14.074	24.607	16.726	31.674	22.374	39.1	24.385	
23.464	14.164	25.572	12.329	26.921	17.621	29.95	21.859	38.463	29.163	51.022	21.899	
25.813	16.513	28.454	15.395	31.832	22.532	37.927	22.893	39.677	30.377	53.27	19.343	
28.994	19.694	32.892	19.61	37.882	28.582	48.192	20.224	37.229	27.929	48.153	16.771	
33.272	23.972	39.563	21.246	39.589	30.289	51.535	17.533	34.487	25.187	42.72	14.24	
38.458	29.158	48.241	18.43	36.668	27.368	45.798	14.876	31.486	22.186	37.062	11.806	
39.019	29.719	49.253	15.636	33.458	24.158	39.794	12.313	28.282	18.982	31.295	9.526	
35.588	26.288	42.87	12.927	30.022	20.722	33.649	9.902	24.949	15.649	25.551	7.456	
31.903	22.603	36.304	10.367	26.441	17.141	27.508	7.705	21.565	12.265	19.97	5.652	
28.054	18.754	29.715	8.022	22.803	13.503	21.525	5.785	18.213	8.913	14.698	4.169	
24.137	14.837	23.277	5.967	19.196	9.896	15.863	4.209	14.969	5.669	9.878	3.058	
20.251	10.951	17.175	4.283	15.707	6.407	10.69	3.041	11.909	2.609	5.65	2.343	
16.491	7.191	11.608	3.06	12.419	3.119	6.179	2.324	9.115	0	2.324	2.003	
15.044	5.744	9.58	2.715	11.18	1.88	4.595	2.16	8.096	0	2.16	1.955	
12.83	3.53	6.038	1.199	9.332	0.032	1.231	0.38	6.651	0	0.38	0.21	
10.798	1.498	3.288	0.75	7.702	0	0.75	0.096	5.495	0	0.096	xxx	
8.947	0	1.146	0.343	6.306	0	0.343	xxx	xxx	xxx	xxx	xxx	
7.297	0	0.603	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
5.946	0	0.221	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	

170 day RTE	190 day RTE	210 day RTE
52.696	17.411	10.329
49.253	51.535	53.27
6.038	1.231	0.38

230 day RTE				250 day RTE				5 day RTE			
arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space
0.577	0	4 018	3.965	0.525	0	3.965	xxx	xxx	xxx	xxx	xxx
1.219	0	4.322	4.197	1.134	0	4.197	xxx	xxx	xxx	xxx	xxx
1.874	0	5.851	5.426	1.814	0	5.426	xxx	xxx	xxx	xxx	xxx
2.624	0	6.446	5 861	2.541	0	5.861	xxx	xxx	xxx	xxx	xxx
3.37	0	6.865	6.133	3.318	0	6.133	xxx	xxx	xxx	xxx	xxx
4.13	0	7.153	6.279	4.119	0	6.279	xxx	xxx	xxx	xxx	xxx
4.912	0	7.35	6.332	4.947	0	6.332	xxx	xxx	xxx	xxx	xxx
5.716	0	7.467	6.305	5.796	0	6.305	xxx	xxx	xxx	xxx	xxx
6.533	0	7.499	6.193	6.656	0	6.193	xxx	xxx	xxx	xxx	xxx
7.349	0	7.441	5.997	7.516	0	5.997	xxx	xxx	xxx	xxx	xxx
8.136	0	7.271	5.703	8.348	0	5.703	xxx	xxx	xxx	xxx	xxx
8.928	0	7.054	5.376	9.193	0	5.376	xxx	xxx	xxx	xxx	xxx
9.685	0.385	7.133	4.996	10.015	0.715	5.711	xxx	xxx	xxx	xxx	xxx
10.415	1.115	7.508	4.619	10.828	1.528	6.147	xxx	xxx	xxx	xxx	xxx
11.108	1.808	7.792	4.279	11.626	2.326	6.605	xxx	xxx	xxx	xxx	xxx
11.769	2.469	8.027	4.062	12.422	3.122	7.184	xxx	xxx	xxx	xxx	xxx
12.39	3.09	8.223	4.051	13.213	3.913	7.964	xxx	xxx	xxx	xxx	xxx
12.976	3.676	8.44	4.331	14.016	4.716	9.047	xxx	xxx	xxx	xxx	xxx
13.515	4.215	8.717	4.932	14.826	5 526	10.458	xxx	xxx	xxx	xxx	xxx
14.032	4.732	9.176	5.843	15.687	6.387	12.23	xxx	xxx	xxx	xxx	xxx
14.034	4.734	10.077	7.058	15.69	6.39	13.448	xxx	xxx	xxx	xxx	xxx
14.216	4.916	10.52	7.597	16.158	6.858	14.455	xxx	xxx	xxx	xxx	xxx
14.665	5.365	11.536	8.848	17.361	8.061	16.909	xxx	xxx	xxx	xxx	xxx
15.294	5.994	12.811	10.447	19.102	9.802	20.249	xxx	xxx	xxx	xxx	xxx
16.209	6.909	14.5	12.633	21.697	12.397	25.03	xxx	xxx	xxx	xxx	xxx
17.565	8.265	16.854	15.77	25.605	16.305	32.075	xxx	xxx	xxx	xxx	xxx
19.596	10.296	20.292	20.207	31.265	21.965	42.172	xxx	xxx	xxx	xxx	xxx
22.663	13.363	25.487	25.647	38.331	29.031	54.678	xxx	xxx	xxx	xxx	xxx
27.252	17.952	33.356	27.66	40.138	30.838	58.498	xxx	xxx	xxx	xxx	xxx
33.626	24.326	44.399	25.588	38.599	29.299	54.887	xxx	xxx	xxx	xxx	xxx
41.108	31.808	58.559	23.349	36.889	27.589	50.938	xxx	xxx	xxx	xxx	xxx
39.321	30.021	54.406	20.986	34.967	25.667	46.653	xxx	xxx	xxx	xxx	xxx
37.286	27.986	49.885	18.55	32.811	23.511	42.061	xxx	xxx	xxx	xxx	xxx
34.9873	25.6873	45.0303	16.098	30.422	21.122	37.22	xxx	xxx	xxx	xxx	xxx
32.417	23.117	39.888	13.687	27.824	18.524	32.211	xxx	xxx	xxx	xxx	xxx
29.619	20.319	34.559	11.374	25.06	15.76	27.134	xxx	xxx	xxx	xxx	xxx
26.638	17.338	29.144	9.212	22.186	12.886	22.098	xxx	xxx	xxx	xxx	xxx
23.539	14.239	23.765	7.256	19.269	9.969	17.225	xxx	xxx	xxx	xxx	xxx
20.394	11.094	18.55	5.553	16.375	7.075	12.628	xxx	xxx	xxx	xxx	xxx
17.278	7.978	13.63	4.153	13.569	4.269	8.422	xxx	xxx	xxx	xxx	xxx
14.259	4.959	9.128	3.094	10.917	1.617	4.711	xxx	xxx	xxx	xxx	xxx
11.41	2.11	5.168	2.394	8.498	0	2.394	xxx	xxx	xxx	xxx	xxx
8.807	0	2.343	2.036	6.431	0	2.036	xxx	xxx	xxx	xxx	xxx
6.563	0	2.003	1.968	4.953	0	1.968	xxx	xxx	xxx	xxx	xxx
5.805	0	1.955	2.013	4.625	0	2.013	xxx	xxx	xxx	xxx	xxx
								xxx	xxx	xxx	xxx
4.901	0	0.21	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	11.035
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	7.24
xxx	xxx	xxx	xxx	xxx	xxx	xxx	33.736	40.057	30.757	64.493	4.067
xxx	xxx	xxx	xxx	xxx	xxx	xxx	20.005	25.607	16.307	36.312	0.998
xxx	xxx	xxx	xxx	xxx	xxx	xxx	7.008	12.306	3.008	10.014	xxx

230 day RTE	250 day RTE	5 day RTE
9.176	12.23	0
58.559	58.498	0
0.21	0	64.493

Appendix A.2: 2015 deep space maneuver mission aborts

Mission Phase	Days From Earth	Days in Phase	10 day RTE ΔV in space	10 day RTE arrival Vhp	10 day RTE ΔV at Earth	10 day RTE Total ΔV	30 day RTE ΔV in space	30 day RTE arrival Vhp	30 day RTE ΔV at Earth	30 day RTE Total ΔV	50 day RTE ΔV in space	50 day RTE arrival Vhp	50 day RTE ΔV at Earth	50 day RTE Total ΔV	ΔV in space
Outbound	13.6	13.6	15.355	8.613	0	15.355	9.751	2.809	0	9.751	8.66	1.744	0	8.66	8.13
Outbound	27.2	27.2	25.461	17.988	8.688	34.149	13.61	6.019	0	13.61	11.177	3.859	0	11.177	9.949
Outbound	40.8	40.8	36.394	28.363	19.063	55.457	17.522	9.675	0.375	17.897	13.514	6.295	0	13.514	11.466
Outbound	54.4	54.4	312.15	311.359	302.059	614.209	21.056	13.6	4.3	25.356	15.353	8.873	0	15.353	12.442
Outbound	68	68	315.768	312.713	303.413	619.181	23.788	17.451	8.151	31.939	16.435	11.336	2.036	18.471	12.723
Outbound	81.6	81.6	322.156	312.247	302.947	625.103	25.442	20.84	11.54	36.982	16.655	13.421	4.121	20.776	12.287
Outbound	95.2	95.2	330.61	324.394	315.094	645.704	25.947	23.447	14.147	40.094	16.07	14.93	5.63	21.7	11.254
Outbound	108.8	108.8	340.35	333.38	324.08	664.43	25.401	25.069	15.769	41.17	14.864	15.745	6.445	21.309	9.85
Outbound	122.4	122.4	350.819	343.556	334.256	685.075	23.996	25.631	16.331	40.327	13.282	15.835	6.535	19.817	8.378
Outbound	136	136	361.238	354.063	344.763	706.001	22.063	25.166	15.866	37.929	11.71	15.24	5.94	17.65	7.317
Outbound	149.6	149.6	371.371	364.552	355.252	726.623	20.045	23.836	14.536	34.581	10.639	14.074	4.774	15.413	7.206
Outbound	163.2	163.2	380.923	374.653	365.353	746.276	18.59	21.888	12.588	31.178	10.655	12.51	3.21	13.865	8.3
Outbound	176.8	176.8	389.659	384.075	374.775	764.434	18.503	19.765	10.465	28.968	12.053	10.874	1.574	13.627	10.312
Outbound	190.4	190.4	56.785	57.382	48.082	104.867	20.32	18.154	8.854	29.174	14.599	9.714	0.414	15.013	12.831
Outbound	204	204	59.961	56.878	47.578	107.539	23.886	17.869	8.569	32.455	17.837	9.723	0.423	18.26	15.55
Outbound	217.6	217.6	68.542	61.625	52.325	120.867	28.797	19.66	10.36	39.157	21.493	11.343	2.043	23.536	18.352
Outbound	231.2	231.2	81.515	71.602	62.302	143.817	34.53	23.424	14.124	48.654	25.326	14.252	4.952	30.278	21.113
Outbound	244.8	244.8	97.337	85.502	76.202	173.539	40.641	28.568	19.268	59.909	29.132	17.918	8.618	37.75	23.712
Outbound	258.4	258.4	115.063	102.164	92.864	207.927	46.96	34.612	25.312	72.272	32.872	22.012	12.712	45.584	26.149
Outbound	272	272	133.575	120.275	110.975	244.55	53.19	41.093	31.793	84.983	36.384	26.263	16.963	53.347	28.316
Mars	272	0	125.909	120.207	110.907	236.816	45.92	41.071	31.771	77.691	29.515	26.249	16.949	46.464	21.866
Mars	276	4	129.704	123.907	114.607	244.311	47.233	42.407	33.107	80.34	30.292	27.117	17.817	48.109	22.383
Mars	280	8	133.536	127.667	118.367	251.903	48.55	43.757	34.457	83.007	31.069	27.995	18.695	49.764	22.899
Mars	284	12	137.398	131.474	122.174	259.572	49.87	45.117	35.817	85.687	31.896	28.853	19.553	51.449	23.415
Mars	288	16	141.285	135.321	126.021	267.306	51.192	46.485	37.185	88.377	32.623	29.719	20.419	53.042	23.93
Mars	292	20	145.192	139.2	129.9	275.092	52.517	47.858	38.558	91.075	33.401	30.582	21.282	54.683	24.445
Mars	296	24	149.116	143.105	133.805	282.921	53.845	49.236	39.936	93.781	34.179	31.442	22.142	56.321	24.96
Mars	300	28	153.055	147.032	137.732	290.787	55.175	50.617	41.317	96.492	34.958	32.299	22.999	57.957	25.475
Mars	304	32	157.008	150.976	141.676	298.684	56.509	51.999	42.699	99.208	35.738	33.153	23.853	59.591	25.991
Mars	308	36	160.972	154.936	145.636	306.608	57.845	53.383	44.083	101.928	36.519	34.002	24.702	61.221	26.507
Mars	312	40	164.949	158.91	149.61	314.559	59.186	54.768	45.468	104.654	37.302	34.848	25.548	62.85	27.025
Inbound-before DSM	312	0													
Inbound-before DSM	319.6	7.6	180.352	168.818	159.518	339.87	66.994	58.206	48.906	115.9	42.798	36.917	27.617	70.415	31.078
Inbound-before DSM	334.9	22.9	197.043	187.28	177.98	375.023	71.191	64.542	55.242	126.433	44.243	40.606	31.306	75.549	31.227
Inbound-before DSM	350.2	38.2	210.415	202.911	193.611	404.026	73.974	69.796	60.496	134.47	44.698	43.474	34.174	78.872	30.627
Inbound-before DSM	365.5	53.5	219.955	215.059	205.759	425.714	75.275	73.735	64.435	139.71	44.199	45.393	36.093	80.292	29.365
Inbound-before DSM	380.8	68.8	224.92	222.981	213.681	438.601	74.846	76.092	66.792	141.638	42.611	46.222	36.922	79.533	27.359
Inbound-before DSM	396.1	84.1	225.026	226.227	216.927	441.953	72.749	76.733	67.433	140.182	40.098	45.937	36.637	76.735	24.81
Inbound-before DSM	411.4	99.4	219.423	224.007	214.707	434.13	68.69	75.405	66.105	134.795	36.498	44.428	35.128	71.626	21.608
Inbound-before DSM	426.7	114.7	208.168	216.176	206.876	415.044	62.908	72.132	62.832	125.74	32.115	41.796	32.496	64.611	18.078
Inbound-before DSM	442	130	190.809	202.237	192.937	383.746	55.367	66.831	57.531	112.898	27.027	38.056	28.756	55.783	14.361
Inbound-before DSM	457.2	145.2	167.834	181.988	172.688	340.522	46.311	59.55	50.25	96.561	21.553	33.319	24.019	45.572	10.824
Inbound-before DSM	464.9	152.9	153.964	169.926	160.626	314.59	41.473	55.339	46.039	87.512	18.864	30.697	21.397	40.261	9.29
Inbound-after DSM	464.9	152.9	137.648	153.399	144.099	281.747	36.263	49.618	40.318	76.581	16.096	27.186	17.886	33.982	7.696
Inbound-after DSM	475.5	163.5	96.871	114.722	105.422	202.293	21.978	36.469	27.169	49.147	8.127	19.369	10.069	18.196	3.244
Inbound-after DSM	496.9	184.9	59.454	74.959	65.659	125.113	11.483	23.244	13.944	25.427	4.239	11.881	2.581	6.82	3.055
Inbound-after DSM	518.2	206.2	36.563	45.182	35.882	72.445	8.907	13.773	4.473	13.38	5.153	7.165	0	5.153	3.791
Inbound-after DSM	539.5	227.5	29.291	31.446	22.146	51.437	9.202	10.126	0.826	10.028	5.25	6.146	0	5.25	3.22
Inbound-after DSM	582.1	270.1	27.546	28.395	19.095	46.641	8.355	9.717	0.417	8.772	4.09	6.283	0	4.09	1.89
Inbound-after DSM	603.4	291.4	23.994	26.062	16.762	40.756	6.218	9.017	0	6.218	2.277	5.757	0	2.277	0.333
Inbound-after DSM	624.7	312.7	17.524	20.88	11.58	29.104	3.346	7.156	0	3.346	0.303	4.425	0	0.303	xxx
Inbound-after DSM	646	334	9.233	13.275	3.975	13.208	0.305	4.463	0	0.305	xxx	xxx	xxx	xxx	xxx
Inbound-after DSM	667.3	355.3	0.371	4.529	0	0.371	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Inbound-after DSM	678	366													

	10 day RTE	30 day RTE	50 day RTE
Max. total ΔV, outbound	764.434	84.983	53.347
Max. total ΔV, from Mars	314.559	104.654	62.85
Max. total ΔV, inbound	441.953	141.638	80.292

70 day RTE			90 day RTE				110 day RTE				130 day RTE				150 day RTE	
arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp
1.395	0	8.13	7.748	1.257	0	7.748	7.421	1.184	0	7.421	7.122	1.141	0	7.122	6.838	1.141
3.11	0	9.949	9.069	2.757	0	9.069	8.337	2.539	0	8.337	7.691	2.387	0	7.691	7.107	2.318
5.041	0	11.466	10.019	4.383	0	10.019	8.848	3.945	0	8.848	7.845	3.624	0	7.845	6.975	3.42
7.015	0	12.442	10.427	5.978	0	10.427	8.839	5.264	0	8.839	7.519	4.728	0	7.519	6.411	4.343
8.824	0	12.723	10.21	7.368	0	10.21	8.284	6.35	0	8.284	6.731	5.578	0	6.731	5.473	4.998
10.271	0.971	13.258	9.407	8.402	0	9.407	7.267	7.086	0	7.267	5.606	6.087	0	5.606	4.336	5.319
11.217	1.917	13.171	8.176	8.983	0	8.176	5.986	7.405	0	5.986	4.397	6.208	0	4.397	3.339	5.281
11.595	2.295	12.145	6.787	9.071	0	6.787	4.777	7.288	0	4.777	3.554	5.941	0	3.554	3.044	4.896
11.393	2.093	10.471	5.636	8.671	0	5.636	4.174	6.751	0	4.174	3.658	5.31	0	3.658	3.746	4.198
10.665	1.365	8.682	5.298	7.846	0	5.298	4.636	5.868	0	4.636	4.68	4.398	0	4.68	4.972	3.278
9.507	0.207	7.413	6.089	6.688	0	6.089	5.962	4.734	0	5.962	6.147	3.313	0	6.147	6.359	2.273
8.075	0	8.3	7.731	5.363	0	7.731	7.695	3.548	0	7.695	7.744	2.336	0	7.744	7.734	1.637
6.687	0	10.312	9.79	4.247	0	9.79	9.551	2.834	0	9.551	9.317	2.217	0	9.317	9.012	2.178
5.931	0	12.831	12.004	4.062	0	12.004	11.394	3.357	0	11.394	10.794	3.304	0	10.794	10.151	3.504
6.474	0	15.55	14.201	5.219	0	14.201	13.117	4.899	0	13.117	12.101	4.927	0	12.101	11.099	5.055
8.346	0	18.352	16.34	7.251	0	16.34	14.715	6.871	0	14.715	13.253	6.725	0	13.253	11.881	6.609
11.007	1.707	22.82	18.344	9.665	0.365	18.709	16.137	8.989	0	16.137	14.214	8.555	0	14.214	12.477	8.274
14.035	4.735	28.447	20.129	12.206	2.906	23.035	17.321	11.108	1.808	19.129	14.938	10.327	1.027	15.965	12.864	9.834
17.228	7.928	34.077	21.717	14.766	5.466	27.183	18.3	13.172	3.872	22.172	15.469	12.015	2.715	18.184	13.146	11.465
20.416	11.116	39.432	23.031	17.222	7.922	30.953	19.014	15.098	5.798	24.812	15.769	13.567	4.267	20.036	13.383	14.327
20.405	11.105	32.971	17.011	17.212	7.912	24.923	13.434	15.089	5.789	19.223	10.66	13.558	4.258	14.918	9.485	14.32
21.031	11.731	34.114	17.408	17.605	8.305	25.713	13.684	15.419	6.119	19.803	10.847	13.813	4.513	15.36	10.844	16.458
21.652	12.352	35.251	17.717	18.125	8.825	26.542	13.935	15.743	6.443	20.378	11.038	14.066	4.766	15.804	14.592	21.988
22.268	12.968	36.383	18.072	18.565	9.265	27.337	14.187	16.06	6.76	20.947	11.235	14.32	5.02	16.255	26.656	38.511
22.877	13.577	37.507	18.427	18.999	9.699	28.126	14.439	16.37	7.07	21.509	11.439	14.578	5.278	16.717	21.911	31.089
23.479	14.179	38.624	18.782	19.426	10.126	28.908	14.694	16.676	7.376	22.07	11.652	14.843	5.543	17.195	14.403	20.621
24.076	14.776	39.736	19.138	19.845	10.545	29.683	14.95	16.976	7.676	22.626	11.877	15.12	5.82	17.697	11.984	17.106
24.666	15.366	40.841	19.495	20.259	10.959	30.454	15.208	17.271	7.971	23.179	12.12	15.418	6.118	18.238	11.052	15.695
25.25	15.95	41.941	19.852	20.666	11.366	31.218	15.468	17.562	8.262	23.73	12.388	15.75	6.45	18.838	10.652	15.05
25.828	16.528	43.035	20.211	21.067	11.767	31.978	15.731	17.849	8.549	24.28	12.694	16.138	6.838	19.532	10.484	14.739
26.401	17.101	44.126	20.571	21.463	12.163	32.734	15.996	18.134	8.834	24.83	13.064	16.62	7.32	20.384	10.434	14.594
27.767	18.467	49.545	23.577	22.379	13.079	36.656	18.197	18.766	9.466	27.663	15.613	18.563	9.263	24.876	10.622	14.439
30.079	20.779	52.008	23.013	23.831	14.531	37.544	17.278	19.723	10.423	27.701	16.713	23.171	13.871	30.584	9.105	14.461
31.692	22.392	53.019	21.883	24.696	15.396	37.279	16.047	20.289	10.989	27.036	11.265	17.075	7.775	19.04	7.45	14.325
32.552	23.252	52.617	20.297	24.958	15.658	35.955	15.477	21.304	12.004	27.481	9.334	16.463	7.163	16.497	5.714	13.881
32.587	23.287	50.646	18.188	24.576	15.276	33.464	12.856	20.623	11.323	24.179	7.33	15.076	5.776	13.106	3.881	13.061
31.834	22.534	47.344	15.747	23.598	14.298	30.045	9.561	18.253	8.953	18.514	5.381	14.547	5.247	10.628	2.296	11.9
30.233	20.933	42.541	12.897	22.018	12.718	25.615	7.499	16.702	7.402	14.901	3.544	13	3.7	7.244	1.535	10.351
27.908	18.608	36.686	10.191	20.056	10.756	20.947	6.144	14.908	5.608	11.752	2.525	11.151	1.851	4.376	2.211	8.54
24.891	15.591	29.952	7.894	17.614	8.314	16.208	7.835	13.541	4.241	12.076	2.913	9.123	0	2.913	3.012	6.606
21.299	11.999	22.823	5.905	14.625	5.325	11.23	41.54	33.813	24.513	66.053	4.435	7.372	0	4.435	3.425	4.905
19.385	10.085	19.375	5.151	13.063	3.763	8.914	17.28	15.787	6.487	23.767	5.968	7.087	0	5.968	3.559	4.331
16.858	7.558	15.254	4.133	11.036	1.736	5.869	7.033	8.676	0	7.033	10.122	9.05	0	10.122	2.731	3.933
11.467	2.167	5.411	2.366	7.038	0	2.366	3.139	4.553	0	3.139	5.605	4.305	0	5.605	6.31	5.992
6.78	0	3.055	2.877	4.258	0	2.877	2.516	3.327	0	2.516	1.92	3.357	0	1.92	1.111	3.783
4.684	0	3.791	2.731	3.904	0	2.731	1.666	3.848	0	1.666	0.529	4.036	0	0.529	xxx	xxx
4.847	0	3.22	1.721	4.379	0	1.721	0.435	4.19	0	0.435	xxx	xxx	xxx	xxx	xxx	xxx
4.978	0	1.89	0.377	4.301	0	0.377	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.378	0	0.333	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

70 day RTE	90 day RTE	110 day RTE	130 day RTE
39.432	30.953	24.812	20.036
44.126	32.734	24.83	20.384
53.019	37.544	66.053	30.584

		170 day RTE				190 day RTE				210 day RTE				230 day RTE		
ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth
0	6.838	6.581	1.526	0	6.581	6.71	1.65	0	6.71	6.212	1.089	0	6.212	5.933	1.05	0
0	7.107	6.68	2.71	0	6.68	8.138	4.557	0	8.138	5.873	2.186	0	5.873	5 274	2.041	0
0	6.975	6.363	3.598	0	6.363	28.023	23.05	13.75	41.773	5.378	3.256	0	5 378	4.363	2.878	0
0	6.411	5.63	4.258	0	5.63	11.651	9.997	0.697	12.348	5.146	4.374	0	5 146	3.395	3.486	0
0	5.473	4.607	4.671	0	4.607	6.285	6.092	0	6.285	6.102	5.936	0	6.102	2 72	3.812	0
0	4.336	3.549	4.791	0	3.549	4.37	5.099	0	4.37	9.957	9.438	0.138	10 095	2.713	3.83	0
0	3.339	2.905	4.596	0	2.905	3.617	4.443	0	3.617	22.896	21.385	12.085	34.981	3 286	3.52	0
0	3.044	3.142	4.103	0	3.142	3.836	3.716	0	3.836	36.204	34 328	25.028	61.232	4.076	2.885	0
0	3.746	4.108	3.346	0	4.108	4.656	2.842	0	4.656	25.786	25.287	15.987	41.773	4 919	1.998	0
0	4.972	5.297	2.427	0	5.297	5.626	1.896	0	5.626	22.865	24.564	15.264	38.129	5.68	1.165	0
0	6.359	6.504	1.546	0	6.504	6.578	1.178	0	6.578	6.594	2.614	0	6.594	6 317	1.245	0
0	7.734	7.63	1.428	0	7.63	7.428	1.575	0	7.428	7.168	1.881	0	7.168	6.782	2.226	0
0	9.012	8.621	2.416	0	8.621	8.149	2.869	0	8.149	7.728	3.14	0	7.728	7.058	3.391	0
0	10.151	9.457	3.79	0	9.457	9.02	5.477	0	9.02	8.054	4.365	0	8.054	7.151	4.573	0
0	11.099	10.102	5.281	0	10.102	14.224	14.753	5.453	19.677	8.166	5.544	0	8.166	7.051	5.71	0
0	11.881	10.623	6.916	0	10.623	9.813	7.478	0	9.813	8.119	6.679	0	8.119	6.801	6.797	0
0	12.477	11.348	9.497	0.197	11.545	9.552	8.079	0	9.552	7.912	7.746	0	7.912	6.404	7.81	0
0.534	13.398	25.721	33.842	24.342	50.063	9.3	9.005	0	9.3	7.536	8.807	0	7.536	5.857	8.72	0
2.165	15.311	11.56	11.581	2.281	13.841	8.953	9.921	0.621	9.574	7.04	9.577	0.277	7.317	5.211	9.545	0.245
5.027	18.41	10.816	11.685	2.385	13.201	8.464	10.731	1.431	9.895	6.414	10.319	1.019	7.433	4.47	10.257	0.957
5.02	14.505	6.996	11.677	2.377	9.373	5.372	10.722	1.422	6.794	4.368	10.311	1.011	5.379	3.871	10.249	0.949
7.158	18.002	7.045	11.739	2.439	9.484	5.443	10.805	1.505	6.948	4.429	10.376	1.076	5.505	3.927	10.304	1.004
12.688	27.28	7.107	11.812	2.512	9.619	5.516	10.886	1.586	7.102	4.491	10.439	1.139	5.63	3.984	10.36	1.06
29.211	55.867	7.177	11,89	2.59	9.767	5.591	10.965	1.665	7.256	4.554	10.501	1.201	5.755	4.042	10.416	1.116
21.789	43.7	7.255	11.972	2.672	9.927	5.668	11.042	1.742	7.41	4.619	10.562	1.262	5.881	4.1	10.472	1.172
11.321	25.724	7.34	12.057	2.757	10.097	5.747	11.119	1.819	7.566	4.685	10.624	1.324	6.009	4.16	10 528	1.228
7.806	19.79	7.429	12.144	2.844	10.273	5.829	11.194	1.894	7.723	4.753	10.685	1.385	6.138	4.22	10.586	1.286
6.395	17.447	7.523	12.231	2.931	10.454	5.912	11.269	1.969	7.881	4.822	10.746	1.446	6.268	4.28	10.645	1.345
5.75	16.402	7.622	12.32	3.02	10.642	5.998	11.344	2.044	8.042	4.893	10.809	1.509	6.402	4.341	10.706	1.406
5.439	15.923	7.724	12.409	3.109	10.833	6.086	11.419	2.119	8.205	4.965	10.872	1.572	6.537	4.403	10.769	1.469
5.294	15.728	7.83	12.5	3.2	11.03	6.176	11.494	2.194	8.37	5.038	10.936	1.636	6.674	4.465	10.834	1.534
5.139	15.761	7.585	12.659	3.359	10.944	5.019	11.622	2.322	7.341	2.674	11.04	1.74	4.414	0.941	10.943	1.643
5.161	14.266	6.086	12.777	3.477	9.563	3.471	11.668	2.368	5.839	1.243	11.043	1.743	2.986	1.939	10.959	1.659
5.025	12.475	4.439	12.582	3.282	7.721	1.9	11.404	2.104	4.004	1.303	10.736	1.436	2.739	3.636	10.657	1.357
4.581	10.295	2.804	12.066	2.766	5.57	1.036	10.822	1.522	2.558	2.755	10.101	0.801	3.556	5.273	9.994	0.694
3.761	7.642	1.39	11.183	1.883	3.273	2.047	9.869	0.569	2.616	4.243	9.064	0	4.243	6.685	8.854	0
2.6	4.896	1.517	9.97	0.67	2.187	3.355	8.577	0	3.355	5.382	7.644	0	5.382	7.534	7.218	0
1.051	2.586	2.656	8.386	0	2.656	4.387	6.909	0	4.387	6.003	5.809	0	6.003	7.572	5.052	0
0	2.211	3.541	6.583	0	3.541	4.803	5.072	0	4.803	5.796	3.899	0	5.796	6.49	3.053	0
0	3.012	3.844	4.769	0	3.844	4.466	3.461	0	4.466	4.711	2.804	0	4.711	4.45	3.216	0
0	3.425	3.492	3.447	0	3.492	3.462	2.904	0	3.462	3.156	3.418	0	3.156	xxx	xxx	xxx
0	3.559	3.191	3.162	0	3.191	2.95	3.091	0	2.95	2.715	3.955	0	2.715	xxx	xxx	xxx
0	2.731	1.539	3.152	0	1.539	0.687	3.549	0	0.687	xxx	xxx	xxx	xxx	xxx	xxx	xxx
0	6.31	0.863	3.85	0	0.863	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
0	1.111	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

150 day RTE	170 day RTE	190 day RTE	210 day RTE
18.41	50.063	41.773	61.232
55.867	11.03	8.37	6.674
15.761	10.944	7.341	6.003

Total ΔV	ΔV in space	250 day RTE arrival Vhp	ΔV at Earth	Total ΔV
5.933	5.659	1.077	0	5.659
5.274	4.737	2.054	0	4.737
4.363	3.612	2.827	0	3.612
3.395	2.542	3.316	0	2.542
2.72	2.046	3.477	0	2.046
2.713	2.492	3.306	0	2.492
3.286	3.386	2.835	0	3.386
4.076	4.295	2.131	0	4.295
4.919	5.092	1.313	0	5.092
5.68	5.686	0.878	0	5.686
6.317	6.095	1.541	0	6.095
6.782	6.314	2.625	0	6.314
7.058	6.349	3.784	0	6.349
7.151	6.212	4.942	0	6.212
7.051	5.895	6.054	0	5.895
6.801	5.442	7.12	0	5.442
6.404	4.862	8.121	0	4.862
5.857	4.163	9.033	0	4.163
5.456	3.417	9.879	0.579	3.996
5.427	2.703	10.633	1.333	4.036
4.82	3.998	10.624	1.324	5.322
4.931	4.083	10.687	1.387	5.45
5.044	4.128	10.751	1.451	5.579
5.158	4.194	10.817	1.517	5.711
5.272	4.259	10.884	1.584	5.843
5.388	4.326	10.954	1.654	5.98
5.506	4.392	11.026	1.726	6.118
5.625	4.459	11.101	1.801	6.26
5.747	4.526	11.18	1.88	6.406
5.872	4.594	11.263	1.963	6.557
5.999	4.663	11.35	2.05	6.713
2.584	2.799	11.519	2.219	5.018
3.598	4.698	11.668	2.368	7.066
4.993	6.648	11.492	2.192	8.84
5.967	8.413	10.902	1.602	10.015
6.685	9.782	9.678	0.378	10.16
7.534	10.264	7.87	0	10.264
7.572	9.352	4.741	0	9.352
6.49	6.732	2.783	0	6.732
4.45	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx

230 day RTE	250 day RTE
7.151	6.349
5.999	6.713
7.572	10.264

Appendix A.3: 2015 Venus swingby mission aborts

Mission Phase	Days From Earth	Days in Phase		10 day RTE				30 day RTE				50 day RTE				
			ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space
Outbound	13.95	13.95	15.559	8.82	0	15.559	9.829	2.87	0	9.829	8.721	1.775	0	8.721	8.187
Outbound	27.9	27.9	26.161	18.589	9.289	35.45	13.916	6.22	0	13.916	11.404	3.988	0	11.404	10.138
Outbound	41.85	41.85	37.246	29.284	19.984	57.23	17.947	9.99	0.69	18.637	13.815	6.501	0	13.815	11.704
Outbound	55.8	55.8	311.751	310.848	301.548	613.299	21.677	14.124	4.824	26.501	15.76	9.216	0	15.76	12.743
Outbound	69.75	69.75	315.58	312.396	303.096	618.676	24.437	18.077	8.777	33.214	16.833	11.741	2.441	19.274	13
Outbound	83.7	83.7	322.314	317.249	307.949	630.263	26.128	21.566	12.266	38.394	17.051	13.881	4.581	21.632	12.545
Outbound	97.65	97.65	331.224	324.861	315.561	646.785	26.624	24.292	14.992	41.616	16.41	15.456	6.156	22.566	11.441
Outbound	111.6	111.6	341.326	334.281	324.981	666.307	25.894	25.812	16.512	42.406	15.065	16.194	6.894	21.959	9.926
Outbound	125.55	125.55	352.052	344.773	335.473	687.525	24.395	26.312	17.012	41.407	13.418	16.234	6.934	20.352	8.41
Outbound	139.5	139.5	362.72	355.605	346.305	709.025	22.248	25.632	16.332	38.58	11.732	15.491	6.191	17.923	7.302
Outbound	153.45	153.45	373.037	366.347	357.047	730.084	20.062	24.051	14.751	34.813	10.63	14.155	4.855	15.485	7.251
Outbound	167.4	167.4	382.547	376.459	367.159	749.706	18.631	21.978	12.678	31.309	10.747	12.511	3.211	13.958	8.449
Outbound	181.35	181.35	391.186	385.848	376.548	767.734	18.624	19.678	10.378	29.002	12.266	10.771	1.471	13.737	10.542
Outbound	195.3	195.3	57.045	57.314	48.014	105.059	20.691	18.091	8.791	29.482	14.964	9.672	0.372	15.336	13.137
Outbound	209.25	209.25	61.215	57.624	48.324	109.539	24.6	18.125	8.825	33.425	18.365	9.944	0.644	19.009	15.94
Outbound	223.2	223.2	70.631	63.173	53.873	124.504	29.732	20.255	10.955	40.687	22.093	11.835	2.535	24.628	18.749
Outbound	237.15	237.15	84.364	74.1	64.8	149.164	35.595	24.374	15.074	50.669	25.939	14.963	5.663	31.602	21.476
Outbound	251.1	251.1	101.009	89.015	79.715	180.724	41.871	29.874	20.574	62.445	29.783	18.833	9.533	39.316	24.059
Outbound	265.05	265.05	119.071	106.225	96.925	215.996	48.182	36.098	26.798	74.98	33.452	23.011	13.711	47.163	26.402
Outbound	279	279	137.827	124.784	115.484	253.311	54.367	42.724	33.424	87.791	36.863	27.322	18.022	54.885	28.443
Mars	279	0	130.659	124.842	115.542	246.201	47.562	42.743	33.443	81.005	30.486	27.334	18.034	48.52	22.512
Mars	283	4	134.499	128.614	119.314	253.813	48.879	44.096	34.796	83.675	31.263	28.202	18.902	50.165	23.028
Mars	287	8	138.368	132.432	123.132	261.5	50.2	45.458	36.158	86.358	32.04	29.069	19.769	51.809	23.544
Mars	291	12	142.26	136.288	126.988	269.248	51.523	46.828	37.528	89.051	32.818	29.935	20.635	53.453	24.059
Mars	295	16	146.171	140.174	130.874	277.045	52.849	48.202	38.902	91.751	33.595	30.797	21.497	55.092	24.574
Mars	299	20	150.099	144.085	134.785	284.884	54.177	49.581	40.281	94.458	34.373	31.657	22.357	56.73	25.089
Mars	303	24	154.042	148.016	138.716	292.758	55.508	50.962	41.662	97.17	35.152	32.513	23.213	58.365	25.604
Mars	307	28	157.998	151.965	142.665	300.663	56.843	52.345	43.045	99.888	35.933	33.365	24.065	59.998	26.12
Mars	311	32	161.966	155.929	146.629	308.595	58.18	53.729	44.429	102.609	36.715	34.214	24.914	61.629	26.637
Mars	315	36	165.945	159.905	150.605	316.55	59.521	55.115	45.815	105.336	37.498	35.059	25.759	63.257	27.154
Mars	319	40	169.937	163.894	154.594	324.531	60.867	56.501	47.201	108.068	38.284	35.901	26.601	64.885	27.673
Inbound-before Venus	319	0													
Inbound-before Venus	328.475	9.475	187.994	176.564	167.264	355.258	69.23	60.878	51.578	120.808	43.733	38.5	29.2	72.933	31.343
Inbound-before Venus	347.425	28.425	206.423	198.053	188.753	395.176	73.086	68.174	58.874	131.96	44.378	42.601	33.301	77.679	30.513
Inbound-before Venus	366.375	47.375	218.806	214.095	204.795	423.601	74.54	73.389	64.089	138.629	43.428	45.163	35.863	79.291	28.545
Inbound-before Venus	385.325	66.325	222.771	222.385	213.085	435.856	72.811	75.716	66.416	139.227	40.492	45.749	36.449	76.941	25.256
Inbound-before Venus	404.275	85.275	217.662	222.095	212.795	430.457	67.863	74.885	65.585	133.448	35.718	44.292	34.992	70.71	20.903
Inbound-before Venus	423.225	104.225	201.266	211.035	201.735	403.001	59.091	70.225	60.925	120.016	28.919	40.508	31.208	60.127	15.518
Inbound-before Venus	442.175	123.175	172.648	188.133	178.833	351.481	46.51	61.548	52.248	98.758	20.405	34.434	25.134	45.539	9.517
Inbound-before Venus	461.125	142.125	131.713	152.624	143.324	275.037	30.659	48.855	39.555	70.214	10.967	26.282	16.982	27.949	4.132
Inbound-before Venus	480.075	161.075	84.717	107.367	98.067	182.784	15.341	33.43	24.13	39.471	4.379	17.149	7.849	12.228	3.883
Inbound-before Venus	499.025	180.025	48.417	65.13	55.83	104.247	8.74	19.775	10.475	19.215	5.027	9.993	0.693	5.72	4.487
Inbound-before Venus	508.5	189.5	37.266	49.404	40.104	77.37	8.199	15.054	5.754	13.953	5.182	7.974	0	5.182	4.158
Inbound-after Venus	508.5	189.5													
Inbound-after Venus	512.075	193.075	33.708	44.696	35.396	69.104	5.937	13.694	4.394	10.331	1.625	7.411	0	1.625	xxx
Inbound-after Venus	519.225	200.225	28.312	36.885	27.585	55.897	5.101	11.472	2.172	7.273	1.078	6.488	0	1.078	xxx
Inbound-after Venus	526.375	207.375	23.592	30.649	21.349	44.941	4.043	9.726	0.426	4.469	0.4	5.749	0	0.4	xxx
Inbound-after Venus	533.525	214.525	19.449	25.524	16.224	35.673	2.896	8.269	0	2.896	xxx		xxx	xxx	xxx
Inbound-after Venus	540.675	221.675	15.659	21.2	11.9	27.559	1.708	7.01	0	1.708	xxx	xxx	xxx	xxx	xxx
Inbound-after Venus	547.825	228.825	11.825	17.155	7.855	19.68	0.394	5.763	0	0.394	xxx	xxx	xxx	xxx	xxx
Inbound-after Venus	554.975	235.975	7.95	13.254	3.954	11.904	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Inbound-after Venus	562.125	243.125	4.274	9.607	0.307	4.581	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Inbound-after Venus	569.275	250.275	0.316	5.705	0	0.316	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Inbound-after Venus	580	261										xxx			

	10 day RTE	30 day RTE	50 day RTE
Max. total ΔV, outbound	767.734	87.791	54.885
Max. total ΔV, from Mars	324.531	108.068	64.885
Max. total ΔV, inbound	435.856	139.227	79.291

70 day RTE				90 day RTE				110 day RTE				130 day RTE				150 day RTE
arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp
1.418	0	8.187	7.803	1.279	0	7.803	7.473	1.208	0	7.473	7.17	1.167	0	7.17	6.881	1.169
3.214	0	10.138	9.23	2.85	0	9.23	8.474	2.625	0	8.474	7.807	2.468	0	7.807	7.204	2.395
5.206	0	11.704	10.214	4.528	0	10.214	9.008	4.075	0	9.008	7.975	3.742	0	7.975	7.078	3.529
7.283	0	12.743	10.655	6.202	0	10.655	9.012	5.456	0	9.012	7.645	4.896	0	7.645	6.499	4.49
9.134	0	13	10.408	7.621	0	10.408	8.423	6.561	0	8.423	6.821	5.758	0	6.821	5.523	5.149
10.61	1.31	13.855	9.575	8.664	0	9.575	7.364	7.288	0	7.364	5.63	6.232	0	5.63	4.252	5.395
11.598	2.298	13.739	8.273	9.274	0	8.273	6.021	7.632	0	6.021	4.391	6.384	0	4.391	3.308	5.415
11.907	2.607	12.533	6.796	9.297	0	6.796	4.75	7.453	0	4.75	3.516	6.058	0	3.516	3.019	4.975
11.659	2.359	10.769	5.625	8.853	0	5.625	4.157	6.875	0	4.157	3.661	5.388	0	3.661	3.771	4.24
10.811	1.511	8.813	5.302	7.925	0	5.302	4.677	5.902	0	4.677	4.746	4.398	0	4.746	5.045	3.253
9.518	0.218	7.469	6.192	6.657	0	6.192	6.092	4.677	0	6.092	6.275	3.244	0	6.275	6.47	2.204
8.031	0	8.449	7.898	5.299	0	7.898	7.851	3.483	0	7.851	7.874	2.299	0	7.874	7.831	1.661
6.589	0	10.542	9.995	4.185	0	9.995	9.714	2.847	0	9.714	9.433	2.325	0	9.433	9.082	2.346
5.951	0	13.137	12.238	4.181	0	12.238	11.556	3.567	0	11.556	10.89	3.554	0	10.89	10.188	3.759
6.749	0	15.94	14.479	5.549	0	14.479	13.3	5.241	0	13.3	12.203	5.253	0	12.203	11.131	5.36
8.833	0	18.749	16.587	7.716	0	16.587	14.844	7.291	0	14.844	13.287	7.095	0	13.287	11.839	7
11.62	2.32	23.796	18.534	10.192	0.892	19.426	16.197	9.433	0.133	16.33	14.173	8.928	0	14.173	12.363	8.606
14.764	5.464	29.523	20.274	12.795	3.495	23.769	17.32	11.58	2.28	19.6	14.83	10.709	1.409	16.239	12.695	10.194
17.983	8.683	35.085	21.757	15.344	6.044	27.801	18.193	13.613	4.313	22.506	15.263	12.361	3.061	18.324	12.959	11.938
21.177	11.877	40.32	22.973	17.709	8.409	31.382	18.777	15.492	6.192	24.969	15.446	13.868	4.568	20.014	15.038	17.346
21.187	11.887	34.399	17.496	17.718	8.418	25.914	13.747	15.501	6.201	19.948	10.894	13.876	4.576	15.47	11.432	17.355
21.807	12.507	35.535	17.805	18.236	8.936	26.741	13.998	15.822	6.522	20.52	11.087	14.129	4.829	15.916	16.465	24.637
22.42	13.12	36.664	18.161	18.675	9.375	27.536	14.25	16.138	6.838	21.088	11.285	14.384	5.084	16.369	31.325	44.704
23.028	13.728	37.787	18.516	19.106	9.806	28.322	14.503	16.447	7.147	21.65	11.491	14.643	5.343	16.834	19.137	27.267
23.629	14.329	38.903	18.871	19.531	10.231	29.102	14.758	16.751	7.451	22.209	11.707	14.911	5.611	17.318	13.544	19.388
24.224	14.924	40.013	19.227	19.949	10.649	29.876	15.014	17.05	7.75	22.764	11.936	15.192	5.892	17.828	11.669	16.636
24.813	15.513	41.117	19.584	20.361	11.061	30.645	15.273	17.344	8.044	23.317	12.184	15.498	6.198	18.382	10.919	15.487
25.395	16.095	42.215	19.942	20.766	11.466	31.408	15.533	17.634	8.334	23.867	12.46	15.841	6.541	19.001	10.595	14.95
25.972	16.672	43.309	20.301	21.166	11.866	32.167	15.797	17.921	8.621	24.418	12.78	16.247	6.947	19.727	10.463	14.691
26.543	17.243	44.397	20.661	21.561	12.261	32.922	16.063	18.204	8.904	24.967	13.172	16.763	7.463	20.635	10.433	14.574
27.109	17.809	45.482	21.023	21.95	12.65	33.673	16.333	18.486	9.186	25.519	13.696	17.48	8.18	21.876	10.461	14.538
28.792	19.492	50.835	23.428	23.06	13.76	37.188	17.754	19.292	9.992	27.746	19.956	28.214	18.914	38.87	10.391	14.606
31.22	21.92	52.433	21.835	24.506	15.206	37.041	16.057	20.704	11.404	27.461	13.551	19.189	9.889	23.44	7.962	14.538
32.4	23.1	51.645	19.493	25.019	15.719	35.212	19.42	28.063	18.763	38.183	9.66	17.059	7.759	17.419	5.382	13.932
32.11	22.81	48.066	16.563	24.646	15.346	31.909	20.529	28.464	19.164	39.693	6.539	15.594	6.294	12.833	2.815	12.653
30.38	21.08	41.983	14.21	23.713	14.413	28.623	12.055	20.195	10.895	22.95	3.85	13.593	4.293	8.143	1.928	10.709
27.026	17.726	33.244	12.468	21.2	11.9	24.368	10.198	17.093	7.793	17.991	3.132	10.919	1.619	4.751	3.709	8.106
27.08	17.78	27.297	8.127	15.77	6.47	14.597	19.072	19.393	10.093	29.165	4.689	7.896	0	4.689	xxx	xxx
15.915	6.615	10.747	4.611	10.087	0.787	5.398	8.865	7.474	0	8.865	xxx	xxx	xxx	xxx	xxx	xxx
9.761	0.461	4.344	4.65	5.885	0	4.65	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.073	0	4.487	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.482	0	4.158	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

70 day RTE	90 day RTE	110 day RTE	130 day RTE
40.32	31.382	24.969	20.014
45.482	33.673	25.519	21.876
52.433	37.188	39.693	38.87

		170 day RTE				190 day RTE				210 day RTE				230 day RTE		
ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth
0	6.881	6.621	1.574	0	6.621	6.748	1.685	0	6.748	6.238	1.12	0	6.238	5.951	1.082	0
0	7.204	6.766	2.789	0	6.766	8.312	4.734	0	8.312	5.925	2.258	0	5.925	5.303	2.109	0
0	7.078	6.446	3.696	0	6.446	31.745	26.214	16.914	48.659	5.428	3.364	0	5.428	4.369	2.97	0
0	6.499	5.682	4.377	0	5.682	10.844	9.317	0.017	10.861	5.247	4.551	0	5.247	3.374	3.595	0
0	5.523	4.618	4.791	0	4.618	6.049	5.98	0	6.049	6.448	6.29	0	6.448	2.681	3.915	0
0	4.252	3.177	4.722	0	3.177	2.412	4.182	0	2.412	2.019	3.751	0	2.019	2.042	3.417	0
0	3.308	2.861	4.689	0	2.861	3.496	4.437	0	3.496	34.023	31.607	22.307	56.33	3.315	3.567	0
0	3.019	3.134	4.144	0	3.134	3.79	3.682	0	3.79	23.424	22.041	12.741	36.165	4.105	2.859	0
0	3.771	4.141	3.353	0	4.141	4.658	2.781	0	4.658	16.438	15.608	6.308	22.746	4.955	1.917	0
0	5.045	5.362	2.379	0	5.362	5.657	1.793	0	5.657	31.052	33.797	24.497	55.549	5.714	1.074	0
0	6.47	6.589	1.492	0	6.589	6.622	1.135	0	6.622	6.495	1.71	0	6.495	6.337	1.34	0
0	7.831	7.692	1.53	0	7.692	7.449	1.745	0	7.449	7.228	2.139	0	7.228	6.761	2.397	0
0	9.082	8.652	2.594	0	8.652	8.147	2.903	0	8.147	7.572	3.227	0	7.572	6.923	3.574	0
0	10.188	9.442	4.051	0	9.442	9.437	7.031	0	9.437	7.967	4.602	0	7.967	7.013	4.78	0
0	11.131	10.084	5.601	0	10.084	11.908	11.154	1.854	13.762	8.048	5.785	0	8.048	6.884	5.932	0
0	11.839	10.566	7.356	0	10.566	9.598	7.596	0	9.598	7.913	6.905	0	7.913	6.551	7.004	0
0	12.363	11.771	11.108	1.808	13.579	9.307	8.278	0	9.307	7.634	7.943	0	7.634	6.087	7.991	0
0.894	13.589	15.226	17.592	8.292	23.518	8.99	9.199	0	8.99	7.19	8.884	0	7.19	5.476	8.88	0
2.638	15.597	11.032	11.407	2.107	13.139	8.564	10.071	0.771	9.335	6.621	9.704	0.404	7.025	4.767	9.659	0.359
8.046	23.084	10.332	11.75	2.45	12.782	7.981	10.819	1.519	9.5	5.911	10.384	1.084	6.995	3.965	10.311	1.011
8.055	19.487	7.06	11.757	2.457	9.517	5.461	10.826	1.526	6.987	4.444	10.391	1.091	5.535	3.941	10.318	1.018
15.337	31.802	7.124	11.831	2.531	9.655	5.534	10.906	1.606	7.14	4.506	10.454	1.154	5.66	3.999	10.374	1.074
35.404	66.729	7.196	11.91	2.61	9.806	5.61	10.984	1.684	7.294	4.57	10.516	1.216	5.786	4.057	10.43	1.13
17.967	37.104	7.276	11.994	2.694	9.97	5.688	11.062	1.762	7.45	4.635	10.578	1.278	5.913	4.115	10.486	1.186
10.088	23.632	7.361	12.079	2.779	10.14	5.767	11.138	1.838	7.605	4.702	10.639	1.339	6.041	4.175	10.543	1.243
7.336	19.005	7.452	12.166	2.866	10.318	5.849	11.213	1.913	7.762	4.77	10.7	1.4	6.17	4.235	10.601	1.301
6.187	17.106	7.548	12.253	2.953	10.501	5.934	11.288	1.988	7.922	4.84	10.762	1.462	6.302	4.295	10.66	1.36
5.65	16.245	7.647	12.342	3.042	10.689	6.02	11.363	2.063	8.083	4.911	10.824	1.524	6.435	4.357	10.721	1.421
5.391	15.854	7.75	12.432	3.132	10.882	6.109	11.438	2.138	8.247	4.983	10.888	1.588	6.571	4.419	10.785	1.485
5.274	15.707	7.857	12.522	3.222	11.079	6.199	11.513	2.213	8.412	5.056	10.952	1.652	6.708	4.481	10.851	1.551
5.238	15.699	7.968	12.614	3.314	11.282	6.291	11.59	2.29	8.581	5.131	11.019	1.719	6.85	4.544	10.919	1.619
5.306	15.697	7.159	12.798	3.498	10.657	4.506	11.713	2.413	6.919	2.154	11.108	1.808	3.962	1.191	11.015	1.715
5.238	13.2	4.784	12.708	3.408	8.192	2.193	11.523	2.223	4.416	1.244	10.859	1.559	2.803	3.42	10.777	1.477
4.632	10.014	2.414	12.031	2.731	5.145	1.342	10.761	1.461	2.803	3.345	10.029	0.729	4.074	xxx	xxx	xxx
3.353	6.168	1.54	10.69	1.39	2.93	3.361	9.329	0.029	3.39	xxx	xxx	xxx	xxx	xxx	xxx	xxx
1.409	3.337	3.438	8.702	0	3.438	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
0	3.709	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

150 day RTE	170 day RTE	190 day RTE	210 day RTE
23.084	23.518	48.659	56.33
66.729	11.282	8.581	6.85
15.697	10.657	6.919	4.074

	250 day RTE				5 day RTE				20 day RTE			
Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV
5.951	5.668	1.11	0	5.668	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.303	4.747	2.122	0	4.747	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.369	3.587	2.915	0	3.587	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
3.374			0	0	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.681	1.983	3.56	0	1.983	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.042	2.391	3.173	0	2.391	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
3.315	3.438	2.854	0	3.438	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.105	4.343	2.098	0	4.343	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.955	5.131	1.255	0	5.131	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.714	5.702	0.892	0	5.702	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.337	6.079	1.681	0	6.079	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.761	6.254	2.799	0	6.254	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.923	6.183	3.976	0	6.183	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
7.013	6.03	5.143	0	6.03	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.884	5.684	6.271	0	5.684	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.551	5.151	7.322	0	5.151	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.087	4.51	8.299	0	4.51	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.476	3.758	9.193	0	3.758	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.126	2.985	9.996	0.696	3.681	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.976	2.316	10.695	1.395	3.711	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.959	4.079	10.703	1.403	5.482	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.073	4.144	10.767	1.467	5.611	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.187	4.21	10.833	1.533	5.743	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.301	4.276	10.901	1.601	5.877	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.418	4.342	10.972	1.672	6.014	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.536	4.409	11.045	1.745	6.154	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.655	4.476	11.121	1.821	6.297	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.778	4.543	11.201	1.901	6.444	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.904	4.611	11.285	1.985	6.596	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.032	4.68	11.373	2.073	6.753	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.163	4.75	11.466	2.166	6.916	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.906	3.536	11.645	2.345	5.881	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.897	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	8.731	14.98	5.68	14.411	1.778	7.167	0	1.778
xxx	xxx	xxx	xxx	xxx	6.947	12.569	3.269	10.216	0.87	6.2	0	0.87
xxx	xxx	xxx	xxx	xxx	5.178	10.522	1.222	6.4	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	3.273	8.571	0	3.273	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	1.303	6.657	0	1.303	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

230 day RTE	250 day RTE	5 day RTE	20 day RTE
7.013	6.254	0	0
6.163	6.916	0	0
4.897	5.881	14.411	1.778

Appendix A.4: 2014 2BSO mission aborts

Mission Phase	Days From Earth	Days in Phase		10 day RTE arrival Vhp				30 day RTE arrival Vhp				50 day RTE arrival Vhp				70 day RTE arrival Vhp
			ΔV in space		ΔV at Earth	Total ΔV	ΔV in space		ΔV at Earth	Total ΔV	ΔV in space		ΔV at Earth	Total ΔV	ΔV in space	
Outbound	10.7	10.7	6.358	3.298	0	6.358	4.17	1.086	0	4.17	3.76	0.623	0	3.76	3.608	0.416
Outbound	21.4	21.4	9.682	6.563	0	9.682	5.395	2.118	0	5.395	4.644	1.177	0	4.644	4.389	0.767
Outbound	32.1	32.1	13.279	9.884	0.584	13.863	6.911	3.135	0	6.911	5.844	1.709	0	5.844	5.488	1.118
Outbound	42.8	42.8	17.486	13.503	4.203	21.689	8.846	4.244	0	8.846	7.404	2.324	0	7.404	6.895	1.584
Outbound	53.5	53.5	22.677	17.785	8.485	31.162	11.289	5.602	0	11.289	9.335	3.15	0	9.335	8.586	2.271
Outbound	64.2	64.2	29.256	23.24	13.94	43.196	14.211	7.329	0	14.211	11.563	4.272	0	11.563	10.472	3.22
Outbound	74.9	74.9	36.822	29.531	20.231	57.053	17.663	9.552	0.252	17.915	14.106	5.75	0	14.106	12.563	4.449
Outbound	85.6	85.6	46.047	37.459	28.159	74.206	21.581	12.299	2.999	24.58	16.895	7.584	0	16.895	14.794	5.943
Outbound	96.3	96.3	56.602	46.774	37.474	94.076	25.887	15.553	6.253	32.14	19.865	9.746	0.446	20.311	17.106	7.673
Outbound	107	107	68.271	57.328	48.028	116.299	30.469	19.254	9.954	40.423	22.929	12.187	2.887	25.816	19.426	9.595
Outbound	117.7	117.7	81.163	69.211	59.911	141.074	35.384	23.418	14.118	49.502	26.136	14.91	5.61	31.746	21.802	11.71
Outbound	128.4	128.4	95.165	82.327	73.027	168.192	40.582	28.008	18.708	59.29	29.454	17.887	8.587	38.041	24.207	13.992
Outbound	139.1	139.1	109.945	96.385	87.085	197.03	45.925	32.921	23.621	69.546	32.781	21.05	11.75	44.531	26.56	16.389
Outbound	149.8	149.8	125.37	111.248	101.948	227.318	51.374	38.106	28.806	80.18	36.097	24.364	15.064	51.161	28.848	18.87
Outbound	160.5	160.5	141.409	126.876	117.576	258.985	56.919	43.546	34.246	91.165	39.399	27.816	18.516	57.915	31.07	21.425
Outbound	171.2	171.2	157.813	143.006	133.706	291.519	62.492	49.148	39.848	102.34	42.654	31.344	22.044	64.698	33.211	24.004
Outbound	181.9	181.9	174.356	159.47	150.17	324.526	67.973	54.855	45.555	113.528	45.763	34.908	25.608	71.371	35.179	26.571
Outbound	192.6	192.6	191.003	176.161	166.861	357.864	73.401	60.625	51.325	124.726	48.78	38.481	29.181	77.961	37.039	29.109
Outbound	203.3	203.3	207.486	192.856	183.556	391.042	78.655	66.38	57.08	135.735	51.612	42.007	32.707	84.319	38.711	31.569
Outbound	214	214	223.646	209.385	200.085	423.731	83.688	72.059	62.759	146.447	54.236	45.444	36.144	90.38	40.187	33.919
Mars	214	0	215.871	209.421	200.121	415.992	76.057	72.071	62.771	138.828	46.861	45.452	36.152	83.013	33.111	33.926
Mars	218	4	220.012	213.726	204.426	424.438	77.328	73.546	64.246	141.574	47.52	46.313	37.013	84.533	33.482	34.47
Mars	222	8	224.095	217.976	208.676	432.771	78.58	74.998	65.698	144.278	48.165	47.154	37.854	86.019	33.844	34.997
Mars	226	12	228.123	222.169	212.869	440.992	79.812	76.427	67.127	146.939	48.799	47.977	38.677	87.476	34.197	35.507
Mars	230	16	232.094	226.306	217.006	449.1	81.025	77.832	68.532	149.557	49.42	48.779	39.479	88.899	34.543	36
Mars	234	20	236.009	230.385	221.085	457.094	82.219	79.214	69.914	152.133	50.03	49.563	40.263	90.293	34.822	36.477
Mars	238	24	239.87	234.407	225.107	464.977	83.396	80.573	71.273	154.669	50.629	50.328	41.028	91.657	35.214	36.939
Mars	242	28	243.678	238.372	229.072	472.75	84.556	81.908	72.608	157.164	51.218	51.074	41.774	92.992	35.539	37.385
Mars	246	32	247.434	242.282	232.982	480.416	85.7	83.221	73.921	159.621	51.797	51.802	42.502	94.299	35.859	37.817
Mars	250	36	251.139	246.137	236.837	487.976	86.828	84.511	75.211	162.039	52.366	52.512	43.212	95.578	36.174	38.234
Mars	254	40	254.796	249.939	240.639	495.435	87.941	85.78	76.48	164.421	52.927	53.205	43.905	96.832	36.484	38.638
Inbound	254	0														
Inbound	264.8	10.8	271.827	262.922	253.622	525.449	94.76	90.037	80.737	175.497	56.662	55.409	46.109	102.771	38.502	39.817
Inbound	275.6	21.6	280.523	273.824	264.524	545.047	95.961	93.498	84.198	180.159	56.199	57.038	47.738	103.937	37.366	40.557
Inbound	286.4	32.4	286.345	282.128	272.828	559.173	96.011	95.975	86.675	182.686	54.971	57.983	48.683	103.654	35.687	40.796
Inbound	297.2	43.2	289.209	287.642	278.342	567.551	94.961	97.397	88.097	183.058	53.077	58.224	48.924	102.001	33.586	40.549
Inbound	308	54	289.221	290.395	281.095	570.316	92.906	97.776	88.476	181.382	50.615	57.796	48.496	99.111	31.189	39.887
Inbound	318.8	64.8	285.741	289.806	280.506	566.247	89.615	96.92	87.62	177.235	47.453	56.608	47.308	94.761	28.522	38.584
Inbound	329.6	75.6	278.783	285.833	276.533	555.316	85.154	94.839	85.539	170.693	43.673	54.693	45.393	89.066	26.318	37.974
Inbound	340.4	86.4	268.092	278.226	268.926	537.018	79.485	91.483	82.183	161.668	39.282	52.042	42.742	82.024	28.055	39.537
Inbound	351.2	97.2	253.387	266.716	257.416	510.803	72.581	86.814	77.514	150.095	34.301	48.646	39.346	73.647	31.745	40.774
Inbound	362	108	234.282	250.981	241.681	475.963	64.382	80.787	71.487	135.869	28.747	44.496	35.196	63.943	17.548	29.89
Inbound	372.8	118.8	210.249	230.591	221.291	431.54	54.815	73.341	64.041	118.856	22.681	39.596	30.296	52.977	9.521	24.603
Inbound	383.6	129.6	180.682	204.985	195.685	376.367	43.815	64.388	55.088	98.903	16.248	33.975	24.675	40.923	4.96	20.371
Inbound	394.4	140.4	145.89	173.965	164.665	310.555	31.713	53.974	44.674	76.387	9.861	27.78	18.48	28.341	1.391	16.058
Inbound	405.2	151.2	109.208	138.961	129.661	238.869	20.018	42.622	33.322	53.34	4.429	21.439	12.139	16.568	xxx	xxx
Inbound	416	162	76.857	104.236	94.936	171.793	11.163	31.671	22.371	33.534	0.895	15.719	6.419	7.314	xxx	xxx
Inbound	426.8	172.8	51.782	74.265	64.965	116.747	5.432	22.451	13.151	18.583	xxx	xxx	xxx	xxx	xxx	xxx
Inbound	437.6	183.6	32.375	50.35	41.05	73.425	0.974	15.264	5.964	6.938	xxx	xxx	xxx	xxx	xxx	xxx
Inbound	448.4	194.4	15.276	30.36	21.06	36.336	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Inbound	459.2	205.2	1.105	15.036	5.736	6.841	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Inbound	470	216														

	10 day RTE	30 day RTE	50 day RTE
Max. total ΔV, outbound	423.731	146.447	90.38
Max. total ΔV, from Mars	495.435	164.421	96.832
Max. total ΔV, inbound	570.316	183.058	103.937

		90 day RTE				110 day RTE				130 day RTE				150 day RTE		
ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth
0	3.608	3.537	0.311	0	3.537	3.494	0.274	0	3.494	3.456	0.3	0	3.456	3.404	0.422	0
0	4.389	4.276	0.577	0	4.276	4.207	0.529	0	4.207	4.144	0.594	0	4.144	4.073	0.818	0
0	5.488	5.319	0.881	0	5.319	5.202	0.846	0	5.202	5.094	0.946	0	5.094	4.99	1.238	0
0	6.895	6.623	1.328	0	6.623	6.415	1.304	0	6.415	6.222	1.415	0	6.222	6.05	1.731	0
0	8.586	8.143	1.984	0	8.143	7.79	1.943	0	7.79	7.468	2.032	0	7.468	7.187	2.333	0
0	10.472	9.789	2.859	0	9.789	9.239	2.761	0	9.239	8.747	2.796	0	8.747	8.324	3.052	0
0	12.563	11.569	3.957	0	11.569	10.77	3.758	0	10.77	10.068	3.706	0	10.068	9.471	3.893	0
0	14.794	13.421	5.257	0	13.421	12.327	4.914	0	12.327	11.38	4.745	0	11.38	10.584	4.845	0
0	17.106	15.293	6.732	0	15.293	13.862	6.203	0	13.862	12.643	5.887	0	12.643	11.63	5.887	0
0.295	19.721	17.122	8.344	0	17.122	15.321	7.589	0	15.321	13.808	7.099	0	13.808	12.571	6.995	0
2.41	24.212	18.957	10.09	0.79	19.747	16.753	9.072	0	16.753	14.924	8.382	0	14.924	13.463	8.179	0
4.692	28.899	20.773	11.951	2.651	23.424	18.137	10.631	1.331	19.468	15.976	9.717	0.417	16.393	14.305	9.448	0.148
7.089	33.649	22.501	13.877	4.577	27.078	19.415	12.222	2.922	22.337	16.915	11.066	1.766	18.681	15.091	10.836	1.536
9.57	38.418	24.135	15.844	6.544	30.679	20.584	13.826	4.526	25.11	17.743	12.412	3.112	20.855	15.954	12.58	3.28
12.125	43.195	25.681	17.832	8.532	34.213	21.649	15.431	6.131	27.78	18.469	13.753	4.453	22.922	17.824	16.409	7.109
14.704	47.915	27.121	19.829	10.529	37.65	22.615	17.01	7.71	30.325	19.109	15.072	5.772	24.881	30.607	39.088	29.788
17.271	52.45	28.386	21.772	12.472	40.858	23.405	18.526	9.226	32.631	19.608	16.364	7.064	26.672	16.807	16.068	6.768
19.809	56.848	29.54	23.663	14.363	43.903	24.094	19.983	10.683	34.777	20.098	17.739	8.439	28.537	16.385	15.634	6.334
22.269	60.98	30.517	25.46	16.16	46.677	24.624	21.345	12.045	36.669	21.137	20.325	11.025	32.162	16.307	16.247	6.947
24.619	64.806	31.317	27.141	17.841	49.158	25.003	22.599	13.299	38.302	21.602	23.006	13.706	35.308	16.182	16.949	7.649
24.626	57.737	24.554	27.147	17.847	42.401	18.556	22.605	13.305	31.861	16.704	23.013	13.713	30.417	10.767	16.955	7.655
25.17	58.652	24.765	27.495	18.195	42.96	18.682	22.845	13.545	32.227	15.178	20.762	11.462	26.64	10.804	17.044	7.744
25.697	59.541	24.97	27.83	18.53	43.5	18.809	23.084	13.784	32.593	14.819	20.278	10.978	25.797	10.842	17.127	7.827
26.207	60.404	25.172	28.151	18.851	44.023	18.942	23.328	14.028	32.97	14.707	20.153	10.853	25.56	10.882	17.205	7.905
26.7	61.243	25.369	28.46	19.16	44.529	19.088	23.589	14.289	33.377	14.679	20.143	10.843	25.522	10.924	17.278	7.978
27.177	61.999	25.563	28.758	19.458	45.021	19.258	23.889	14.589	33.847	14.69	20.18	10.88	25.57	10.967	17.346	8.046
27.639	62.853	25.755	29.044	19.744	45.499	19.484	24.281	14.981	34.465	14.721	20.237	10.937	25.658	11.013	17.41	8.11
28.085	63.624	25.945	29.321	20.021	45.966	19.846	24.901	15.601	35.447	14.764	20.303	11.003	25.767	11.061	17.471	8.171
28.517	64.376	26.133	29.588	20.288	46.421	20.62	26.202	16.902	37.522	14.816	20.374	11.074	25.89	11.112	17.528	8.228
28.934	65.108	26.321	29.848	20.548	46.869	23.088	30.162	20.862	43.95	14.874	20.446	11.146	26.02	11.165	17.582	8.282
29.338	65.822	26.51	30.101	20.801	47.311	33.62	45.59	36.29	69.91	14.938	20.517	11.217	26.155	11.221	17.634	8.334
30.517	69.019	27.459	30.798	21.498	48.957	20.37	25.741	16.441	36.811	14.139	20.579	11.279	25.418	9.631	17.627	8.327
31.257	68.623	26.217	31.398	22.098	48.315	18.38	24.943	15.643	34.023	12.516	20.431	11.131	23.647	7.989	17.415	8.115
31.496	67.183	27.049	35.513	26.213	53.262	16.413	24.488	15.188	31.601	10.635	20.02	10.72	21.355	6.133	16.955	7.655
31.249	64.835	23.904	33.025	23.725	47.629	14.286	23.819	14.519	28.805	8.608	19.341	10.041	18.649	4.182	16.244	6.944
30.587	61.776	19.984	29.89	20.59	40.574	12.041	22.891	13.591	25.632	6.511	18.411	9.111	15.622	2.218	15.295	5.995
29.284	57.806	17.12	28.345	19.045	36.165	9.607	21.636	12.336	21.943	4.303	17.178	7.878	12.181	0.221	14.052	4.752
28.674	54.992	14.173	26.608	17.308	31.481	7.064	20.06	10.76	17.824	2.078	15.649	6.349	8.427	xxx	xxx	xxx
30.237	58.292	11.086	24.527	15.227	26.313	4.473	18.154	8.854	13.327	xxx	xxx	xxx	xxx	xxx	xxx	xxx
31.474	63.219	7.915	22.07	12.77	20.685	1.934	15.925	6.625	8.559	xxx	xxx	xxx	xxx	xxx	xxx	xxx
20.59	38.138	4.766	19.245	9.945	14.711	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
15.303	24.824	1.818	16.107	6.807	8.625	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
11.071	16.031	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.758	8.149	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

70 day RTE	90 day RTE	110 day RTE	130 day RTE
64.806	49.158	38.302	35.308
65.822	47.311	69.91	30.417
69.019	53.262	36.811	25.418

		170 day RTE				190 day RTE				210 day RTE				230 day RTE		
Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV
3.404	3.314	0.962	0	3.314	4.861	2.28	0	4.861	3.691	0.545	0	3 691	3.566	0.349	0	3.566
4.073	4.078	1.724	0	4.078	7.994	5.618	0	7.994	4.47	1.143	0	4.47	4.188	0.753	0	4.188
4.99	5.079	2.39	0	5.079	11.74	9.581	0.281	12.021	5.291	1.761	0	5.291	4.85	1.217	0	4.85
6.05	6.169	3.05	0	6.169	14.431	12.595	3.295	17.726	6.07	2.368	0	6.07	5.489	1.742	0	5.489
7.187	7.293	3.779	0	7.293	14.838	13.267	3.967	18 805	6.769	2.949	0	6.769	6.075	2.327	0	6.075
8.324	8.404	4.633	0	8.404	13.608	12.014	2.714	16.322	7.356	3.511	0	7.356	6.571	2.963	0	6.571
9.471	9.545	5.682	0	9.545	12.117	10.146	0.846	12.963	7.874	4.093	0	7.874	7.006	3 658	0	7.006
10.584	10.743	7.037	0	10.743	11.115	8.591	0	11.115	8.319	4.72	0	8.319	7.358	4.402	0	7.358
11.63	12.154	8.995	0	12.154	10.684	7.715	0	10.684	8.684	5.406	0	8.684	7.616	5.182	0	7.616
12.571	14.458	12.648	3.348	17.806	10.603	7.492	0	10.603	8.948	6.137	0	8.948	7.759	5.976	0	7.759
13.463	22.437	24.584	15.284	37.721	10.718	7.754	0	10.718	9.156	6.917	0	9.156	7 834	6.794	0	7.834
14.453	22.77	26.132	16.832	39.602	10.902	8.318	0	10.902	9.301	7.731	0	9.301	7.838	7.626	0	7.838
16.627	14.397	13.134	3.834	18.231	11.052	9.032	0	11.052	9.35	8.547	0	9.35	7.745	8.448	0	7.745
19.234	13.475	11.472	2.172	15.647	11.143	9.81	0.51	11.653	9.313	9.351	0.051	9.364	7.57	9.254	0	7.57
24.933	13.4	11.698	2.398	15.798	11.164	10.609	1.309	12.473	9.196	10.139	0.839	10.035	7.324	10.045	0.745	8.069
60.395	13.45	12.364	3.064	16.514	11.127	11.401	2.101	13.228	9 022	10.906	1.606	10.628	7.032	10.821	1.521	8.553
23.575	13.422	13.113	3.813	17.235	10.97	12.144	2.844	13.814	8.738	11.62	2.32	11.058	6.653	11 554	2.254	8.907
22.719	13.351	13.872	4.572	17.923	10.762	12.855	3.555	14.317	8 415	12.306	3.006	11.421	6.263	12 275	2 975	9.238
23.254	13.181	14.581	5.281	18.462	10.465	13.506	4.206	14.671	8.02	12.94	3.64	11.66	5.848	12 962	3.662	9.51
23.831	12.922	15.224	5.924	18.846	10.093	14.093	4.793	14.886	7.576	13.523	4.223	11.799	5.45	13.619	4.319	9.769
18.422	8.113	15.229	5.929	14.042	6.17	14.099	4.799	10.969	4.972	13.529	4.229	9.201	4.738	13.625	4.325	9.063
18.548	8.139	15.288	5.988	14.127	6.197	14.14	4.84	11.037	5.016	13.568	4.268	9 284	4.824	13 685	4 385	9.209
18.669	8.167	15.343	6.043	14.21	6.226	14.179	4.879	11.105	5.062	13.606	4.306	9.368	4.912	13.746	4.446	9.358
18.787	8.197	15.393	6.093	14.29	6.257	14.215	4.915	11.172	5.111	13.643	4.343	9.454	5.004	13.807	4.507	9.511
18.902	8.23	15.44	6.14	14.37	6.291	14.248	4.948	11.239	5.162	13.679	4.379	9.541	5.098	13.87	4.57	9.668
19.013	8.265	15.484	6.184	14.449	6.328	14.28	4.98	11.308	5.215	13.714	4.414	9.629	5.194	13.934	4.634	9.828
19.123	8.302	15.525	6.225	14.527	6.367	14.31	5.01	11.377	5.27	13.748	4.448	9.718	5.293	14	4.7	9.993
19.232	8.342	15.564	6.264	14.606	6.408	14.339	5.039	11.447	5.328	13.783	4.483	9.811	5.394	14.069	4.769	10.163
19.34	8.385	15.6	6.3	14.685	6.451	14.367	5.067	11.518	5.387	13.818	4.518	9.905	5.498	14.141	4.841	10.339
19.447	8.43	15.635	6.335	14.765	6.497	14.394	5.094	11.591	5.448	13.854	4.554	10.002	5.604	14.216	4.916	10.52
19.555	8.477	15.668	6.368	14.845	6.545	14.422	5.122	11.667	5.511	13.892	4.592	10.103	5.712	14.296	4.996	10.708
17.958	5.857	15.605	6.305	12.162	2.467	14.342	5.042	7.509	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
16.104	4.191	15.351	6.051	10.242	0.762	14.077	4.777	5.539	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
13.788	2.354	14.859	5.559	7.913	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
11.126	0.47	14.119	4.819	5.289	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
8.213	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.973	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

150 day RTE	170 day RTE	190 day RTE	210 day RTE	230 day RTE
60.395	39.602	18.805	11.799	9.769
19.555	14.845	11.667	10.103	10.708
17.958	12.162	7.509	0	0

250 day RTE				5 day RTE				20 day RTE				40 day RTE				
ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space
3.503	0.296	0	3.503	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.041	0.665	0	4.041	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.602	1.12	0	4.602	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.128	1.657	0	5.128	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.594	2.273	0	5.594	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.963	2.95	0	5.963	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.263	3.689	0	6.263	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.474	4.477	0	6.474	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.586	5.296	0	6.586	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.584	6.124	0	6.584	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.512	6.975	0	6.512	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.371	7.843	0	6.371	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.145	8.705	0	6.145	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.855	9.56	0.26	6.115	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.519	10.415	1.115	6.634	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.18	11.275	1.975	7.155	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.829	12.116	2.816	7.645	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.573	12.977	3.677	8.25	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.462	13.843	4.543	9.005	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
4.589	14.727	5.427	10.016	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.845	14.734	5.434	11.279	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.017	14.863	5.563	11.58	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.193	14.997	5.697	11.89	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.375	15.138	5.838	12.213	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.563	15.285	5.985	12.548	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.756	15.44	6.14	12.896	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.956	15.604	6.304	13.26	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
7.162	15.778	6.478	13.64	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
7.376	15.962	6.662	14.038	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
7.597	16.158	6.858	14.455	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
7.827	16.367	7.067	14.894	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	59.869	84.894	75.594	135.463	17.901	37.813	28.513	46.414	4.766
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	41.436	67.507	58.207	99.643	9.983	29.564	20.264	30.247	1.104
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	26.533	50.432	41.132	67.665	4.371	21.825	12 525	16.896	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	16.116	35.828	26.528	42.644	0.879	15.474	6.174	7.053	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	8.213	24.283	14 983	23.196	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	1.053	15 111	5 811	6.864	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	16.135	30.298	20.998	37.133	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

250 day RTE	5 day RTE	20 day RTE	40 day RTE
11.279	0	0	0
14.894	0	0	0
0	37.133	135.463	46.414

Appendix A.5: 2014 2BLO mission aborts

Mission Phase	Days From Earth	Days in Phase		10 day RTE				30 day RTE				50 day RTE				70 day RTE
			ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp
Outbound	13.2	13.2	29.944	16.431	7.131	37.075	19.462	5.165	0	19.462	17.637	2.973	0	17.637	16.871	2.255
Outbound	26.4	26.4	50.919	34.765	25.465	76.384	28.572	11.178	1.878	30.45	24.428	6.81	0	24.428	22.502	5.423
Outbound	39.6	39.6	282.546	290.907	281.607	564.153	39.853	18.827	9.527	49.38	32.564	11.98	2.68	35.244	28.953	9.73
Outbound	52.8	52.8	275.693	278.807	269.507	545.2	52.378	28.466	19.166	71.544	41.054	18.573	9.273	50.327	35.279	15.115
Outbound	66	66	277.674	274.282	264.982	542.656	89.285	78.071	68.771	158.056	47.929	26.082	16.782	64.711	39.819	21.079
Outbound	79.2	79.2	287.614	278.748	269.448	557.062	94.301	79.695	70.395	164.696	62.299	41.577	32.277	94.576	41.346	26.739
Outbound	92.4	92.4	302.37	290.436	281.136	583.506	99.697	84.411	75.111	174.808	62.135	43.496	34.196	96.331	40.25	31.349
Outbound	105.6	105.6	319.058	306.121	296.821	615.879	105.083	90.671	81.371	186.454	63.103	47.482	38.182	101.285	49.433	33.358
Outbound	118.8	118.8	335.965	323.228	313.928	649.893	110.253	97.347	88.047	198.3	64.756	52.114	42.814	107.57	47.337	35.97
Outbound	132	132	352.233	340.284	330.984	683.217	115.095	103.871	94.571	209.666	66.683	56.719	47.419	114.102	47.066	39.569
Outbound	145.2	145.2	367.397	356.496	347.196	714.593	119.531	109.977	100.677	220.208	68.64	61.032	51.732	120.372	47.62	43.235
Outbound	158.4	158.4	381.165	371.419	362.119	743.284	123.491	115.533	106.233	229.724	70.48	64.951	55.651	126.131	48.493	46.659
Outbound	171.6	171.6	393.627	385.061	375.761	769.388	127.026	120.572	111.272	238.298	72.174	68.504	59.204	131.378	20.589	33.761
Outbound	184.8	184.8	404.734	397.345	388.045	792.779	130.119	125.087	115.787	245.906	73.677	71.697	62.397	136.074	17.316	31.167
Outbound	198	198	414.195	407.983	398.683	812.878	132.657	128.987	119.687	252.344	74.894	74.48	65.18	140.074	14.493	28.067
Outbound	211.2	211.2	422.349	417.3	408	830.349	134.764	132.404	123.104	257.868	22.167	35.995	26.695	48.862	12.493	24.613
Outbound	224.4	224.4	428.908	425.021	415.721	844.629	136.328	135.247	125.947	262.275	19.304	31.541	22.241	41.545	11.71	20.972
Outbound	237.6	237.6	433.842	431.124	421.824	855.666	137.333	137.514	128.214	265.547	17.75	26.993	17.693	35.443	12.257	17.376
Outbound	250.8	250.8	437.433	435.882	426.582	864.015	31.908	40.933	31.633	63.541	17.888	22.708	13.408	31.296	13.884	14.164
Outbound	264	264											0	0		
Mars	264	0	432.925	438.967	429.667	862.592	25.767	35.353	26.053	51.82	13.569	19.204	9.904	23.473	9.64	11.882
Mars	268	4	432.211	428.287	418.987	851.198	25.45	33.905	24.605	50.055	13.808	18.339	9.039	22.847	10.019	11.406
Mars	272	8	431.482	437.591	428.291	859.773	25.217	32.482	23.182	48.399	14.128	17.582	8.282	22.41	10.429	11.036
Mars	276	12	88.793	98.807	89.507	178.3	25.194	31.268	21.968	47.162	14.521	16.941	7.641	22.162	10.867	10.776
Mars	280	16	86.772	95.614	86.314	173.086	25.332	30.216	20.916	46.248	14.978	16.426	7.126	22.104	11.326	10.629
Mars	284	20	85.245	92.875	83.575	168.82	25.622	29.338	20.038	45.66	15.492	16.042	6.742	22.234	11.804	10.594
Mars	288	24	84.218	90.613	81.313	165.531	26.052	28.643	19.343	45.395	16.055	15.792	6.492	22.547	12.297	10.667
Mars	292	28	83.689	88.846	79.546	163.235	26.612	28.135	18.835	45.447	16.659	15.679	6.379	23.038	12.801	10.839
Mars	296	32	83.648	87.584	78.284	161.932	27.286	27.817	18.517	45.803	17.298	15.695	6.395	23.693	13.314	11.101
Mars	300	36	84.076	86.828	77.528	161.604	28.064	27.689	18.389	46.453	17.966	15.838	6.538	24.504	13.833	11.442
Mars	304	40	84.947	86.574	77.274	162.221	28.931	27.744	18.444	47.375	18.659	16.097	6.797	25.456	14.358	11.85
Inbound	304	0			0	0							0	0		
Inbound	312.8	8.8	81.003	82.624	73.324	154.327	27.293	26.897	17.597	44.89	16.903	16.186	6.886	23.789	12.08	12.374
Inbound	321.6	17.6	81.238	81.041	71.741	152.979	27.891	26.855	17.555	45.446	17.068	16.661	7.361	24.429	11.872	13.006
Inbound	330.4	26.4	82.569	81.331	72.031	154.6	28.426	27.383	18.083	46.509	17.063	17.332	8.032	25.095	11.505	13.603
Inbound	339.2	35.2	83.985	82.515	73.215	157.2	28.591	28.12	18.82	47.411	16.709	17.982	8.682	25.391	10.836	14.066
Inbound	348	44	85.091	84.01	74.71	159.801	28.383	28.854	19.554	47.937	16.065	18.5	9.2	25.265	9.967	14.339
Inbound	356.8	52.8	85.475	85.247	75.947	161.422	27.747	29.398	20.098	47.845	15.132	18.795	9.495	24.627	8.907	14.388
Inbound	365.6	61.6	84.829	85.78	76.48	161.309	26.65	29.614	20.314	46.964	13.921	18.811	9.511	23.432	7.678	14.193
Inbound	374.4	70.4	82.798	85.166	75.866	158.664	25.01	29.367	20.067	45.077	12.394	18.483	9.183	21.577	6.26	13.725
Inbound	383.2	79.2	79.441	83.328	74.028	153.469	22.927	28.645	19.345	42.272	10.656	17.829	8.529	19.185	4.754	13.019
Inbound	392	88	74.599	80.039	70.739	145.338	20.382	27.386	18.086	38.468	8.707	16.826	7.526	16.233	3.168	12.07
Inbound	400.8	96.8	68.349	75.276	65.976	134.325	17.462	25.599	16.299	33.761	6.63	15.502	6.202	12.832	1.58	10.913
Inbound	409.6	105.6	58.971	67.342	58.042	117.013	13.59	22.673	13.373	26.963	4.141	13.394	4.094	8.235	0.439	9.039
Inbound	418.4	114.4	52.459	61.768	52.468	104.927	10.984	20.663	11.363	22.347	2.47	12.098	2.798	5.268	xxx	xxx
Inbound	427.2	123.2	43.385	53.416	44.116	87.501	7.692	17.6	8.3	15.992	0.564	10.16	0.86	1.424	xxx	xxx
Inbound	436	132	34.063	44.437	35.137	69.2	4.563	14.545	5.245	9.808	xxx	xxx	xxx	xxx	xxx	xxx
Inbound	444.8	140.8	24.798	35.16	25.86	50.658	1.634	11.37	2.07	3.704	xxx	xxx	xxx	xxx	xxx	xxx
Inbound	453.6	149.6	15.85	25.95	16.65	32.5	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Inbound	462.4	158.4	7.233	16.988	7.688	14.921	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Inbound	471.2	167.2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Inbound	480	176														

	10 day RTE	30 day RTE	50 day RTE
Max. total ΔV, outbound	864.015	265.547	140.074
Max. total ΔV, from Mars	862.592	51.82	25.456
Max. total ΔV, inbound	161.422	47.937	25.391

	170 day RTE				190 day RTE				210 day RTE				230 day RTE			
Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV
15.019	14.581	1.947	0	14.581	14.137	1.958	0	14.137	13.677	1.987	0	13.677	13.19	2.053	0	13.19
17.708	16.645	4.353	0	16.645	15.598	4.313	0	15.598	14.524	4.303	0	14.524	13.411	4.38	0	13.411
20.054	18.198	7.132	0	18.198	16.548	7.131	0	16.548	14.612	6.795	0	14.612	12.791	6.784	0	12.791
22.841	18.742	10.058	0.758	19.5	16.163	9.561	0.261	16.424	13.7	9.212	0	13.7	11.196	8.965	0	11.196
25.769	17.805	12.743	3.443	21.248	14.606	11.85	2.55	17.156	11.609	11.133	1.833	13.442	8.734	10.588	1.288	10.022
26.351	15.47	14.759	5.459	20.929	11.97	13.432	4.132	16.102	8.785	12.321	3.021	11.806	5.861	11.423	2.123	7.984
24.943	12.408	15.884	6.584	18.992	8.936	14.16	4.86	13.796	5.858	12.698	3.398	9.256	3.157	11.476	2.176	5.333
22.306	9.925	16.141	6.841	16.766	6.061	14.103	4.803	10.864	3.349	12.371	3.071	6.42	1.582	10.907	1.607	3.189
19.015	6.494	15.685	6.385	12.879	3.697	13.427	4.127	7.824	1.932	11.511	2.211	4.143	2.379	9.89	0.59	2.969
15.429	4.232	14.677	5.377	9.609	2.389	12.288	2.988	5.377	2.544	10.271	0.971	3.515	3.811	8.568	0	3.811
11.891	2.987	13.257	3.957	6.944	2.847	10.819	1.519	4.366	3.899	8.777	0	3.899	5.072	7.062	0	5.072
8.945	3.297	11.548	2.248	5.545	4.118	9.138	0	4.118	5.168	7.141	0	5.168	6.075	5.486	0	6.075
7.15	4.517	9.65	0.35	4.867	5.438	7.341	0	5.438	6.252	5.465	0	6.252	6.85	3.96	0	6.85
6.175	5.895	7.671	0	5.895	6.613	5.55	0	6.613	7.122	3.908	0	7.122	7.401	2.753	0	7.401
6.526	7.129	5.765	0	7.129	7.547	3.977	0	7.547	7.732	2.821	0	7.732	7.702	2.451	0	7.702
7.903	8.203	4.174	0	8.203	8.279	3.039	0	8.279	8.137	2.784	0	8.137	7.9	3.715	0	7.9
9.094	9.032	3.435	0	9.032	8.76	3.283	0	8.76	8.298	3.736	0	8.298	7.682	4.469	0	7.682
10.041	9.599	3.946	0	9.599	8.983	4.391	0	8.983	8.223	5.049	0	8.223	7.314	5.695	0	7.314
10.771	9.943	5.24	0	9.943	8.992	5.784	0	8.992	8.424	7.785	0	8.424	6.779	6.931	0	6.779
0			0	0			0	0			0	0			0	0
5.305	4.536	6.726	0	4.536	3.844	7.156	0	3.844	3.18	7.586	0	3.18	2.772	8.038	0	2.772
5.449	4.628	6.983	0	4.628	3.891	7.365	0	3.891	3.232	7.749	0	3.232	2.808	8.182	0	2.808
5.591	4.717	7.237	0	4.717	3.932	7.57	0	3.932	3.282	7.916	0	3.282	2.845	8.32	0	2.845
5.73	4.804	7.488	0	4.804	3.967	7.782	0	3.967	3.331	8.079	0	3.331	2.883	8.453	0	2.883
5.867	4.889	7.734	0	4.889	4.012	8.075	0	4.012	3.378	8.238	0	3.378	2.92	8.581	0	2.92
6.001	4.972	7.977	0	4.972	4.794	9.963	0.663	5.457	3.424	8.391	0	3.424	2.959	8.703	0	2.959
6.133	5.054	8.215	0	5.054	6.71	11.842	2.542	9.252	3.469	8.538	0	3.469	2.998	8.821	0	2.998
6.263	5.135	8.451	0	5.135	4.838	9.204	0	4.838	3.513	8.678	0	3.513	3.038	8.933	0	3.038
6.391	5.217	8.686	0	5.217	4.642	9.044	0	4.642	3.557	8.813	0	3.557	3.079	9.04	0	3.079
6.518	5.3	8.926	0	5.3	4.606	9.097	0	4.606	3.601	8.941	0	3.601	3.12	9.142	0	3.12
6.642	5.39	9.179	0	5.39	4.615	9.2	0	4.615	3.646	9.063	0	3.646	3.163	9.239	0	3.163
0	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.213	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
1.289	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

150 day RTE	170 day RTE	190 day RTE	210 day RTE	230 day RTE
26.351	21.248	17.156	14.612	13.411
6.642	5.39	9.252	3.646	3.163
2.213	0	0	0	0

250 day RTE				5 day RTE				20 day RTE			
ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV	ΔV in space	arrival Vhp	ΔV at Earth	Total ΔV
12.651	2.174	0	12.651	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
12.202	4.566	0	12.202	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
10.868	6.926	0	10.868	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
8.675	8.915	0	8.675	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.891	10.222	0.922	6.813	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
3.095	10.716	1.416	4.511	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
1.733	10.505	1.205	2.938	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.364	9.68	0.38	2.744	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
3.878	8.519	0	3.878	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.128	7.127	0	5.128	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.088	5.622	0	6.088	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.778	4.142	0	6.778	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
7.424	3.612	0	7.424	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
7.49	2.352	0	7.49	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
7.465	2.732	0	7.465	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
7.275	3.874	0	7.275	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.876	5.16	0	6.876	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.275	6.405	0	6.275	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
5.51	7.575	0	5.51	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
		0	0	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.624	8.607	0	2.624	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.667	8.732	0	2.667	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.712	8.851	0	2:712	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.758	8.966	0	2.758	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.806	9.077	0	2.806	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.855	9.182	0	2.855	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.905	9.284	0	2.905	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
2.957	9.381	0.081	3.038	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
3.01	9.474	0.174	3.184	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
3.065	9.564	0.264	3.329	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
3.12	9.65	0.35	3.47	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	78.497	88.887	79.587	158.084	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	59.963	70.416	61.116	121.079	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	41.807	52.04	42.74	84.547	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	24.225	34.109	24.809	49.034	xxx	xxx	xxx	xxx
xxx	xxx	xxx	xxx	7.254	16.851	7.551	14.805	xxx	xxx	xxx	xxx

250 day RTE	5 day RTE	20 day RTE
12.651	0	0
3.47	0	0
0	158.084	0

APPENDIX B MASS STUDIES

This appendix contains the full mass impact studies for the 2014 minimum energy, 2015 Venus swingby and 2015 deep space maneuver missions.

Each subsection consists of two tables, one for split fuel missions and one for all fuel piloted missions. Each table details the piloted mission, cargo mission and total IMLEOs; available abort delta-Vs for each phase; and the delta-V available to the nominal configuration at Mars.

The tables are indexed by type of abort, abort insertion delta-V, abort braking delta-V, transfer vehicle mass, abort transfer vehicle mass, cargo payload mass and samples mass to be returned. Entries in the abort table where the piloted IMLEO is listed as "NOM" indicate that the nominal mission is capable of this abort. This is done rather than simply re-listing the parameters of the nominal mission to emphasize that these case have capabilities beyond their neighbors, while having s smaller IMLEO.

All values on the tables are in units of metric tons and meters/sec.

Appendix B.1.1: 2015 Venus swingby abort mass impacts - split fuel missions

Abort location	Abort insertion	ΔVs braking	Transfer nominal	Vehicles abort	Cargo payload	Samples	piloted	IMLEOs cargo	TOTAL	abort outbound	ΔV available during mission phases: abort from Mars before cargo mission	abort from Mars after rendezvous	nominal from Mars	abort inbound
inbound	5000	0	50	50	100	0	158.05	536.8	694.85	3014	0	9599	9291	5000
						25	158.05	580.37	738.42	3014	0	10305	8280	5000
						50	158.05	623.94	781.99	3014	0	10936	7644	5000
					200	0	158.05	758.03	916.08	3014	0	9599	9291	5000
						25	158.05	801.6	959.65	3014	0	10305	8280	5000
						50	158.05	845.18	1003.23	3014	0	10936	7644	5000
					300	0	158.05	979.27	1137.32	3014	0	9599	9291	5000
						25	158.05	1022.84	1180.89	3014	0	10305	8280	5000
						50	158.05	1066.41	1224.46	3014	0	10936	7644	5000
				20	100	0	158.05	438.28	596.33	5272	0	11297	7354	5000
						25	158.05	481.85	639.9	5272	0	12349	6713	5000
						50	158.05	525.42	683.47	5272	0	13228	6331	5000
					200	0	158.05	659.52	817.57	5272	0	11297	7354	5000
						25	158.05	703.09	861.14	5272	0	12349	6713	5000
						50	158.05	746.66	904.71	5272	0	13228	6331	5000
					300	0	158.05	880.75	1038.8	5272	0	11297	7354	5000
						25	158.05	924.32	1082.37	5272	0	12349	6713	5000
						50	158.05	967.89	1125.94	5272	0	13228	6331	5000
			75	75	100	0	223.57	662.47	886.04	3049	0	9566	9349	5000
						25	223.57	706.04	929.61	3049	0	10071	8570	5000
						50	223.57	749.61	973.18	3049	0	10537	8022	5000
					200	0	223.57	883.7	1107.27	3049	0	9566	9349	5000
						25	223.57	927.27	1150.84	3049	0	10071	8570	5000
						50	223.57	970.65	1194.42	3049	0	10537	8022	5000
					300	0	223.57	1104.94	1328.51	3049	0	9566	9349	5000
						25	223.57	1148.51	1372.08	3049	0	10071	8570	5000
						50	223.57	1192.08	1415.65	3049	0	10537	8022	5000
				20	100	0	223.57	481.85	705.42	6791	0	12349	6713	5000
						25	223.57	525.42	748.99	6791	0	13228	6331	5000
						50	223.57	568.99	792.56	6791	0	13978	6077	5000
					200	0	223.57	703.09	926.66	6791	0	12349	6713	5000
						25	223.57	746.66	970.23	6791	0	13228	6331	5000
						50	223.57	790.23	1013.8	6791	0	13978	6077	5000
					300	0	223.57	924.32	1147.89	6791	0	12349	6713	5000
						25	223.57	967.89	1191.46	6791	0	13228	6331	5000
						50	223.57	1011.47	1235.04	6791	0	13978	6077	5000
	2500	2500	50	50	100	0	158.05	528.57	686.62	3014	0	9456	9150	4842
						25	158.05	572.14	730.19	3014	0	10177	8162	4842
						50	158.05	615.71	773.76	3014	0	10822	7593	4842
					200	0	158.05	749.81	907.86	3014	0	9456	9150	4842
						25	158.05	793.38	951.43	3014	0	10177	8162	4842
						50	158.05	836.95	995	3014	0	10822	7593	4842
					300	0	158.05	971.04	1129.09	3014	0	9456	9150	4842
						25	158.05	1014.61	1172.66	3014	0	10177	8162	4842
						50	158.05	1058.18	1216.23	3014	0	10822	7593	4842
				20	100	0	158.05	471.77	629.82	5272	0	11122	7203	4740
						25	158.05	475.34	633.39	5272	0	12204	6595	4740
						50	158.05	518.91	676.96	5272	0	13106	6234	4740
					200	0	158.05	653	811.05	5272	0	11122	7203	4740
						25	158.05	696.58	854.63	5272	0	12204	6595	4740
						50	158.05	740.15	898.2	5272	0	13106	6234	4740
					300	0	158.05	874.24	1032.29	5272	0	11122	7203	4740
						25	158.05	917.81	1075.86	5272	0	12204	6595	4740
						50	158.05	961.38	1119.43	5272	0	13106	6234	4740
			75	75	100	0	223.57	652.81	876.38	3049	0	9449	9232	4870
						25	223.57	696.38	919.95	3049	0	9963	8468	4870
						50	223.57	739.95	963.52	3049	0	10437	7931	4870
					200	0	223.57	874.05	1097.62	3049	0	9449	9232	4870
						25	223.57	917.62	1141.19	3049	0	9963	8468	4870
						50	223.57	961.19	1184.76	3049	0	10437	7931	4870
					300	0	223.57	1095.28	1318.85	3049	0	9449	9232	4870
						25	223.57	1138.85	1362.42	3049	0	9963	8468	4870
						50	223.57	1182.42	1405.99	3049	0	10437	7931	4870
				20	100	0	223.57	475.34	698.91	6791	0	12204	6595	4740
						25	223.57	518.91	742.48	6791	0	13106	6234	4740
						50	223.57	562.48	786.05	6791	0	13872	5995	4740
					200	0	223.57	696.58	920.15	6791	0	12204	6595	4740
						25	223.57	740.15	963.72	6791	0	13106	6234	4740
						50	223.57	783.72	1007.29	6791	0	13872	5995	4740
					300	0	223.57	917.81	1141.38	6791	0	12204	6595	4740
						25	223.57	961.38	1184.95	6791	0	13106	6234	4740
						50	223.57	1004.96	1228.53	6791	0	13872	5995	4740
	10000	0	50	50	100	0	158.05	923.95	1082	3014	0	14007	13687	10000
						25	158.05	967.52	1125.57	3014	0	14331	12201	10000
						50	158.05	1011.1	1169.15	3014	0	14634	11158	10000
					200	0	158.05	1145.19	1303.24	3014	0	14007	13687	10000
						25	158.05	1188.76	1346.81	3014	0	14331	12201	10000
						50	158.05	1232.33	1390.38	3014	0	14634	11158	10000
					300	0	158.05	1366.43	1524.48	3014	0	14007	13687	10000
						25	158.05	1410	1568.05	3014	0	14331	12201	10000
						50	158.05	1453.57	1611.62	3014	0	14634	11158	10000
				20	100	0	158.05	626.35	784.4	5272	0	14814	10649	10000
						25	158.05	669.92	827.97	5272	0	15360	9437	10000
						50	158.05	713.49	871.54	5272	0	15845	8648	10000
					200	0	158.05	847.59	1005.64	5272	0	14814	10649	10000

					25	158.05	891.16	1049.21	5272	0	15360	9437	10000
					50	158.05	934.73	1092.78	5272	0	15845	8648	10000
				300	0	158.05	1068.82	1226.87	5272	0	14814	10649	10000
					25	158.05	1112.39	1270.44	5272	0	15360	9437	10000
					50	158.05	1155.96	1314.01	5272	0	15845	8648	10000
		75	75	100	0	223.57	1215.53	1439.1	3049	0	13992	13766	10000
					25	223.57	1259.1	1482.67	3049	0	14222	12648	10000
					50	223.57	1302.67	1526.24	3049	0	14442	11790	10000
				200	0	223.57	1437.76	1661.33	3049	0	13992	13766	10000
					25	223.57	1480.33	1703.9	3049	0	14222	12648	10000
					50	223.57	1523.91	1747.48	3049	0	14442	11790	10000
				300	0	223.57	1658	1881.57	3049	0	13992	13766	10000
					25	223.57	1701.57	1925.14	3049	0	14222	12648	10000
					50	223.57	1745.14	1968.71	3049	0	14442	11790	10000
			20	100	0	223.57	669.92	893.49	6791	0	15360	9437	10000
					25	223.57	713.49	937.06	6791	0	15845	8648	10000
					50	223.57	757.06	980.63	6791	0	16278	8092	10000
				200	0	223.57	891.16	1114.73	6791	0	15360	9437	10000
					25	223.57	934.73	1158.3	6791	0	15845	8648	10000
					50	223.57	978.3	1201.87	6791	0	16278	8092	10000
				300	0	223.57	1112.39	1335.96	6791	0	15360	9437	10000
					25	223.57	1155.96	1379.53	6791	0	15845	8648	10000
					50	223.57	1199.54	1423.11	6791	0	16278	8092	10000
5000	5000	50	50	100	0	158.05	871.58	1029.63	3014	0	13585	13264	9510
					25	158.05	915.15	1073.2	3014	0	13938	11802	9510
					50	158.05	958.72	1116.77	3014	0	14267	10786	9510
				200	0	158.05	1092.82	1250.87	3014	0	13585	13264	9510
					25	158.05	1136.62	1294.67	3014	0	13938	11802	9510
					50	158.05	1179.96	1338.01	3014	0	14267	10786	9510
				300	0	158.05	1314.05	1472.1	3014	0	13585	13264	9510
					25	158.05	1357.62	1515.67	3014	0	13938	11802	9510
					50	158.05	1401.19	1559.24	3014	0	14267	10786	9510
			20	100	0	158.05	592.75	750.8	5272	0	14342	10175	9344
					25	158.05	636.32	794.37	5272	0	14945	9027	9344
					50	158.05	679.89	837.94	5272	0	15476	8289	9344
				200	0	158.05	813.98	972.03	5272	0	14342	10175	9344
					25	158.05	857.56	1015.61	5272	0	14945	9027	9344
					50	158.05	901.13	1059.18	5272	0	15476	8289	9344
				300	0	158.05	1035.22	1193.27	5272	0	14342	10175	9344
					25	158.05	1078.79	1236.84	5272	0	14945	9027	9344
					50	158.05	1122.36	1280.41	5272	0	15476	8289	9344
		75	75	100	0	223.57	1147.51	1371.08	3049	0	13610	13383	9556
					25	223.57	1191.08	1414.65	3049	0	13858	12278	9556
					50	223.57	1234.65	1458.22	3049	0	14094	11437	9556
				200	0	223.57	1368.75	1592.32	3049	0	13610	13383	9556
					25	223.57	1412.32	1635.89	3049	0	13858	12278	9556
					50	223.57	1455.89	1679.46	3049	0	14094	11437	9556
				300	0	223.57	1589.98	1813.55	3049	0	13610	13383	9556
					25	223.57	1633.55	1857.12	3049	0	13858	12278	9556
					50	223.57	1677.13	1900.7	3049	0	14094	11437	9556
			20	100	0	223.57	636.32	859.89	6791	0	14945	9027	9344
					25	223.57	679.89	903.46	6791	0	15476	8289	9344
					50	223.57	723.46	947.03	6791	0	15948	7773	9344
				200	0	223.57	857.56	1081.13	6791	0	14945	9027	9344
					25	223.57	901.13	1124.7	6791	0	15476	8289	9344
					50	223.57	944.7	1168.27	6791	0	15948	7773	9344
				300	0	223.57	1078.79	1302.36	6791	0	14945	9027	9344
					25	223.57	1122.36	1345.93	6791	0	15476	8289	9344
					50	223.57	1165.93	1389.5	6791	0	15948	7773	9344
15000	0	50	50	100	0	158.05	1829.72	1987.77	3014	0	18120	17866	15000
					25	158.05	1873.3	2031.35	3014	0	18236	16402	15000
					50	158.05	1916.86	2074.91	3014	0	18349	15270	15000
				200	0	158.05	2050.96	2209.01	3014	0	18120	17866	15000
					25	158.05	2094.53	2252.58	3014	0	18236	16402	15000
					50	158.05	2138.1	2296.15	3014	0	18349	15270	15000
				300	0	158.05	2272.19	2430.24	3014	0	18120	17866	15000
					25	158.05	2315.77	2473.82	3014	0	18236	16402	15000
					50	158.05	2359.34	2517.39	3014	0	18349	15270	15000
			20	100	0	158.05	1066.35	1224.4	5272	0	18417	14680	15000
					25	158.05	1109.92	1267.97	5272	0	18631	13157	15000
					50	158.05	1153.49	1311.54	5272	0	18830	12062	15000
				200	0	158.05	1287.58	1445.63	5272	0	18417	14680	15000
					25	158.05	1331.16	1489.21	5272	0	18631	13157	15000
					50	158.05	1374.73	1532.78	5272	0	18830	12062	15000
				300	0	158.05	1508.82	1666.87	5272	0	18417	14680	15000
					25	158.05	1552.39	1710.44	5272	0	18631	13157	15000
					50	158.05	1595.96	1754.01	5272	0	18830	12062	15000
		75	75	100	0	223.57	2509.44	2733.01	3049	0	18115	17929	15000
					25	223.57	2553.01	2776.58	3049	0	18197	16858	15000
					50	223.57	2596.58	2820.15	3049	0	18277	15968	15000
				200	0	223.57	2730.68	2954.25	3049	0	18115	17929	15000
					25	223.57	2774.25	2997.82	3049	0	18197	16858	15000
					50	223.57	2817.82	3041.39	3049	0	18277	15968	15000
				300	0	223.57	2951.91	3175.48	3049	0	18115	17929	15000
					25	223.57	2995.48	3219.05	3049	0	18197	16858	15000
					50	223.57	3039.05	3262.62	3049	0	18277	15968	15000
			20	100	0	223.57	1109.91	1333.48	6791	0	18631	13157	15000
					25	223.57	1153.49	1377.06	6791	0	18830	12062	15000
					50	223.57	1197.06	1420.63	6791	0	19017	11232	15000
				200	0	223.57	1416.3	1641.87	6791	0	18631	13157	15000
					25	223.57	1374.73	1598.3	6791	0	18830	12062	15000
					50	223.57	1416.3	1641.87	6791	0	19017	11232	15000
				300	0	223.57	1639.53	1863.1	6791	0	18631	13157	15000

						25	223.57	1595.96	1819.53	6791	0	18830	12062	15000
						50	223.57	1639.99	1863.56	6791	0	19017	11232	15000
	7500	7500	50	50	100	0	158.05	1532.87	1690.92	3014	0	17192	16909	13831
						25	158.05	1576.42	1734.47	3014	0	17345	15404	13831
						50	158.05	1619.99	1778.04	3014	0	17492	14260	13831
					200	0	158.05	1754.08	1912.13	3014	0	17192	16909	13831
						25	158.05	1797.66	1955.71	3014	0	17345	15404	13831
						50	158.05	1841.23	1999.28	3014	0	17492	14260	13831
					300	0	158.05	1975.32	2133.37	3014	0	17192	16909	13831
						25	158.05	2018.89	2176.94	3014	0	17345	15404	13831
						50	158.05	2062.46	2220.51	3014	0	17492	14260	13831
				20	100	0	158.05	901.7	1059.75	5272	0	17442	13512	13639
						25	158.05	945.27	1103.32	5272	0	17730	12035	13639
						50	158.05	988.84	1146.89	5272	0	17994	11003	13639
					200	0	158.05	1122.94	1280.99	5272	0	17442	13512	13639
						25	158.05	1166.51	1324.56	5272	0	17730	12035	13639
						50	158.05	1210.08	1368.13	5272	0	17994	11003	13639
					300	0	158.05	1344.17	1502.22	5272	0	17442	13512	13639
						25	158.05	1387.75	1545.8	5272	0	17730	12035	13639
						50	158.05	1431.32	1589.37	5272	0	17994	11003	13639
			75	75	100	0	223.57	2102.37	2325.94	3049	0	17228	17079	13884
						25	223.57	2145.95	2369.52	3049	0	17335	15916	13884
						50	223.57	2189.52	2413.09	3049	0	17438	15008	13884
					200	0	223.57	2323.61	2547.18	3049	0	17228	17079	13884
						25	223.57	2367.18	2590.75	3049	0	17335	15916	13884
						50	223.57	2410.75	2634.32	3049	0	17438	15008	13884
					300	0	223.57	2544.85	2768.42	3049	0	17228	17079	13884
						25	223.57	2588.42	2811.99	3049	0	17335	15916	13884
						50	223.57	2631.99	2855.56	3049	0	17438	15008	13884
				20	100	0	223.57	945.27	1168.84	6791	0	17730	12035	13639
						25	223.57	988.84	1212.41	6791	0	17994	11003	13639
						50	223.57	1032.42	1255.99	6791	0	18239	10236	13639
					200	0	223.57	1166.51	1390.08	6791	0	17730	12035	13639
						25	223.57	1210.08	1433.65	6791	0	17994	11003	13639
						50	223.57	1253.65	1477.22	6791	0	18239	10236	13639
					300	0	223.57	1387.75	1611.32	6791	0	17730	12035	13639
						25	223.57	1431.32	1654.89	6791	0	17994	11003	13639
						50	223.57	1474.89	1698.46	6791	0	18239	10236	13639
From Mars	5000	0	50	50	100	0	NOM							
						25	NOM							
						50	NOM							
					200	0	NOM							
						25	NOM							
						50	NOM							
					300	0	NOM							
						25	NOM							
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				20	100	0	NOM							
						25	NOM							
						50	NOM							
					200	0	NOM							
						25	NOM							
						50	NOM							
					300	0	NOM							
						25	NOM							
						50	NOM							
			75	75	100	0	NOM							
						25	NOM							
						50	NOM							
					200	0	NOM							
						25	NOM							
						50	NOM							
					300	0	NOM							
						25	NOM							
						50	NOM							
				20	100	0	NOM							
						25	NOM							
						50	NOM							
					200	0	NOM							
						25	NOM							
						50	NOM							
					300	0	NOM							
						25	NOM							
						50	NOM							
	2500	2500	50	50	100	0	NOM							
						25	NOM							
						50	NOM							
					200	0	NOM							
						25	NOM							
						50	NOM							
					300	0	NOM							
						25	NOM							
						50	NOM							
				20	100	0	NOM							
						25	NOM							
						50	NOM							
					200	0	NOM							
						25	NOM							
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					300	0	NOM							
						25	NOM							
						50	NOM							
			75	75	100	0	NOM							

					25	NCM							
					50	NCM							
				200	0	NCM							
					25	NCM							
					50	NCM							
				300	0	NCM							
					25	NCM							
					50	NCM							
			20	100	0	NCM							
					25	NCM							
					50	NCM							
				200	0	NCM							
					25	NCM							
					50	NCM							
				300	0	NCM							
					25	NCM							
					50	NCM							
10000	0	50	50	100	0	158.05	560.94	718.99	0	0	10000	9688	0
					25	158.05	560.94	718.99	0	0	10000	7998	0
					50	158.05	560.94	718.99	0	0	10000	6834	0
				200	0	158.05	782.17	940.22	0	0	10000	9688	0
					25	158.05	782.17	940.22	0	0	10000	7998	0
					50	158.05	782.17	940.22	0	0	10000	6834	0
				300	0	158.05	1003.41	1161.46	0	0	10000	9688	0
					25	158.05	1003.41	1161.46	0	0	10000	7998	0
					50	158.05	1003.41	1161.46	0	0	10000	6834	0
			20	100	0	158.05	394.47	552.52	0	0	10000	6271	0
					25	158.05	394.47	552.52	0	0	10000	4943	0
					50	NCM							
				200	0	158.05	615.71	773.76	0	0	10000	6271	0
					25	158.05	615.71	773.76	0	0	10000	4943	0
					50	NCM							
				300	0	158.05	836.95	995	0	0	10000	6271	0
					25	158.05	836.95	995	0	0	10000	4943	0
					50	NCM							
		75	75	100	0	223.57	699.66	923.23	0	0	10000	9779	0
					25	223.57	699.66	923.23	0	0	10000	8503	0
					50	223.57	699.66	923.23	0	0	10000	7538	0
				200	0	223.57	920.9	1144.47	0	0	10000	9779	0
					25	223.57	920.9	1144.47	0	0	10000	8503	0
					50	223.57	920.9	1144.47	0	0	10000	7538	0
				300	0	223.57	1142.13	1365.7	0	0	10000	9779	0
					25	223.57	1142.13	1365.7	0	0	10000	8503	0
					50	223.57	1142.13	1365.7	0	0	10000	7538	0
			20	100	0	223.57	394.47	618.04	0	0	10000	4943	0
					25	NCM							
					50	NCM							
				200	0	223.57	615.71	839.28	0	0	10000	4943	0
					25	NCM							
					50	NCM							
				300	0	223.57	836.95	1060.52	0	0	10000	4943	0
					25	NCM							
					50	NCM							
5000	5000	50	50	100	0	158.05	531.64	689.69	0	0	9510	9203	0
					25	158.05	531.64	689.69	0	0	9510	7550	0
					50	158.05	531.64	689.69	0	0	9510	6421	0
				200	0	158.05	752.88	910.93	0	0	9510	9203	0
					25	158.05	752.88	910.93	0	0	9510	7550	0
					50	158.05	752.88	910.93	0	0	9510	6421	0
				300	0	158.05	974.12	1132.17	0	0	9510	9203	0
					25	158.05	974.12	1132.17	0	0	9510	7550	0
					50	158.05	974.12	1132.17	0	0	9510	6421	0
			20	100	0	158.05	375.68	533.73	0	0	9344	5749	0
					25	NCM							
					50	NCM							
				200	0	158.05	596.91	754.96	0	0	9344	5749	0
					25	NCM							
					50	NCM							
				300	0	158.05	818.15	976.2	0	0	9344	5749	0
					25	NCM							
					50	NCM							
		75	75	100	0	223.57	661.61	885.18	0	0	9556	9339	0
					25	223.57	661.61	885.18	0	0	9556	8085	0
					50	223.57	661.61	885.18	0	0	9556	7144	0
				200	0	223.57	882.85	1106.42	0	0	9556	9339	0
					25	223.57	882.85	1106.42	0	0	9556	8085	0
					50	223.57	882.85	1106.42	0	0	9556	7144	0
				300	0	223.57	1104.09	1327.66	0	0	9556	9339	0
					25	223.57	1104.09	1327.66	0	0	9556	8085	0
					50	223.57	1104.09	1327.66	0	0	9556	7144	0
			20	100	0	NCM							
					25	NCM							
					50	NCM							
				200	0	NCM							
					25	NCM							
					50	NCM							
				300	0	NCM							
					25	NCM							
					50	NCM							
15000	0	50	50	100	0	158.05	1067.58	1225.63	0	0	15000	14688	0
					25	158.05	1067.58	1225.63	0	0	15000	12891	0
					50	158.05	1067.58	1225.63	0	0	15000	11534	0
				200	0	158.05	1288.82	1446.87	0	0	15000	14688	0

						25	158.05	1288.82	1446.87	0	0	15000	12891	0
						50	158.05	1288.82	1446.87	0	0	15000	11534	0
					300	0	158.05	1510.05	1668.1	0	0	15000	14688	0
						25	158.05	1510.05	1668.1	0	0	15000	12891	0
						50	158.05	1510.05	1668.1	0	0	15000	11534	0
				20	100	0	158.05	640.59	798.64	0	0	15000	10839	0
						25	158.05	640.59	798.64	0	0	15000	9081	0
						50	158.05	640.59	798.64	0	0	15000	7843	0
					200	0	158.05	861.82	1019.87	0	0	15000	10839	0
						25	158.05	861.82	1019.87	0	0	15000	9081	0
						50	158.05	861.82	1019.87	0	0	15000	7843	0
					300	0	158.05	1083.06	1241.11	0	0	15000	10839	0
						25	158.05	1083.06	1241.11	0	0	15000	9081	0
						50	158.05	1083.06	1241.11	0	0	15000	7843	0
			75	75	100	0	223.57	1202.18	1425.75	0	0	15000	14780	0
						25	223.57	1202.18	1425.75	0	0	15000	13447	0
						50	223.57	1202.18	1425.75	0	0	15000	12367	0
					200	0	223.57	1644.65	1868.22	0	0	15000	14780	0
						25	223.57	1644.65	1868.22	0	0	15000	13447	0
						50	223.57	1644.65	1868.22	0	0	15000	12367	0
					300	0	223.57	1865.88	2089.45	0	0	15000	14780	0
						25	223.57	1865.88	2089.45	0	0	15000	13447	0
						50	223.57	1865.88	2089.45	0	0	15000	12367	0
				20	100	0	223.57	640.59	864.16	0	0	15000	9081	0
						25	223.57	640.59	864.16	0	0	15000	7843	0
						50	223.57	640.59	864.16	0	0	15000	6915	0
					200	0	223.57	861.82	1085.39	0	0	15000	9081	0
						25	223.57	861.82	1085.39	0	0	15000	7843	0
						50	223.57	861.82	1085.39	0	0	15000	6915	0
					300	0	223.57	1083.06	1306.63	0	0	15000	9081	0
						25	223.57	1083.06	1306.63	0	0	15000	7843	0
						50	223.57	1083.06	1306.63	0	0	15000	6915	0
	7500	7500	50	50	100	0	158.05	901.52	1059.57	0	0	13831	13510	0
						25	158.05	901.52	1059.57	0	0	13831	11693	0
						50	158.05	901.52	1059.57	0	0	13831	10350	0
					200	0	158.05	1122.76	1280.81	0	0	13831	13510	0
						25	158.05	1122.76	1280.81	0	0	13831	11693	0
						50	158.05	1122.76	1280.81	0	0	13831	10350	0
					300	0	158.05	1344	1502.05	0	0	13831	13510	0
						25	158.05	1344	1502.05	0	0	13831	11693	0
						50	158.05	1344	1502.05	0	0	13831	10350	0
				20	100	0	158.05	548.49	706.54	0	0	13639	9486	0
						25	158.05	548.49	706.54	0	0	13639	7812	0
						50	158.05	548.49	706.54	0	0	13639	6662	0
					200	0	158.05	769.73	927.78	0	0	13639	9486	0
						25	158.05	769.73	927.78	0	0	13639	7812	0
						50	158.05	769.73	927.78	0	0	13639	6662	0
					300	0	158.05	990.96	1149.01	0	0	13639	9486	0
						25	158.05	990.96	1149.01	0	0	13639	7812	0
						50	158.05	990.96	1149.01	0	0	13639	6662	0
			75	75	100	0	223.57	1195.72	1419.29	0	0	13884	13658	0
						25	223.57	1195.72	1419.29	0	0	13884	12304	0
						50	223.57	1195.72	1419.29	0	0	13884	11224	0
					200	0	223.57	1416.96	1640.53	0	0	13884	13658	0
						25	223.57	1416.96	1640.53	0	0	13884	12304	0
						50	223.57	1416.96	1640.53	0	0	13884	11224	0
					300	0	223.57	1638.19	1861.76	0	0	13884	13658	0
						25	223.57	1638.19	1861.76	0	0	13884	12304	0
						50	223.57	1638.19	1861.76	0	0	13884	11224	0
				20	100	0	223.57	548.49	772.06	0	0	13639	7812	0
						25	223.57	548.49	772.06	0	0	13639	6602	0
						50	223.57	548.49	772.06	0	0	13639	5816	0
					200	0	223.57	769.73	993.3	0	0	13639	7812	0
						25	223.57	769.73	993.3	0	0	13639	6602	0
						50	223.57	769.73	993.3	0	0	13639	5816	0
					300	0	223.57	990.96	1214.53	0	0	13639	7812	0
						25	223.57	990.96	1214.53	0	0	13639	6602	0
						50	223.57	990.96	1214.53	0	0	13639	5816	0
Piloted	5000	0	50	50	100	0	291.91	232.21	524.12	7940	5000	5028	4811	0
						25	291.91	275.78	567.69	7940	5000	6370	4811	0
						50	291.91	319.35	611.26	7940	5000	7494	4811	0
					200	0	291.91	391.35	683.26	7940	5000	5028	4811	0
						25	291.91	497.02	788.93	7940	5000	6370	4811	0
						50	291.91	540.59	832.5	7940	5000	7494	4811	0
					300	0	291.91	674.68	966.59	7940	5000	5028	4811	0
						25	291.91	718.25	1010.16	7940	5000	6370	4811	0
						50	291.91	761.83	1053.74	7940	5000	7494	4811	0
				20	100	0	266.63	287.32	553.95	9193	5000	8111	4811	0
						25	266.63	330.89	597.52	9193	5000	9809	4811	0
						50	266.63	374.46	641.09	9193	5000	11138	4811	0
					200	0	266.63	508.56	775.19	9193	5000	8111	4811	0
						25	266.63	552.12	818.75	9193	5000	9809	4811	0
						50	266.63	595.69	862.32	9193	5000	11138	4811	0
					300	0	266.63	729.79	996.42	9193	5000	8111	4811	0
						25	266.63	773.36	1039.99	9193	5000	9809	4811	0
						50	266.63	816.93	1083.56	9193	5000	11138	4811	0
			75	75	100	0	411.84	231.38	643.22	7940	5000	5000	4846	0
						25	411.84	273.43	685.27	7940	5000	5937	4811	0
						50	411.84	317	728.84	7940	5000	6792	4811	0
					200	0	411.84	452.61	864.45	7940	5000	5000	4846	0
						25	411.84	499.67	911.51	7940	5000	5937	4811	0
						50	411.84	538.24	950.08	7940	5000	6792	4811	0
					300	0	411.84	673.85	1085.68	7940	5000	5000	4846	0

					25	411.84	715.9	1127.74	7940	5000	5937	4811	0
					50	411.84	759.47	1171.31	7940	5000	6792	4811	0
			20	100	0	292.15	330.89	623.04	10075	5000	9809	4811	0
					25	292.15	374.46	666.61	10075	5000	11138	4811	0
					50	292.15	418.03	710.18	10075	5000	12217	4811	0
				200	0	292.15	552.12	844.27	10075	5000	9809	4811	0
					25	292.15	595.69	887.84	10075	5000	11138	4811	0
					50	292.15	639.27	931.42	10075	5000	12217	4811	0
				300	0	292.15	773.36	1065.51	10075	5000	9809	4811	0
					25	292.15	816.93	1109.08	10075	5000	11138	4811	0
					50	292.15	860.5	1152.65	10075	5000	12217	4811	0
2500	2500	50	50	100	0	286.46	236.81	523.27	7790	4842	5028	4811	0
					25	286.46	280.38	566.84	7790	4842	6370	4811	0
					50	286.46	323.95	610.41	7790	4842	7494	4811	0
				200	0	286.46	458.05	744.51	7790	4842	5028	4811	0
					25	286.46	501.62	788.08	7790	4842	6370	4811	0
					50	286.46	545.19	831.65	7790	4842	7494	4811	0
				300	0	286.46	679.28	965.74	7790	4842	5028	4811	0
					25	286.46	722.86	1009.32	7790	4842	6370	4811	0
					50	286.46	766.43	1052.89	7790	4842	7494	4811	0
			20	100	0	222.32	290.96	513.28	8990	4740	8111	4811	0
					25	222.32	334.53	556.85	8990	4740	9809	4811	0
					50	222.32	378.1	600.42	8990	4740	11138	4811	0
				200	0	222.32	512.91	735.23	8990	4740	8111	4811	0
					25	222.32	555.77	778.09	8990	4740	9809	4811	0
					50	222.32	599.34	821.66	8990	4740	11138	4811	0
				300	0	222.32	733.43	955.75	8990	4740	8111	4811	0
					25	222.32	777	999.32	8990	4740	9809	4811	0
					50	222.32	820.57	1042.89	8990	4740	11138	4811	0
		75	75	100	0	405.44	235.26	640.7	7817	4870	4964	4811	0
					25	405.44	278.83	684.27	7817	4870	5937	4811	0
					50	405.44	322.4	727.84	7817	4870	6792	4811	0
				200	0	405.44	456.5	861.94	7817	4870	4964	4811	0
					25	405.44	500.07	905.51	7817	4870	5937	4811	0
					50	405.44	546.64	952.08	7817	4870	6792	4811	0
				300	0	405.44	677.73	1083.17	7817	4870	4964	4811	0
					25	405.44	721.3	1126.74	7817	4870	5937	4811	0
					50	405.44	764.88	1170.32	7817	4870	6792	4811	0
			20	100	0	287.84	334.52	622.36	9899	4740	9809	4811	0
					25	287.84	378.1	665.94	9899	4740	11138	4811	0
					50	287.84	921.67	1209.51	9899	4740	12217	4811	0
				200	0	287.84	555.77	843.61	9899	4740	9809	4811	0
					25	287.84	599.34	887.18	9899	4740	11138	4811	0
					50	287.84	642.91	930.75	9899	4740	12217	4811	0
				300	0	287.84	777	1064.84	9899	4740	9809	4811	0
					25	287.84	820.57	1108.41	9899	4740	11138	4811	0
					50	287.84	864.14	1151.98	9899	4740	12217	4811	0
10000	0	50	50	100	0	548.45	231.38	779.83	12619	10000	10000	9687	0
					25	548.45	231.38	779.83	12619	10000	10000	7998	0
					50	548.45	231.38	779.83	12619	10000	10000	6834	0
				200	0	548.45	452.61	1001.06	12619	10000	10000	9687	0
					25	548.45	452.61	1001.06	12619	10000	10000	7998	0
					50	548.45	452.61	1001.06	12619	10000	10000	6834	0
				300	0	548.45	673.85	1222.3	12619	10000	10000	9687	0
					25	548.45	673.85	1222.3	12619	10000	10000	7998	0
					50	548.45	673.85	1222.3	12619	10000	10000	6834	0
			20	100	0	351.25	231.38	582.63	13213	10000	10000	6271	0
					25	351.25	231.38	582.63	13213	10000	10000	4943	0
					50	351.25	269.26	620.51	13213	10000	11138	4811	0
				200	0	351.25	452.61	803.86	13213	10000	10000	6271	0
					25	351.25	452.61	803.86	13213	10000	10000	4943	0
					50	351.25	490.5	841.75	13213	10000	11138	4811	0
				300	0	351.25	673.85	1025.1	13213	10000	10000	6271	0
					25	351.25	673.85	1025.1	13213	10000	10000	4943	0
					50	351.25	711.73	1062.98	13213	10000	11138	4811	0
		75	75	100	0	778.31	231.38	1009.69	12619	10000	10000	9780	0
					25	778.31	231.38	1009.69	12619	10000	10000	8503	0
					50	778.31	231.38	1009.69	12619	10000	10000	7538	0
				200	0	778.31	452.61	1230.92	12619	10000	10000	9780	0
					25	778.31	452.61	1230.92	12619	10000	10000	8503	0
					50	778.31	452.61	1230.92	12619	10000	10000	7538	0
				300	0	778.31	673.85	1452.16	12619	10000	10000	9780	0
					25	778.31	673.85	1452.16	12619	10000	10000	8503	0
					50	778.31	673.85	1452.16	12619	10000	10000	7538	0
			20	100	0	416.78	231.38	648.16	13661	10000	10000	4943	0
					25	416.78	269.26	686.04	13661	10000	11138	4811	0
					50	416.78	312.83	729.61	13661	10000	12217	4811	0
				200	0	416.78	452.61	869.39	13661	10000	10000	4943	0
					25	416.78	490.5	907.28	13661	10000	11138	4811	0
					50	416.78	534.07	950.85	13661	10000	12217	4811	0
				300	0	416.78	673.85	1090.63	13661	10000	10000	4943	0
					25	416.78	711.73	1128.51	13661	10000	11138	4811	0
					50	416.78	755.31	1172.09	13661	10000	12217	4811	0
5000	5000	50	50	100	0	513.75	231.38	745.13	12168	9510	9510	9203	0
					25	513.75	231.38	745.13	12168	9510	9510	7550	0
					50	513.75	231.38	745.13	12168	9510	9510	6421	0
				200	0	513.75	452.61	966.36	12168	9510	9510	9203	0
					25	513.75	452.61	966.36	12168	9510	9510	7550	0
					50	513.75	452.61	966.36	12168	9510	9510	6421	0
				300	0	513.75	673.85	1187.6	12168	9510	9510	9203	0
					25	513.75	673.85	1187.6	12168	9510	9510	7550	0
					50	513.75	673.85	1187.6	12168	9510	9510	6421	0
			20	100	0	328.99	231.38	560.37	12677	9344	9344	5749	0

					25	3331.51	21333	20130	18616	17574	3552.75	3773.98	3995.22
					50	3383.13	21377	20186	17591	17574	3604.37	3825.6	4046.84
				20	0	1690.55	21351	20096	16865	17394	1911.79	2133.02	2354.26
					25	1742.17	21438	20210	15357	17394	1963.41	2184.64	2405.88
					50	1793.79	21521	20319	14214	17394	2015.03	2236.26	2457.5
			75	75	0	4721.48	21315	20107	19959	17623	4942.72	5163.95	5385.19
					25	4773.1	21346	20147	19056	17623	4994.34	5215.57	5436.81
					50	4824.72	21376	20185	14214	17623	5045.96	5267.19	5488.43
				20	0	1807.69	21472	20210	15357	17394	2028.93	2250.16	2471.4
					25	1859.31	21553	20319	14214	17394	2080.55	2301.78	2523.02
					50	1910.92	21630	20422	13310	17394	2132.16	2353.39	2574.63
From Mars	5000	0	50	50	0	NOM							
					25	NOM							
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
			75	75	0	423.85	8012	5000	4846	0	645.09	866.32	1087.56
					25	NOM							
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
	2500	2500	50	50	0	NOM							
					25	NOM							
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
			75	75	0	NOM							
					25	NOM							
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
	10000	0	50	50	0	560.47	12665	10000	9688	0	781.71	1002.94	1224.18
					25	560.47	12665	10000	7998	0	781.71	1002.94	1224.18
					50	560.47	12665	10000	6834	0	781.71	1002.94	1224.18
				20	0	363.27	13298	10000	6271	0	584.51	805.74	1026.98
					25	363.27	13298	10000	4943	0	584.51	805.74	1026.98
					50	NOM							
			75	75	0	790.32	12651	10000	9779	0	1011.56	1232.79	1454.03
					25	790.32	12651	10000	8503	0	1011.56	1232.79	1454.03
					50	790.32	12651	10000	7538	0	1011.56	1232.79	1454.03
				20	0	428.79	13739	10000	4943	0	650.03	871.26	1092.5
					25	NOM							
					50	NOM							
	5000	5000	50	50	0	525.76	12219	9510	9203	0	747	968.23	1189.47
					25	525.76	12219	9510	7550	0	747	968.23	1189.47
					50	525.76	12219	9510	6421	0	747	968.23	1189.47
				20	0	341	12772	9344	5749	0	562.24	783.47	1004.71
					25	NOM							
					50	NOM							
			75	75	0	745.25	12246	9556	9339	0	966.49	1187.72	1408.96
					25	745.25	12246	9556	8085	0	966.49	1187.72	1408.96
					50	745.25	12246	9556	7144	0	966.49	1187.72	1408.96
				20	0	NOM							
					25	NOM							
					50	NOM							
	15000	0	50	50	0	1160.66	17103	15000	14688	0	1381.9	1603.13	1824.37
					25	1160.66	17103	15000	12891	0	1381.9	1603.13	1824.37
					50	1160.66	17103	15000	11534	0	1381.9	1603.13	1824.37
				20	0	654.82	17341	15000	10839	0	876.06	1097.29	1318.53
					25	654.82	17341	15000	9081	0	876.06	1097.29	1318.53
					50	654.82	17341	15000	7843	0	876.06	1097.29	1318.53
			75	75	0	1647.71	17098	15000	14760	0	1868.95	2090.18	2311.42
					25	1647.71	17098	15000	13447	0	1868.95	2090.18	2311.42
					50	1647.71	17098	15000	12367	0	1868.95	2090.18	2311.42
				20	0	720.34	17515	15000	9081	0	941.58	1162.81	1384.05
					25	720.34	17515	15000	7843	0	941.58	1162.81	1384.05
					50	720.34	17515	15000	6915	0	941.58	1162.81	1384.05
	7500	7500	50	50	0	963.94	16088	13831	13510	0	1185.18	1406.41	1627.65
					25	963.94	16088	13831	11693	0	1185.18	1406.41	1627.65
					50	963.94	16088	13831	10350	0	1185.18	1406.41	1627.65
				20	0	545.72	16242	13639	9486	0	766.96	988.19	1209.43
					25	545.72	16242	13639	7812	0	766.96	988.19	1209.43
					50	545.72	16242	13639	6662	0	766.96	988.19	1209.43
			75	75	0	1377.97	16128	13884	13658	0	1599.21	1820.44	2041.68
					25	1377.97	16128	13884	12304	0	1599.21	1820.44	2041.68
					50	1377.97	16128	13884	11224	0	1599.21	1820.44	2041.68
				20	0	611.25	16474	13639	7812	0	832.49	1053.72	1274.96
					25	611.25	16474	13639	6662	0	832.49	1053.72	1274.96
					50	611.25	16474	13639	5816	0	832.49	1053.72	1274.96
	20000	0	50	50	0	3221.74	21233	20000	19786	0	3442.98	3664.21	3885.45
					25	3221.74	21233	20000	18459	0	3442.98	3664.21	3885.45
					50	3221.74	21233	20000	17345	0	3442.98	3664.21	3885.45
				20	0	1656.04	21281	20000	16733	0	1877.28	2098.51	2319.75
					25	1656.04	21281	20000	15045	0	1877.28	2098.51	2319.75
					50	1656.04	21281	20000	13720	0	1877.28	2098.51	2319.75
			75	75	0	4592.01	21232	20000	19849	0	4813.25	5034.48	5255.72
					25	4592.01	21232	20000	18887	0	4813.25	5034.48	5255.72
					50	4592.01	21232	20000	18041	0	4813.25	5034.48	5255.72
				20	0	1721.56	21318	20000	15045	0	1942.8	2164.03	2385.27

					25	1721.56	21318	20000	13720	0	1942.8	2164.03	2385.27
					50	1721.56	21318	20000	12642	0	1942.8	2164.03	2385.27
	10000	10000	50	50	0	1844.91	19276	17574	17298	0	2066.15	2287.38	2508.62
					25	1844.91	19276	17574	15657	0	2066.15	2287.38	2508.62
					50	1844.91	19276	17574	14355	0	2066.15	2287.38	2508.62
				20	0	955.91	19254	17394	13455	0	1177.15	1398.38	1619.62
					25	955.91	19254	17394	11638	0	1177.15	1398.38	1619.62
					50	955.91	19254	17394	10296	0	1177.15	1398.38	1619.62
			75	75	0	2651.27	19314	17623	17430	0	2872.51	3093.74	3314.98
					25	2651.27	19314	17623	16229	0	2872.51	3093.74	3314.98
					50	2651.27	19314	17623	15217	0	2872.51	3093.74	3314.98
				20	0	1021.43	19347	17394	11638	0	1242.67	1463.9	1685.14
					25	1021.43	19347	17394	10296	0	1242.67	1463.9	1685.14
					50	1021.43	19347	17394	9255	0	1242.67	1463.9	1685.14
Outbound	5000	0	50	50	0	NOM							
					25	NOM							
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
			75	75	0	NOM							
					25	NOM							
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
	2500	2500	50	50	0	NOM							
					25	NOM							
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
			75	75	0	NOM							
					25	NOM							
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
	10000	0	50	50	0	389.09	10000	7100	6831	0	610.33	831.56	1052.8
					25	389.09	10000	7100	5428	0	610.33	831.56	1052.8
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
			75	75	0	547.12	10000	7124	6933	0	768.36	989.59	1210.83
					25	547.12	10000	7124	5859	0	768.36	989.59	1210.83
					50	547.12	10000	7124	5080	0	768.36	989.59	1210.83
				20	0	NOM							
					25	NOM							
					50	NOM							
	5000	5000	50	50	0	365.23	9510	6573	6315	0	586.47	807.7	1028.94
					25	365.23	9510	6573	4981	0	586.47	807.7	1028.94
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
			75	75	0	516.13	9556	6648	5435	0	737.37	958.6	1179.84
					25	NOM							
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
	15000	0	50	50	0	801.72	15000	12597	12273	0	1022.96	1244.19	1465.43
					25	801.72	15000	12597	10465	0	1022.96	1244.19	1465.43
					50	801.72	15000	12597	9159	0	1022.96	1244.19	1465.43
				20	0	453.96	15000	12106	8064	0	675.2	896.43	1117.67
					25	453.96	15000	12106	6517	0	675.2	896.43	1117.67
					50	453.96	15000	12106	5482	0	675.2	896.43	1117.67
			75	75	0	1136.56	15000	12606	12378	0	1357.8	1579.03	1800.27
					25	1136.56	15000	12606	11025	0	1357.8	1579.03	1800.27
					50	1136.56	15000	12606	9984	0	1357.8	1579.03	1800.27
				20	0	499.01	15000	11694	8191	0	720.25	941.48	1162.72
					25	499.01	15000	11694	5190	0	720.25	941.48	1162.72
					50	NOM							
	7500	7500	50	50	0	666.48	13831	11288	10967	0	887.72	1108.95	1330.19
					25	666.48	13831	11288	9203	0	887.72	1108.95	1330.19
					50	666.48	13831	11288	7957	0	887.72	1108.95	1330.19
				20	0	378.95	13639	10423	8617	0	600.19	821.42	1042.66
					25	378.95	13639	10423	5421	0	600.19	821.42	1042.66
					50	NOM							
			75	75	0	951.12	13884	11359	11132	0	1172.36	1393.59	1614.83
					25	951.12	13884	11359	9803	0	1172.36	1393.59	1614.83
					50	951.12	13884	11359	8779	0	1172.36	1393.59	1614.83
				20	0	424	13639	9865	4849	0	645.24	866.47	1087.71
					25	NOM							
					50	NOM							
	20000	0	50	50	0	2218.71	20000	18458	18201	0	2439.95	2661.18	2882.42
					25	2218.71	20000	18458	16654	0	2439.95	2661.18	2882.42
					50	2218.71	20000	18458	15402	0	2439.95	2661.18	2882.42
				20	0	1142.29	20000	18343	14589	0	1363.53	1584.76	1806
					25	1142.29	20000	18343	12789	0	1363.53	1584.76	1806
					50	1142.29	20000	18343	11434	0	1363.53	1584.76	1806

		75	75	0	3160.76	20000	18460	18279	0	3382	3603.23	3824.47
				25	3160.76	20000	18460	17149	0	3382	3603.23	3824.47
				50	3160.76	20000	18460	16182	0	3382	3603.23	3824.47
			20	0	1187.34	20000	18251	12764	0	1408.58	1629.81	1851.05
				25	1187.34	20000	18251	11319	0	1408.58	1629.81	1851.05
				50	1187.34	20000	18251	10252	0	1408.58	1629.81	1851.05
10000	10000	50	50	0	1272.14	17574	15549	15242	0	1493.38	1714.61	1935.85
				25	1272.14	17574	15549	13465	0	1493.38	1714.61	1935.85
				50	1272.14	17574	15549	12110	0	1493.38	1714.61	1935.85
			20	0	660.96	17394	15066	10907	0	882.2	1103.43	1324.67
				25	660.96	17394	15066	9145	0	882.2	1103.43	1324.67
				50	660.96	17394	15066	7903	0	882.2	1103.43	1324.67
		75	75	0	1826.51	17623	15612	15396	0	2047.75	2268.98	2490.22
				25	1826.51	17623	15612	14083	0	2047.75	2268.98	2490.22
				50	1826.51	17623	15612	13010	0	2047.75	2268.98	2490.22
			20	0	706	17394	14842	8928	0	927.24	1148.47	1369.71
				25	706	17394	14842	7699	0	927.24	1148.47	1369.71
				50	706	17394	14842	6781	0	927.24	1148.47	1369.71

Appendix B.2.1: 2015 deep space maneuver abort mass impacts - split fuel missions

Abort location	Abort insertion	ΔVs braking	Transfer nominal	Vehicles abort	Cargo payload	Samples	piloted	IMLEOs cargo	TOTAL	abort outbound	ΔV available during mission phases: abort from Mars before cargo mission	abort from Mars after rendezvous	nominal from Mars	inbound abort before DSM	inbound abort after DSM
inbound	5000	0	50	50	100	0	156.64	653.02	809.66	3159	0	11250	10718	7593	5000
						25	156.64	721.22	877.86	3159	0	12073	9807	8070	5000
						50	156.64	789.43	946.07	3159	0	12789	9228	8514	5000
					200	0	156.64	874.26	1030.9	3159	0	11250	10718	7593	5000
						25	156.64	942.46	1099.1	3159	0	12073	9807	8070	5000
						50	156.64	1010.66	1167.3	3159	0	12789	9228	8514	5000
					300	0	156.64	1095.49	1252.13	3159	0	11250	10718	7593	5000
						25	156.64	1163.7	1320.34	3159	0	12073	9807	8070	5000
						50	156.64	1231.9	1388.54	3159	0	12789	9228	8514	5000
				20	100	0	156.64	529.96	686.6	5491	0	13209	8876	8757	5000
						25	156.64	598.16	754.8	5491	0	14340	8311	9556	5000
						50	156.64	666.37	823.01	5491	0	15251	7969	10263	5000
					200	0	156.64	751.2	907.84	5491	0	13209	8876	8757	5000
						25	156.64	819.4	976.04	5491	0	14340	8311	9556	5000
						50	156.64	887.6	1044.24	5491	0	15251	7969	10263	5000
					300	0	156.64	972.43	1129.07	5491	0	13209	8876	8757	5000
						25	156.64	1040.64	1197.28	5491	0	14340	8311	9556	5000
						50	156.64	1108.84	1265.48	5491	0	15251	7969	10263	5000
			75	75	100	0	221.78	823.77	1045.55	3196	0	11204	10825	7578	5000
						25	221.78	891.98	1113.76	3196	0	11797	9607	7916	5000
						50	221.78	960.18	1181.96	3196	0	12334	7578	8238	5000
					200	0	221.78	1045.01	1266.79	3196	0	11204	10825	7578	5000
						25	221.78	1113.21	1334.99	3196	0	11797	9607	7916	5000
						50	221.78	1181.42	1403.2	3196	0	12334	7578	8238	5000
					300	0	221.78	1266.24	1488.02	3196	0	11204	10825	7578	5000
						25	221.78	1334.45	1556.23	3196	0	11797	9607	7916	5000
						50	221.78	1402.65	1624.43	3196	0	12334	7578	8238	5000
				20	100	0	221.78	598.16	819.94	7046	0	14340	8311	9556	5000
						25	221.78	666.37	888.15	7046	0	15251	7969	10263	5000
						50	221.78	734.57	956.35	7046	0	16004	7740	10897	5000
					200	0	221.78	819.4	1041.18	7046	0	14340	8311	9556	5000
						25	221.78	887.6	1109.38	7046	0	15251	7969	10263	5000
						50	221.78	955.81	1177.59	7046	0	16004	7740	10897	5000
					300	0	221.78	1040.64	1262.42	7046	0	14340	8311	9556	5000
						25	221.78	1108.84	1330.62	7046	0	15251	7969	10263	5000
						50	221.78	1177.04	1398.82	7046	0	16004	7740	10897	5000
	2500	2500	50	50	100	0	156.64	642.54	799.18	3159	0	11114	10583	7443	4842
						25	156.64	710.95	867.59	3159	0	11957	9695	7930	4842
						50	156.64	779.15	935.79	3159	0	12687	9131	8383	4842
					200	0	156.64	863.98	1020.62	3159	0	11114	10583	7443	4842
						25	156.64	932.18	1088.82	3159	0	11957	9695	7930	4842
						50	156.64	1000.39	1157.03	3159	0	12687	9131	8383	4842
					300	0	156.64	1085.22	1241.86	3159	0	11114	10583	7443	4842
						25	156.64	1153.42	1310.06	3159	0	11957	9695	7930	4842
						50	156.64	1221.62	1378.26	3159	0	12687	9131	8383	4842
				20	100	0	156.64	521.83	678.47	5491	0	13055	8733	8550	4740
						25	156.64	590.03	746.67	5491	0	14218	8199	9374	4740
						50	156.64	658.23	814.87	5491	0	15152	7877	10102	4740
					200	0	156.64	743.06	899.7	5491	0	13055	8733	8550	4740
						25	156.64	811.27	967.91	5491	0	14218	8199	9374	4740
						50	156.64	879.47	1036.11	5491	0	15152	7877	10102	4740
					300	0	156.64	964.3	1120.94	5491	0	13055	8733	8550	4740
						25	156.64	1032.5	1189.14	5491	0	14218	8199	9374	4740
						50	156.64	1100.71	1257.35	5491	0	15152	7877	10102	4740
			75	75	100	0	221.78	811.71	1033.49	3196	0	11092	10714	7455	4870
						25	221.78	879.91	1101.69	3196	0	11697	10015	7799	4870
						50	221.78	948.12	1169.9	3196	0	12243	9520	8126	4870
					200	0	221.78	1032.95	1254.73	3196	0	11092	10714	7455	4870
						25	221.78	1101.15	1322.93	3196	0	11697	10015	7799	4870
						50	221.78	1169.35	1391.13	3196	0	12243	9520	8126	4870
					300	0	221.78	1254.18	1475.96	3196	0	11092	10714	7455	4870
						25	221.78	1322.39	1544.17	3196	0	11697	10015	7799	4870
						50	221.78	1390.59	1612.37	3196	0	12243	9520	8126	4870
				20	100	0	221.78	590.03	811.81	7046	0	14218	8199	9374	4740
						25	221.78	658.23	880.01	7046	0	15152	7877	10102	4740
						50	221.78	726.44	948.22	7046	0	15921	7662	10752	4740
					200	0	221.78	811.27	1033.05	7046	0	14218	8199	9374	4740
						25	221.78	879.47	1101.25	7046	0	15152	7877	10102	4740
						50	221.78	947.67	1169.45	7046	0	15921	7662	10752	4740
					300	0	221.78	1032.5	1254.28	7046	0	14218	8199	9374	4740
						25	221.78	1100.71	1322.49	7046	0	15152	7877	10102	4740
						50	221.78	1168.91	1390.69	7046	0	15921	7662	10752	4740
	10000	0	50	50	100	0	156.64	1136.62	1293.26	3159	0	15378	14863	12294	10000
						25	156.64	1204.82	1361.46	3159	0	15750	13525	12516	10000
						50	156.64	1273.03	1429.67	3159	0	16091	12572	12730	10000
					200	0	156.64	1357.86	1514.5	3159	0	15378	14863	12294	10000
						25	156.64	1426.06	1582.7	3159	0	15750	13525	12516	10000
						50	156.64	1494.26	1650.9	3159	0	16091	12572	12730	10000
					300	0	156.64	1578.09	1735.73	3159	0	15378	14863	12294	10000
						25	156.64	1647.3	1803.94	3159	0	15750	13525	12516	10000
						50	156.64	1715.5	1872.14	3159	0	16091	12572	12730	10000
				20	100	0	156.64	764.88	921.52	5491	0	16299	12005	12849	10000
						25	156.64	833.08	989.72	5491	0	16891	10910	13254	10000
						50	156.64	901.29	1057.93	5491	0	17041	10187	13629	10000
					200	0	156.64	986.12	1142.76	5491	0	16299	12005	12849	10000

					25	156.64	1054.32	1210.96	5491	0	16891	10910	13254	10000
					50	156.64	1122.52	1279.16	5491	0	17041	10187	13629	10000
				300	0	156.64	1207.35	1363.99	5491	0	16299	12005	12849	10000
					25	156.64	1275.56	1432.2	5491	0	16891	10910	13254	10000
					50	156.64	1343.76	1500.4	5491	0	17041	10187	13629	10000
		75	75	100	0	221.78	1514.61	1736.39	3196	0	15358	14993	12287	10000
					25	221.78	1582.81	1804.59	3196	0	15623	13977	12444	10000
					50	221.78	1651.01	1872.79	3196	0	15872	12597	13189	10000
				200	0	221.78	1735.84	1957.62	3196	0	15358	14993	12287	10000
					25	221.78	1804.05	2025.83	3196	0	15623	13977	12444	10000
					50	221.78	1872.25	2094.03	3196	0	15872	12597	13189	10000
				300	0	221.78	1957.08	2178.86	3196	0	15358	14993	12287	10000
					25	221.78	2025.28	2247.06	3196	0	15623	13977	12444	10000
					50	221.78	2093.49	2315.27	3196	0	15872	12597	13189	10000
			20	100	0	221.78	833.08	1054.86	7046	0	16891	10910	13254	10000
					25	221.78	901.29	1123.07	7046	0	17401	10187	13629	10000
					50	221.78	969.49	1191.27	7046	0	17845	9674	13978	10000
				200	0	221.78	1054.32	1276.1	7046	0	16891	10910	13254	10000
					25	221.78	1122.52	1344.3	7046	0	17401	10187	13629	10000
					50	221.78	1190.73	1412.51	7046	0	17845	9674	13978	10000
				300	0	221.78	1275.56	1497.34	7046	0	16891	10910	13254	10000
					25	221.78	1343.76	1565.54	7046	0	17401	10187	13629	10000
					50	221.78	1411.96	1633.74	7046	0	17845	9674	13978	10000
5000	5000	50	50	100	0	156.64	1071.2	1227.84	3159	0	14988	14467	11839	9510
					25	156.64	1139.4	1296.04	3159	0	15394	13149	12081	9510
					50	156.64	1207.61	1364.25	3159	0	15764	12220	12312	9510
				200	0	156.64	1292.44	1449.08	3159	0	14988	14467	11839	9510
					25	156.64	1360.64	1517.28	3159	0	15394	13149	12081	9510
					50	156.64	1428.84	1585.48	3159	0	15764	12220	12312	9510
				300	0	156.64	1513.67	1670.31	3159	0	14988	14467	11839	9510
					25	156.64	1581.88	1738.52	3159	0	15394	13149	12081	9510
					50	156.64	1650.08	1806.72	3159	0	15764	12220	12312	9510
			20	100	0	156.64	722.91	879.55	5491	0	15885	11555	12303	9344
					25	156.64	791.11	947.75	5491	0	16538	10520	12751	9344
					50	156.64	859.32	1015.96	5491	0	17096	9845	13163	9344
				200	0	156.64	944.15	1100.79	5491	0	15885	11555	12303	9344
					25	156.64	1012.35	1168.99	5491	0	16538	10520	12751	9344
					50	156.64	1080.55	1237.19	5491	0	17096	9845	13163	9344
				300	0	156.64	1165.38	1322.02	5491	0	15885	11555	12303	9344
					25	156.64	1233.59	1390.23	5491	0	16538	10520	12751	9344
					50	156.64	1301.79	1458.43	5491	0	17096	9845	13163	9344
		75	75	100	0	221.78	1429.65	1651.43	3196	0	15003	14634	11875	9556
					25	221.78	1497.85	1719.63	3196	0	15290	13629	12044	9556
					50	221.78	1566.05	1787.83	3196	0	15559	12856	12208	9556
				200	0	221.78	1650.88	1872.66	3196	0	15003	14634	11875	9556
					25	221.78	1719.09	1940.87	3196	0	15290	13629	12044	9556
					50	221.78	1787.29	2009.07	3196	0	15559	12856	12208	9556
				300	0	221.78	1872.12	2093.9	3196	0	15003	14634	11875	9556
					25	221.78	1940.32	2162.1	3196	0	15290	13629	12044	9556
					50	221.78	2008.53	2230.31	3196	0	15559	12856	12208	9556
			20	100	0	221.78	791.11	1012.89	7046	0	16538	10520	12751	9344
					25	221.78	859.32	1081.1	7046	0	17096	9845	13163	9344
					50	221.78	927.52	1149.3	7046	0	17579	9369	13545	9344
				200	0	221.78	1012.35	1234.13	7046	0	16538	10520	12751	9344
					25	221.78	1080.55	1302.33	7046	0	17096	9845	13163	9344
					50	221.78	1148.76	1370.54	7046	0	17579	9369	13545	9344
				300	0	221.78	1233.59	1455.37	7046	0	16538	10520	12751	9344
					25	221.78	1301.79	1523.57	7046	0	17096	9845	13163	9344
					50	221.78	1369.99	1591.77	7046	0	17579	9369	13545	9344
15000	0	50	50	100	0	160.17	2268.03	2428.2	3159	0	19114	18712	16825	15000
					25	160.17	2336.23	2496.4	3159	0	19243	17432	16907	15000
					50	160.17	2404.43	2564.6	3159	0	19366	16419	16988	15000
				200	0	160.17	2489.26	2649.43	3159	0	19114	18712	16825	15000
					25	160.17	2557.47	2717.64	3159	0	19243	17432	16907	15000
					50	160.17	2625.67	2785.84	3159	0	19366	16419	16988	15000
				300	0	160.17	2710.5	2870.67	3159	0	19114	18712	16825	15000
					25	160.17	2778.7	2938.87	3159	0	19243	17432	16907	15000
					50	160.17	2846.91	3007.08	3159	0	19366	16419	16988	15000
			20	100	0	160.17	1314.49	1474.66	5491	0	19444	15789	17034	15000
					25	160.17	1382.69	1542.86	5491	0	19674	14423	17194	15000
					50	160.17	1450.89	1611.06	5491	0	19884	13426	17346	15000
				200	0	160.17	1535.72	1695.89	5491	0	19444	15789	17034	15000
					25	160.17	1603.93	1764.1	5491	0	19674	14423	17194	15000
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				300	0	160.17	1756.96	1917.13	5491	0	19444	15789	17034	15000
					25	160.17	1825.16	1985.33	5491	0	19674	14423	17194	15000
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		75	75	100	0	226.79	3130.85	3357.64	3196	0	19107	18823	16822	15000
					25	226.79	3199.05	3425.84	3196	0	19199	17877	16880	15000
					50	226.79	3267.25	3494.04	3196	0	19287	17080	16938	15000
				200	0	226.79	3352.08	3578.87	3196	0	19107	18823	16822	15000
					25	226.79	3420.29	3647.08	3196	0	19199	17877	16880	15000
					50	226.79	3488.49	3715.28	3196	0	19287	17080	16938	15000
				300	0	226.79	3573.32	3800.11	3196	0	19107	18823	16822	15000
					25	226.79	3641.52	3868.31	3196	0	19199	17877	16880	15000
					50	226.79	3709.73	3936.52	3196	0	19287	17080	16938	15000
			20	100	0	226.79	1382.69	1609.48	7046	0	19764	14423	17194	15000
					25	226.79	1450.89	1677.68	7046	0	19884	13426	17346	15000
					50	226.79	1519.1	1745.89	7046	0	20077	12662	17492	15000
				200	0	226.79	1603.93	1830.72	7046	0	19764	14423	17194	15000
					25	226.79	1672.13	1898.92	7046	0	19884	13426	17346	15000
					50	226.79	1740.33	1967.12	7046	0	20077	12662	17492	15000
				300	0	226.79	1825.16	2051.95	7046	0	19764	14423	17194	15000

						25	226.79	1893.37	2120.16	7046	0	19884	13426	17346	15000
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	7500	7500	50	50	100	0	160.17	1897.2	2057.37	3159	0	18284	17848	15786	13831
						25	160.17	1965.4	2125.57	3159	0	18455	16513	15893	13831
						50	160.17	2033.6	2193.77	3159	0	18617	15483	15998	13831
					200	0	160.17	2118.43	2278.6	3159	0	18284	17848	15786	13831
						25	160.17	2186.64	2346.81	3159	0	18455	16513	15893	13831
						50	160.17	2254.84	2415.01	3159	0	18617	15483	15998	13831
					300	0	160.17	2339.67	2499.84	3159	0	18284	17848	15786	13831
						25	160.17	2407.87	2568.04	3159	0	18455	16513	15893	13831
						50	160.17	2476.08	2636.25	3159	0	18617	15483	15998	13831
				20	100	0	160.17	1108.83	1269	5491	0	18599	14699	15897	13639
						25	160.17	1177.03	1337.2	5491	0	18909	13369	16110	13639
						50	160.17	1245.23	1405.4	5491	0	19187	12425	16312	13639
					200	0	160.17	1330.06	1490.23	5491	0	18599	14699	15897	13639
						25	160.17	1398.27	1558.44	5491	0	18909	13369	16110	13639
						50	160.17	1466.47	1626.64	5491	0	19187	12425	16312	13639
					300	0	160.17	1551.3	1711.47	5491	0	18599	14699	15897	13639
						25	160.17	1619.5	1779.67	5491	0	18909	13369	16110	13639
						50	160.17	1687.71	1847.88	5491	0	19187	12425	16312	13639
			75	75	100	0	226.79	2622.38	2849.17	3196	0	18313	18006	15830	13884
						25	226.79	2690.58	2917.37	3196	0	18433	17015	15904	13884
						50	226.79	2758.78	2985.57	3196	0	18548	16196	15978	13884
					200	0	226.79	2843.61	3070.4	3196	0	18313	18006	15830	13884
						25	226.79	2911.82	3138.61	3196	0	18433	17015	15904	13884
						50	226.79	2980.02	3206.81	3196	0	18548	16196	15978	13884
					300	0	226.79	3064.85	3291.64	3196	0	18313	18006	15830	13884
						25	226.79	3133.05	3359.84	3196	0	18433	17015	15904	13884
						50	226.79	3201.26	3428.05	3196	0	18548	16196	15978	13884
				20	100	0	226.79	1177.03	1403.82	7046	0	18909	13369	16110	13639
						25	226.79	1245.23	1472.02	7046	0	19187	12425	16312	13639
						50	226.79	1313.44	1540.23	7046	0	19440	11719	16504	13639
					200	0	226.79	1398.27	1625.06	7046	0	18909	13369	16110	13639
						25	226.79	1466.47	1693.26	7046	0	19187	12425	16312	13639
						50	226.79	1534.67	1761.46	7046	0	19440	11719	16504	13639
					300	0	226.79	1619.5	1846.29	7046	0	18909	13369	16110	13639
						25	226.79	1687.71	1914.5	7046	0	19187	12425	16312	13639
						50	226.79	1755.91	1982.7	7046	0	19440	11719	16504	13639
From Mars	5000	0	50	50	100	0	NOM								
						25	NOM								
						50	NOM								
					200	0	NOM								
						25	NOM								
						50	NOM								
					300	0	NOM								
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				20	100	0	NOM								
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						50	NOM								
					300	0	NOM								
						25	NOM								
						50	NOM								
			75	75	100	0	NOM								
						25	NOM								
						50	NOM								
					200	0	NOM								
						25	NOM								
						50	NOM								
					300	0	NOM								
						25	NOM								
						50	NOM								
				20	100	0	NOM								
						25	NOM								
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						25	NOM								
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						50	NOM								
	2500	2500	50	50	100	0	NOM								
						25	NOM								
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					200	0	NOM								
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					200	0	NOM								
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						50	NOM								
					300	0	NOM								
						25	NOM								
						50	NOM								
			75	75	100	0	NOM								

					25	NOM								
					50	NOM								
				200	0	NOM								
					25	NOM								
					50	NOM								
				300	0	NOM								
					25	NOM								
					50	NOM								
			20	100	0	NOM								
					25	NOM								
					50	NOM								
				200	0	NOM								
					25	NOM								
					50	NOM								
				300	0	NOM								
					25	NOM								
					50	NOM								
10000	0	50	50	100	0	156.64	566.51	723.15	0	0	10000	9483	2802	0
					25	156.64	566.51	723.15	0	0	10000	7862	3710	0
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				200	0	156.64	787.75	944.39	0	0	10000	9483	2802	0
					25	156.64	787.75	944.39	0	0	10000	7862	3710	0
					50	156.64	787.75	944.39	0	0	10000	6736	4519	0
				300	0	156.64	1008.99	1165.63	0	0	10000	9483	2802	0
					25	156.64	1008.99	1165.63	0	0	10000	7862	3710	0
					50	156.64	1008.99	1165.63	0	0	10000	6736	4519	0
			20	100	0	NOM								
					25	NOM								
					50	NOM								
				200	0	NOM								
					25	NOM								
					50	NOM								
				300	0	NOM								
					25	NOM								
					50	NOM								
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					25	221.78	705.23	927.01	0	0	10000	8394	3422	0
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					25	221.78	926.47	1148.25	0	0	10000	8394	3422	0
					50	221.78	926.47	1148.25	0	0	10000	7453	4020	0
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			20	100	0	NOM								
					25	NOM								
					50	NOM								
				200	0	NOM								
					25	NOM								
					50	NOM								
				300	0	NOM								
					25	NOM								
					50	NOM								
5000	5000	50	50	100	0	156.64	537.22	693.86	0	0	9510	9002	2801	0
					25	156.64	537.22	693.86	0	0	9510	7418	3710	0
					50	NOM								
				200	0	156.64	758.45	915.09	0	0	9510	9002	2801	0
					25	156.64	758.45	915.09	0	0	9510	7418	3710	0
					50	NOM								
				300	0	156.64	979.69	1136.33	0	0	9510	9002	2801	0
					25	156.64	979.69	1136.33	0	0	9510	7418	3710	0
					50	NOM								
			20	100	0	NOM								
					25	NOM								
					50	NOM								
				200	0	NOM								
					25	NOM								
					50	NOM								
				300	0	NOM								
					25	NOM								
					50	NOM								
		75	75	100	0	221.78	667.19	888.97	0	0	9556	9193	2772	0
					25	221.78	667.19	888.97	0	0	9556	7979	3422	0
					50	221.78	667.19	888.97	0	0	9556	7061	4020	0
				200	0	221.78	888.42	1110.2	0	0	9556	9193	2772	0
					25	221.78	888.42	1110.2	0	0	9556	7979	3422	0
					50	221.78	888.42	1110.2	0	0	9556	7061	4020	0
				300	0	221.78	1109.66	1331.44	0	0	9556	9193	2772	0
					25	221.78	1109.66	1331.44	0	0	9556	7979	3422	0
					50	221.78	1109.66	1331.44	0	0	9556	7061	4020	0
			20	100	0	NOM								
					25	NOM								
					50	NOM								
				200	0	NOM								
					25	NOM								
					50	NOM								
				300	0	NOM								
					25	NOM								
					50	NOM								
15000	0	50	50	100	0	160.17	1073.16	1233.33	0	0	15000	14479	2801	0
					25	160.17	1073.16	1233.33	0	0	15000	12737	3710	0
					50	160.17	1073.16	1233.33	0	0	15000	11415	4519	0
				200	0	160.17	1294.39	1454.56	0	0	15000	14479	2801	0

						25	160.17	1294.39	1454.56	0	0	15000	12737	3710	0
						50	160.17	1294.39	1454.56	0	0	15000	11415	4519	0
					300	0	160.17	1515.63	1675.8	0	0	15000	14479	2801	0
						25	160.17	1515.63	1675.8	0	0	15000	12737	3710	0
						50	160.17	1515.63	1675.8	0	0	15000	11415	4519	0
				20	100	0	160.17	646.16	806.33	0	0	15000	10628	4947	0
						25	160.17	646.16	806.33	0	0	15000	8937	6298	0
						50	160.17	646.16	806.33	0	0	15000	7737	7430	0
					200	0	160.17	867.4	1027.57	0	0	15000	10628	4947	0
						25	160.17	867.4	1027.57	0	0	15000	8937	6298	0
						50	160.17	867.4	1027.57	0	0	15000	7737	7430	0
					300	0	160.17	1088.63	1248.8	0	0	15000	10628	4947	0
						25	160.17	1088.63	1248.8	0	0	15000	8937	6298	0
						50	160.17	1088.63	1248.8	0	0	15000	7737	7430	0
			75	75	100	0	226.79	1428.99	1655.78	0	0	15000	14631	2772	0
						25	226.79	1428.99	1655.78	0	0	15000	13328	3422	0
						50	226.79	1428.99	1655.78	0	0	15000	12269	4020	0
					200	0	226.79	1650.22	1877.01	0	0	15000	14631	2772	0
						25	226.79	1650.22	1877.01	0	0	15000	13328	3422	0
						50	226.79	1650.22	1877.01	0	0	15000	12269	4020	0
					300	0	226.79	1871.46	2098.25	0	0	15000	14631	2772	0
						25	226.79	1871.46	2098.25	0	0	15000	13328	3422	0
						50	226.79	1871.46	2098.25	0	0	15000	12269	4020	0
				20	100	0	226.79	646.16	872.95	0	0	15000	8937	6298	0
						25	226.79	646.16	872.95	0	0	15000	7737	7430	0
						50	226.79	646.16	872.95	0	0	15000	6835	8398	0
					200	0	226.79	867.4	1094.19	0	0	15000	8937	6298	0
						25	226.79	867.4	1094.19	0	0	15000	7737	7430	0
						50	226.79	867.4	1094.19	0	0	15000	6835	8398	0
					300	0	226.79	1088.63	1315.42	0	0	15000	8937	6298	0
						25	226.79	1088.63	1315.42	0	0	15000	7737	7430	0
						50	226.79	1088.63	1315.42	0	0	15000	6835	8398	0
	7500	7500	50	50	100	0	160.17	907.1	1067.27	0	0	13831	13297	2801	0
						25	160.17	907.1	1067.27	0	0	13831	11540	3710	0
						50	160.17	907.1	1067.27	0	0	13831	10233	4519	0
					200	0	160.17	1128.34	1288.51	0	0	13831	13297	2801	0
						25	160.17	1128.34	1288.51	0	0	13831	11540	3710	0
						50	160.17	1128.34	1288.51	0	0	13831	10233	4519	0
					300	0	160.17	1349.57	1509.74	0	0	13831	13297	2801	0
						25	160.17	1349.57	1509.74	0	0	13831	11540	3710	0
						50	160.17	1349.57	1509.74	0	0	13831	10233	4519	0
				20	100	0	160.17	554.07	714.24	0	0	13639	9283	4947	0
						25	160.17	554.07	714.24	0	0	13639	7677	6298	0
						50	160.17	554.07	714.24	0	0	13639	6565	7430	0
					200	0	160.17	775.3	935.47	0	0	13639	9283	4947	0
						25	160.17	775.3	935.47	0	0	13639	7677	6298	0
						50	160.17	775.3	935.47	0	0	13639	6565	7430	0
					300	0	160.17	996.54	1156.71	0	0	13639	9283	4947	0
						25	160.17	996.54	1156.71	0	0	13639	7677	6298	0
						50	160.17	996.54	1156.71	0	0	13639	6565	7430	0
			75	75	100	0	226.79	1201.29	1428.08	0	0	13884	13505	2772	0
						25	226.79	1201.29	1428.08	0	0	13884	12185	3422	0
						50	226.79	1201.29	1428.08	0	0	13884	11127	4020	0
					200	0	226.79	1422.53	1649.32	0	0	13884	13505	2772	0
						25	226.79	1422.53	1649.32	0	0	13884	12185	3422	0
						50	226.79	1422.53	1649.32	0	0	13884	11127	4020	0
					300	0	226.79	1643.77	1870.56	0	0	13884	13505	2772	0
						25	226.79	1643.77	1870.56	0	0	13884	12185	3422	0
						50	226.79	1643.77	1870.56	0	0	13884	11127	4020	0
				20	100	0	226.79	554.07	780.86	0	0	13639	7677	6298	0
						25	226.79	554.07	780.86	0	0	13639	6565	7430	0
						50	226.79	618.32	845.11	0	0	14629	6522	8398	0
					200	0	226.79	775.3	1002.09	0	0	13639	7677	6298	0
						25	226.79	775.3	1002.09	0	0	13639	6565	7430	0
						50	226.79	839.56	1066.35	0	0	14629	6522	8398	0
					300	0	226.79	996.54	1223.33	0	0	13639	7677	6298	0
						25	226.79	996.54	1223.33	0	0	13639	6565	7430	0
						50	226.79	1060.79	1287.58	0	0	14629	6522	8398	0
Piloted	5000	0	50	50	100	0	289.74	300.71	590.45	8080	5000	6892	6455	2801	0
						25	289.74	368.91	658.65	8080	5000	8465	6490	3710	0
						50	289.74	437.11	726.85	8080	5000	9731	6510	4519	0
					200	0	289.74	521.94	811.68	8080	5000	6892	6455	2801	0
						25	289.74	590.15	879.89	8080	5000	8465	6490	3710	0
						50	289.74	658.35	948.09	8080	5000	9731	6510	4519	0
					300	0	289.74	743.18	1032.92	8080	5000	6892	6455	2801	0
						25	289.74	811.38	1101.12	8080	5000	8465	6490	3710	0
						50	289.74	879.59	1169.33	8080	5000	9731	6510	4519	0
				20	100	0	224.83	355.81	580.64	9373	5000	10436	6455	4947	0
						25	224.83	424.02	648.85	9373	5000	12226	6490	6298	0
						50	224.83	492.22	717.05	9373	5000	13571	6510	7430	0
					200	0	224.83	577.05	801.88	9373	5000	10436	6455	4947	0
						25	224.83	645.25	870.08	9373	5000	12226	6490	6298	0
						50	224.83	713.46	938.29	9373	5000	13571	6510	7430	0
					300	0	224.83	798.29	1023.12	9373	5000	10436	6455	4947	0
						25	224.83	866.49	1091.32	9373	5000	12226	6490	6298	0
						50	224.83	934.69	1159.52	9373	5000	13571	6510	7430	0
			75	75	100	0	408.98	322.99	731.97	8080	5000	6800	6490	2772	0
						25	408.98	391.19	800.17	8080	5000	7954	6510	3422	0
						50	408.98	459.4	868.38	8080	5000	8935	6522	4020	0
					200	0	408.98	544.23	953.21	8080	5000	6800	6490	2772	0
						25	408.98	612.43	1021.41	8080	5000	7954	6510	3422	0
						50	408.98	680.63	1089.61	8080	5000	8935	6522	4020	0
					300	0	408.98	765.46	1174.44	8080	5000	6800	6490	2772	0

					25	408.98	833.67	1242.65	8080	5000	7954	6510	3422	0
					50	408.98	901.87	1310.85	8080	5000	8935	6522	4020	0
			20	100	0	289.98	424.01	713.99	10278	5000	12226	6490	6298	0
					25	289.98	492.22	782.2	10278	5000	13571	6510	7430	0
					50	289.98	560.42	850.4	10278	5000	146624	6522	8398	0
				200	0	289.98	645.25	935.23	10278	5000	12226	6490	6298	0
					25	289.98	713.46	1003.44	10278	5000	13571	6510	7430	0
					50	289.98	781.66	1071.64	10278	5000	146624	6522	8398	0
				300	0	289.98	866.49	1156.47	10278	5000	12226	6490	6298	0
					25	289.98	934.69	1224.67	10278	5000	13571	6510	7430	0
					50	289.98	1002.9	1292.88	10278	5000	146624	6522	8398	0
2500	2500	50	50	100	0	284.32	305.31	589.63	7929	4842	6892	6455	2801	0
					25	284.32	373.51	657.83	7929	4842	8465	6490	3710	0
					50	284.32	441.72	726.04	7929	4842	9731	6510	4519	0
				200	0	284.32	526.54	810.86	7929	4842	6892	6455	2801	0
					25	284.32	594.75	879.07	7929	4842	8465	6490	3710	0
					50	284.32	662.95	947.27	7929	4842	9731	6510	4519	0
				300	0	284.32	747.78	1032.1	7929	4842	6892	6455	2801	0
					25	284.32	815.98	1100.3	7929	4842	8465	6490	3710	0
					50	284.32	884.19	1168.51	7929	4842	9731	6510	4519	0
			20	100	0	220.54	359.45	579.99	9172	4740	10436	6455	4947	0
					25	220.54	427.66	648.2	9172	4740	12226	6490	6298	0
					50	220.54	495.86	716.4	9172	4740	13571	6510	7430	0
				200	0	220.54	580.69	801.23	9172	4740	10436	6455	4947	0
					25	220.54	648.89	869.43	9172	4740	12226	6490	6298	0
					50	220.54	717.1	937.64	9172	4740	13571	6510	7430	0
				300	0	220.54	801.93	1022.47	9172	4740	10436	6455	4947	0
					25	220.54	870.13	1090.67	9172	4740	12226	6490	6298	0
					50	220.54	938.33	1158.87	9172	4740	13571	6510	7430	0
		75	75	100	0	402.62	328.39	731.01	7956	4870	6800	6490	2772	0
					25	402.62	396.59	799.21	7956	4870	7954	6510	3422	0
					50	402.62	464.8	867.42	7956	4870	8935	6522	4020	0
				200	0	402.62	549.63	952.25	7956	4870	6800	6490	2772	0
					25	402.62	617.83	1020.45	7956	4870	7954	6510	3422	0
					50	402.62	686.03	1088.65	7956	4870	8935	6522	4020	0
				300	0	402.62	770.86	1173.48	7956	4870	6800	6490	2772	0
					25	402.62	839.07	1241.69	7956	4870	7954	6510	3422	0
					50	402.62	907.27	1309.89	7956	4870	8935	6522	4020	0
			20	100	0	285.69	427.66	713.35	10105	4740	12226	6490	6298	0
					25	285.69	495.86	781.55	10105	4740	13571	6510	7430	0
					50	285.69	564.07	849.76	10105	4740	14629	6522	8398	0
				200	0	285.69	648.89	934.58	10105	4740	12226	6490	6298	0
					25	285.69	717.1	1002.79	10105	4740	13571	6510	7430	0
					50	285.69	785.3	1070.99	10105	4740	14629	6522	8398	0
				300	0	285.69	870.13	1155.82	10105	4740	12226	6490	6298	0
					25	285.69	938.33	1224.02	10105	4740	13571	6510	7430	0
					50	285.69	1006.54	1292.23	10105	4740	14629	6522	8398	0
10000	0	50	50	100	0	544.83	236.95	781.78	12740	10000	10000	9483	2801	0
					25	544.83	236.95	781.78	12740	10000	10000	7862	3710	0
					50	544.83	236.95	781.78	12740	10000	10000	6736	4519	0
				200	0	544.83	458.19	1003.02	12740	10000	10000	9483	2801	0
					25	544.83	458.19	1003.02	12740	10000	10000	7862	3710	0
					50	544.83	458.19	1003.02	12740	10000	10000	6736	4519	0
				300	0	544.83	679.43	1224.26	12740	10000	10000	9483	2801	0
					25	544.83	679.43	1224.26	12740	10000	10000	7862	3710	0
					50	544.83	679.43	1224.26	12740	10000	10000	6736	4519	0
			20	100	0	348.75	250.62	599.37	13354	10000	10436	6455	4947	0
					25	348.75	318.82	667.57	13354	10000	12226	6490	6298	0
					50	348.75	387.02	735.77	13354	10000	13571	6510	7430	0
				200	0	348.75	471.85	820.6	13354	10000	10436	6455	4947	0
					25	348.75	540.06	888.81	13354	10000	12226	6490	6298	0
					50	348.75	608.26	957.01	13354	10000	13571	6510	7430	0
				300	0	348.75	693.09	1041.84	13354	10000	10436	6455	4947	0
					25	348.75	761.29	1110.04	13354	10000	12226	6490	6298	0
					50	348.75	829.5	1178.25	13354	10000	13571	6510	7430	0
		75	75	100	0	773.38	236.95	1010.33	12740	10000	10000	9631	2772	0
					25	773.38	236.95	1010.33	12740	10000	10000	8394	3422	0
					50	773.38	236.95	1010.33	12740	10000	10000	7453	4020	0
				200	0	773.38	458.19	1231.57	12740	10000	10000	9631	2772	0
					25	773.38	458.19	1231.57	12740	10000	10000	8394	3422	0
					50	773.38	458.19	1231.57	12740	10000	10000	7453	4020	0
				300	0	773.38	679.43	1452.81	12740	10000	10000	9631	2772	0
					25	773.38	679.43	1452.81	12740	10000	10000	8394	3422	0
					50	773.38	679.43	1452.81	12740	10000	10000	7453	4020	0
			20	100	0	413.9	318.82	732.72	13814	10000	12226	6490	6298	0
					25	413.9	387.02	800.92	13814	10000	13571	6510	7430	0
					50	413.9	455.23	869.13	13814	10000	14629	6522	8398	0
				200	0	413.9	540.06	953.96	13814	10000	12226	6490	6298	0
					25	413.9	608.26	1022.16	13814	10000	13571	6510	7430	0
					50	413.9	676.46	1090.36	13814	10000	14629	6522	8398	0
				300	0	413.9	761.29	1175.19	13814	10000	12226	6490	6298	0
					25	413.9	829.5	1243.4	13814	10000	13571	6510	7430	0
					50	413.9	897.7	1311.6	13814	10000	14629	6522	8398	0
5000	5000	50	50	100	0	510.32	236.95	747.27	12291	9510	9510	9002	2801	0
					25	510.32	236.95	747.27	12291	9510	9510	7418	3710	0
					50	510.32	249.85	760.17	12291	9510	9731	6510	4519	0
				200	0	510.32	458.19	968.51	12291	9510	9510	9002	2801	0
					25	510.32	458.19	968.51	12291	9510	9510	7418	3710	0
					50	510.32	471.09	981.41	12291	9510	9731	6510	4519	0
				300	0	510.32	679.43	1189.75	12291	9510	9510	9002	2801	0
					25	510.32	679.43	1189.75	12291	9510	9510	7418	3710	0
					50	510.32	692.32	1202.64	12291	9510	9731	6510	4519	0
			20	100	0	326.61	269.41	596.02	12823	9344	10436	6455	4947	0

					25	326.61	337.61	664.22	12823	9344	12226	6490	6298	0
					50	326.61	405.82	732.43	12823	9344	13571	6510	7430	0
				200	0	326.61	490.65	817.26	12823	9344	10436	6455	4947	0
					25	326.61	558.85	885.46	12823	9344	12226	6490	6298	0
					50	326.61	627.05	953.66	12823	9344	13571	6510	7430	0
				300	0	326.61	711.88	1038.49	12823	9344	10436	6455	4947	0
					25	326.61	780.09	1106.7	12823	9344	12226	6490	6298	0
					50	326.61	848.29	1174.9	12823	9344	13571	6510	7430	0
		75	75	100	0	728.56	236.95	965.51	12334	9556	9556	9193	2772	0
					25	728.56	236.95	965.51	12334	9556	9556	7979	3422	0
					50	728.56	236.95	965.51	12334	9556	9556	7061	4020	0
				200	0	728.56	458.19	1186.75	12334	9556	9556	9193	2772	0
					25	728.56	458.19	1186.75	12334	9556	9556	7979	3422	0
					50	728.56	458.19	1186.75	12334	9556	9556	7061	4020	0
				300	0	728.56	679.43	1407.99	12334	9556	9556	9193	2772	0
					25	728.56	679.43	1407.99	12334	9556	9556	7979	3422	0
					50	728.56	679.43	1407.99	12334	9556	9556	7061	4020	0
			20	100	0	391.76	337.61	729.37	13332	9344	12226	6490	6298	0
					25	391.76	405.82	797.58	13332	9344	13571	6510	7430	0
					50	391.76	474.02	865.78	13332	9344	14629	6522	8398	0
				200	0	391.76	558.85	950.61	13332	9344	12226	6490	6298	0
					25	391.76	627.05	1018.81	13332	9344	13571	6510	7430	0
					50	391.76	695.26	1087.02	13332	9344	14629	6522	8398	0
				300	0	391.76	780.09	1171.85	13332	9344	12226	6490	6298	0
					25	391.76	848.29	1240.05	13332	9344	13571	6510	7430	0
					50	391.76	916.49	1308.25	13332	9344	14629	6522	8398	0
15000	0	50	50	100	0	1167.38	236.95	1404.33	17180	15000	15000	14479	2801	0
					25	1167.38	236.95	1404.33	17180	15000	15000	12737	3710	0
					50	1167.38	236.95	1404.33	17180	15000	15000	11415	4519	0
				200	0	1167.38	458.19	1625.57	17180	15000	15000	14479	2801	0
					25	1167.38	458.19	1625.57	17180	15000	15000	12737	3710	0
					50	1167.38	458.19	1625.57	17180	15000	15000	11415	4519	0
				300	0	1167.38	679.43	1846.81	17180	15000	15000	14479	2801	0
					25	1167.38	679.43	1846.81	17180	15000	15000	12737	3710	0
					50	1167.38	679.43	1846.81	17180	15000	15000	11415	4519	0
			20	100	0	653.07	236.95	890.02	17409	15000	15000	10628	4947	0
					25	653.07	236.95	890.02	17409	15000	15000	8937	6298	0
					50	653.07	236.95	890.02	17409	15000	15000	7737	7430	0
				200	0	653.07	458.19	1111.26	17409	15000	15000	10628	4947	0
					25	653.07	458.19	1111.26	17409	15000	15000	8937	6298	0
					50	653.07	458.19	1111.26	17409	15000	15000	7737	7430	0
				300	0	653.07	679.43	1332.5	17409	15000	15000	10628	4947	0
					25	653.07	679.43	1332.5	17409	15000	15000	8937	6298	0
					50	653.07	679.43	1332.5	17409	15000	15000	7737	7430	0
		75	75	100	0	1662.6	236.95	1899.55	17180	15000	15000	14631	2772	0
					25	1662.6	236.95	1899.55	17180	15000	15000	13328	3422	0
					50	1662.6	236.95	1899.55	17180	15000	15000	12269	4020	0
				200	0	1662.6	458.19	2120.79	17180	15000	15000	14631	2772	0
					25	1662.6	458.19	2120.79	17180	15000	15000	13328	3422	0
					50	1662.6	458.19	2120.79	17180	15000	15000	12269	4020	0
				300	0	1662.6	679.43	2342.03	17180	15000	15000	14631	2772	0
					25	1662.6	679.43	2342.03	17180	15000	15000	13328	3422	0
					50	1662.6	679.43	2342.03	17180	15000	15000	12269	4020	0
			20	100	0	719.69	236.95	956.64	17589	15000	15000	8937	6298	0
					25	719.69	236.95	956.64	17589	15000	15000	7737	7430	0
					50	719.69	236.95	956.64	17589	15000	15000	6835	8398	0
				200	0	719.69	458.19	1177.88	17589	15000	15000	8937	6298	0
					25	719.69	458.19	1177.88	17589	15000	15000	7737	7430	0
					50	719.69	458.19	1177.88	17589	15000	15000	6835	8398	0
				300	0	719.69	679.43	1399.12	17589	15000	15000	8937	6298	0
					25	719.69	679.43	1399.12	17589	15000	15000	7737	7430	0
					50	719.69	679.43	1399.12	17589	15000	15000	6835	8398	0
7500	7500	50	50	100	0	967.37	236.95	1204.32	16167	13831	13831	13297	2801	0
					25	967.37	236.95	1204.32	16167	13831	13831	11540	3710	0
					50	967.37	236.95	1204.32	16167	13831	13831	10233	4519	0
				200	0	967.37	458.19	1425.56	16167	13831	13831	13297	2801	0
					25	967.37	458.19	1425.56	16167	13831	13831	11540	3710	0
					50	967.37	458.19	1425.56	16167	13831	13831	10233	4519	0
				300	0	967.37	679.43	1646.8	16167	13831	13831	13297	2801	0
					25	967.37	679.43	1646.8	16167	13831	13831	11540	3710	0
					50	967.37	679.43	1646.8	16167	13831	13831	10233	4519	0
			20	100	0	542.14	236.95	779.09	16310	13639	13639	9283	4947	0
					25	542.14	236.95	779.09	16310	13639	13639	7677	6298	0
					50	542.14	236.95	779.09	16310	13639	13639	6565	7430	0
				200	0	542.14	458.19	1000.33	16310	13639	13639	9283	4947	0
					25	542.14	458.19	1000.33	16310	13639	13639	7677	6298	0
					50	542.14	458.19	1000.33	16310	13639	13639	6565	7430	0
				300	0	542.14	679.43	1221.57	16310	13639	13639	9283	4947	0
					25	542.14	679.43	1221.57	16310	13639	13639	7677	6298	0
					50	542.14	679.43	1221.57	16310	13639	13639	6565	7430	0

75	75	100	0	1388.35	236.95	1625.3	16213	13884	13884	13505	2772	0
			25	1388.35	236.95	1625.3	16213	13884	13884	12185	3422	0
			50	1388.35	236.95	1625.3	16213	13884	13884	11127	4020	0
		200	0	1388.35	458.19	1846.54	16213	13884	13884	13505	2772	0
			25	1388.35	458.19	1846.54	16213	13884	13884	12185	3422	0
			50	1388.35	458.19	1846.54	16213	13884	13884	11127	4020	0
		300	0	1388.35	679.43	2067.78	16213	13884	13884	13505	2772	0
			25	1388.35	679.43	2067.78	16213	13884	13884	12185	3422	0
			50	1388.35	679.43	2067.78	16213	13884	13884	11127	4020	0
	20	100	0	608.76	236.95	845.71	16551	13639	13639	7677	6298	0
			25	608.76	236.95	845.71	16551	13639	13639	6565	7430	0
			50	608.76	301.21	909.97	16551	13639	14629	6522	8398	0
		200	0	608.76	458.19	1066.95	16551	13639	13639	7677	6298	0
			25	608.76	458.19	1066.95	16551	13639	13639	6565	7430	0
			50	608.76	522.44	1131.2	16551	13639	14629	6522	8398	0
		300	0	608.76	679.43	1288.19	16551	13639	13639	7677	6298	0
			25	608.76	679.43	1288.19	16551	13639	13639	6565	7430	0
			50	608.76	743.68	1352.44	16551	13639	14629	6522	8398	0

Appendix B.2.2: 2015 deep space maneuver abort mass impacts - all fuel piloted missions

Abort location	Abort insertion	ΔVs braking	Transfer nominal	Vehicles abort	Samples	Piloted IMLEO	ΔV available during mission phases: abort outbound	abort from Mars	nominal from Mars	inbound abort before DSM	inbound abort after DSM	TOTAL IMLEO Cargo payload = 100	200	300
Inbound	5000	0	50	50	0	673.22	13912	11250	10718	7593	5000	894.46	1115.69	1336.93
					25	755.37	14646	12073	9807	8070	5000	976.61	1197.84	1419.08
					50	837.53	15279	12789	9228	8514	5000	1058.77	1280	1501.24
				20	0	525	16009	13209	8876	8757	5000	746.24	967.47	1188.71
					25	607.15	16915	14340	8311	9556	5000	828.39	1049.62	1270.86
					50	689.3	17642	15251	7969	10263	5000	910.54	1131.77	1353.01
			75	75	0	945.51	13859	11204	10825	7578	5000	1166.75	1387.98	1609.22
					25	1027.67	14391	11797	10113	7916	5000	1248.91	1470.14	1691.38
					50	1109.82	14868	12334	9607	8238	5000	1331.06	1552.29	1773.53
				20	0	673.77	17122	14340	8311	9556	5000	895.01	1116.24	1337.48
					25	755.92	17810	15251	7969	10263	5000	977.16	1198.39	1419.63
					50	838.07	18380	16004	7740	10897	5000	1059.31	1280.54	1501.78
	2500	2500	50	50	0	660.84	13791	11115	10584	7443	4842	882.08	1103.31	1324.55
					25	743	14543	11957	9695	7930	4842	964.24	1185.47	1406.71
					50	825.15	15189	12687	9131	8383	4842	1046.39	1267.62	1488.86
				20	0	515.2	15886	13055	8733	8550	4740	736.44	957.67	1178.91
					25	597.35	16818	14218	8199	9374	4740	818.59	1039.82	1261.06
					50	679.5	17563	15152	7677	10102	4740	900.74	1121.97	1343.21
			75	75	0	930.99	13759	11092	10714	7455	4870	1152.23	1373.46	1594.7
					25	1013.14	14301	11697	10015	7799	4870	1234.38	1455.61	1676.85
					50	1095.29	14787	12243	9520	8126	4870	1316.53	1537.76	1759
				20	0	663.97	17030	14218	8199	9374	4740	885.21	1106.44	1327.68
					25	746.12	17735	15152	7877	10102	4740	967.36	1188.59	1409.83
					50	828.28	18317	15921	7662	10752	4740	1049.52	1270.75	1491.99
	10000	0	50	50	0	828.28	17519	15378	14863	12294	10000	1049.52	1270.75	1491.99
					25	1337.87	17834	15750	13525	12516	10000	1559.11	1780.34	2001.58
					50	1420.02	18121	16091	12572	12730	10000	1641.26	1862.49	2083.73
				20	0	807.96	18473	16299	12005	12849	10000	1029.2	1250.43	1471.67
					25	890.11	18939	16891	10910	13254	10000	1111.35	1332.58	1553.82
					50	972.26	19338	17401	10187	13629	10000	1193.5	1414.73	1635.97
			75	75	0	1777.63	17497	15358	14993	12287	10000	1998.87	2220.1	2441.34
					25	1859.78	17722	15623	13977	12444	10000	2081.02	2302.25	2523.49
					50	1941.93	17933	15872	13189	12597	10000	2163.17	2384.4	2605.64
				20	0	956.73	19050	16891	10910	13254	10000	1177.97	1399.2	1620.44
					25	1038.88	19434	17401	10187	13629	10000	1260.12	1481.35	1702.59
					50	1121.03	19769	17845	9674	13978	10000	1342.27	1563.5	1784.74
	5000	5000	50	50	0	1176.92	17186	14988	14467	11839	9510	1398.16	1619.39	1840.63
					25	1259.07	17532	15394	13149	12081	9510	1480.31	1701.54	1922.78
					50	1341.23	17846	15764	12220	12312	9510	1562.47	1783.7	2004.94
				20	0	757.4	18145	15885	11555	12303	9344	978.64	1199.87	1421.11
					25	839.56	18661	16538	10520	12751	9344	1060.8	1282.03	1503.27
					50	921.71	19099	17096	9845	13163	9344	1142.95	1364.18	1585.42
			75	75	0	1675.29	17194	15003	14634	11875	9556	1896.53	2117.76	2339
					25	1757.44	17439	15290	13629	12044	9556	1978.68	2199.91	2421.15
					50	1839.59	17668	15559	12856	12208	9556	2060.83	2282.06	2503.3
				20	0	906.18	18783	16538	10520	12751	9344	1127.42	1348.65	1569.89
					25	988.33	19204	17096	9845	13163	9344	1209.57	1430.8	1652.04
					50	1070.48	19568	17579	9369	13545	9344	1291.72	1512.95	1734.19
	15000	0	50	50	0	2618.5	20591	19114	18712	16825	15000	2839.74	3060.97	3282.21
					25	2700.66	20693	19243	17432	16907	15000	2921.9	3143.13	3364.37
					50	2782.81	20790	19366	16419	16988	15000	3004.05	3225.28	3446.52
				20	0	1469.96	20914	19444	15789	17034	15000	1691.2	1912.43	2133.67
					25	1552.11	21089	19674	14423	17194	15000	1773.35	1994.58	2215.82
					50	1634.27	21247	19884	13426	17346	15000	1855.51	2076.74	2297.98
			75	75	0	3724.39	20584	19107	18823	16822	15000	3945.63	4166.86	4388.1
					25	3806.55	20656	19199	17877	16880	15000	4027.79	4249.02	4470.26
					50	3888.7	20726	19287	17080	16938	15000	4109.94	4331.17	4552.41
				20	0	1618.73	21132	19784	14423	17194	15000	1839.97	2061.2	2282.44
					25	1700.89	21287	19884	13426	17346	15000	1922.13	2143.36	2364.6
					50	1783.04	21429	20077	12682	17492	15000	2004.28	2225.51	2446.75
	7500	7500	50	50	0	2171.84	19927	18284	17846	15786	13831	2393.08	2614.31	2835.55
					25	2253.99	20065	18455	16513	15893	13831	2475.23	2696.46	2917.7
					50	2336.14	20195	18617	15483	15998	13831	2557.38	2778.61	2999.85
				20	0	1222.24	20268	18599	14699	15897	13639	1443.48	1664.71	1885.95
					25	1304.39	20505	18909	13369	16110	13639	1525.63	1746.86	1968.1
					50	1386.55	20719	19187	12425	16312	13639	1607.79	1829.02	2050.26
			75	75	0	3111.94	19949	18313	18006	15830	13884	3333.18	3554.41	3775.65
					25	3194.09	20045	18433	17015	15905	13884	3415.33	3636.56	3857.8
					50	3276.24	20138	18548	16196	15978	13884	3497.48	3718.71	3939.95
				20	0	1371.01	20564	18909	13369	16110	13639	1592.25	1813.48	2034.72
					25	1453.17	20772	19187	12425	16312	13639	1674.41	1895.64	2116.88
					50	1535.32	20959	19440	11719	16504	13639	1756.56	1977.79	2199.03
	20000	0	50	50	0	7296.38	23022	22304	22089	21079	20000	7519.62	7740.85	7962.09
					25	7380.53	23039	22328	21302	21096	20000	7601.77	7823	8044.24
					50	7462.68	23056	22351	20606	21112	20000	7683.92	7905.15	8126.39
				20	0	3743.32	23078	22366	20141	2122	20000	3964.56	4185.79	4407.03
					25	3825.47	23111	22412	19012	21156	20000	4046.71	4267.94	4489.18
					50	3907.62	23143	22456	18078	21189	20000	4128.86	4350.09	4571.33
			75	75	0	10409.7	23021	22303	2215	21078	20000	10630.9	10852.2	11073.4
					25	10491.9	23033	22320	21585	21090	20000	10713.1	10934.3	11155.6
					50	10574	23045	22336	21067	21102	20000	10795.2	11016.5	11237.7
				20	0	3892.09	23120	22412	19012	21156	20000	4113.33	4334.56	4555.8
					25	3974.24	23151	22456	18078	21189	20000	4195.48	4416.71	4637.95
					50	4056.39	23181	22499	17290	21221	20000	4277.63	4498.86	4720.1

	10000	10000	50	50	0	4172.17	21925	20833	20519	19057	17574	4393.41	4614.64	4835.88
					25	4254.32	21972	20894	19443	19099	17574	4475.56	4696.79	4918.03
					50	4336.47	22017	20954	18543	19139	17574	4557.71	4778.94	5000.18
				20	0	2153.61	21998	20887	17807	19015	17394	2374.85	2596.08	2817.32
					25	2235.76	22088	21008	16471	19101	17394	2457	2678.23	2899.47
					50	2317.91	22172	21122	15440	19185	17394	2539.15	2760.38	2981.62
			75	75	0	6003.07	21946	20861	20641	19098	17623	6224.31	6445.54	6666.78
					25	6085.22	21978	20904	19860	19126	17623	6306.46	6527.69	6748.93
					50	6167.37	22010	20945	19174	19155	17623	6388.61	6609.84	6831.08
				20	0	2302.38	22110	21008	16471	19101	17394	2523.62	2744.85	2966.09
					25	2384.53	22193	21122	15440	19185	17394	2605.77	2827	3048.24
					50	2466.68	22270	21228	14616	19266	17394	2687.92	2909.15	3130.39
From Mars	5000	0	50	50	0	NOM								
					25	NOM								
					50	NOM								
				20	0	NOM								
					25	NOM								
					50	NOM								
			75	75	0	NOM								
					25	NOM								
					50	NOM								
				20	0	NOM								
					25	NOM								
					50	NOM								
	2500	2500	50	50	0	NOM								
					25	NOM								
					50	NOM								
				20	0	NOM								
					25	NOM								
					50	NOM								
			75	75	0	NOM								
					25	NOM								
					50	NOM								
				20	0	NOM								
					25	NOM								
					50	NOM								
	10000	0	50	50	0	576.06	12815	10000	9483	2801	0	797.3	1018.53	1239.77
					25	576.06	12815	10000	7862	3710	0	797.3	1018.53	1239.77
					50	576.06	12815	10000	6736	4519	0	797.3	1018.53	1239.77
				20	0	NOM								
					25	NOM								
					50	NOM								
			75	75	0	809.77	12792	10000	9632	2772	0	1031.01	1252.24	1473.48
					25	809.77	12792	10000	8394	3422	0	1031.01	1252.24	1473.48
					50	809.77	12792	10000	7453	4020	0	1031.01	1252.24	1473.48
				20	0	NOM								
					25	NOM								
					50	NOM								
	5000	5000	50	50	0	540.77	12373	9510	9002	2801	0	762.01	983.24	1204.48
					25	540.77	12373	9510	7418	3710	0	762.01	983.24	1204.48
					50	556.31	12572	9731	6510	4519	0	777.55	998.78	1220.02
				20	0	NOM								
					25	NOM								
					50	NOM								
			75	75	0	763.94	12390	9556	9193	2772	0	985.18	1206.41	1427.65
					25	763.94	12390	9556	7979	3422	0	985.18	1206.41	1427.65
					50	763.94	12390	9556	7061	4020	0	985.18	1206.41	1427.65
				20	0	NOM								
					25	NOM								
					50	NOM								
	15000	0	50	50	0	1186.31	17207	15000	14479	2801	0	1407.55	1628.78	1850.02
					25	1186.31	17207	15000	12737	3710	0	1407.55	1628.78	1850.02
					50	1186.31	17207	15000	11415	4519	0	1407.55	1628.78	1850.02
				20	0	672	17461	15000	10628	4947	0	893.24	1114.47	1335.71
					25	672	17461	15000	8937	6298	0	893.24	1114.47	1335.71
					50	672	17461	15000	7737	7430	0	893.24	1114.47	1335.71
			75	75	0	1685.53	17199	15000	14631	2772	0	1906.77	2128	2349.24
					25	1685.53	17199	15000	13328	3422	0	1906.77	2128	2349.24
					50	1685.53	17199	15000		4020	0	1906.77	2128	2349.24
				20	0	738.62	17639	15000	8937	6298	0	959.86	1181.09	1402.33
					25	738.62	17639	15000	7737	7430	0	959.86	1181.09	1402.33
					50	738.62	17639	15000	6835	8398	0	959.86	1181.09	1402.33
	7500	7500	50	50	0	986.3	16202	13831	13297	2801	0	1207.54	1428.77	1650.01
					25	986.3	16202	13831	11540	3710	0	1207.54	1428.77	1650.01
					50	986.3	16202	13831	10233	4519	0	1207.54	1428.77	1650.01
				20	0	561.07	16380	13639	9283	4947	0	782.31	1003.54	1224.78
					25	561.07	16380	13639	7677	6298	0	782.31	1003.54	1224.78
					50	561.07	16380	13639	6565	7430	0	782.31	1003.54	1224.78
			75	75	0	1407.28	16238	13884	13505	2772	0	1628.52	1849.75	2070.99
					25	1407.28	16238	13884	12185	3422	0	1628.52	1849.75	2070.99
					50	1407.28	16238	13884	11127	4020	0	1628.52	1849.75	2070.99
				20	0	627.69	16617	13639	7677	6298	0	848.93	1070.16	1291.4
					25	627.69	16617	13639	6565	7430	0	848.93	1070.16	1291.4
					50	NOM	NOM				0			
	20000	0	50	50	0	3281.96	21287	20000	19640	2801	0	3503.2	3724.43	3945.67
					25	3281.96	21287	20000	18338	3710	0	3503.2	3724.43	3945.67
					50	3281.96	21287	20000	17242	4519	0	3503.2	3724.43	3945.67
				20	0	1690	21339	20000	16541	4947	0	1911.24	2132.47	2353.71
					25	1690	21339	20000	14897	6298	0	1911.24	2132.47	2353.71
					50	1690	21339	20000	13601	7430	0	1911.24	2132.47	2353.71
			75	75	0	4675.22	21286	20000	19746	2772	0	4896.46	5117.69	5338.93
					25	4675.22	21286	20000	18797	3422	0	4896.46	5117.69	5338.93
					50	4675.22	21286	20000	17961	4020	0	4896.46	5117.69	5338.93

				20	0	1756.63	21377	20000	14897	6298	0	1977.87	2199.1	2420.34
					25	1756.63	21377	20000	13601	7430	0	1977.87	2199.1	2420.34
					50	1756.63	21377	20000	12544	8398	0	1977.87	2199.1	2420.34
	10000	10000	50	50	0	1882.05	19355	17574	17113	2801	0	2103.29	2324.52	2545.76
					25	1882.05	19355	17574	15513	3710	0	2103.29	2324.52	2545.76
					50	1882.05	19355	17574	14238	4519	0	2103.29	2324.52	2545.76
				20	0	978.13	19343	17394	13242	4947	0	1199.37	1420.6	1641.84
					25	978.13	19343	17394	11485	6298	0	1199.37	1420.6	1641.84
					50	978.13	19343	17394	10180	7430	0	1199.37	1420.6	1641.84
			75	75	0	2701.93	19392	17623	17298	2772	0	2923.17	3144.4	3365.64
					25	2701.93	19392	17623	16119	3422	0	2923.17	3144.4	3365.64
					50	2701.93	19392	17623	15123	4020	0	2923.17	3144.4	3365.64
				20	0	1044.75	19439	17394	11485	6298	0	1265.99	1487.22	1708.46
					25	1044.75	19439	17394	10180	7430	0	1265.99	1487.22	1708.46
					50	1044.75	19439	17394	8398	8398	0	1265.99	1487.22	1708.46
Outbound	5000	0	50	50	0	NOM								
					25	NOM								
					50	NOM								
				20	0	NOM								
					25	NOM								
					50	NOM								
			75	75	0	NOM								
					25	NOM								
					50	NOM								
				20	0	NOM								
					25	NOM								
					50	NOM								
	2500	2500	50	50	0	NOM								
					25	NOM								
					50	NOM								
				20	0	NOM								
					25	NOM								
					50	NOM								
			75	75	0	NOM								
					25	NOM								
					50	NOM								
				20	0	NOM								
					25	NOM								
					50	NOM								
	10000	0	50	50	0	392.69	10000	6907	6470	2801	0	613.93	835.16	1056.4
					25	NOM								
					50	NOM								
				20	0	NOM								
					25	NOM								
					50	NOM								
			75	75	0	550.46	10000	6947	6633	2772	0	771.7	992.93	1214.17
					25	NOM								
					50	NOM								
				20	0	NOM								
					25	NOM								
					50	NOM								
	5000	5000	50	50	0	NOM								
					25	NOM								
					50	NOM								
				20	0	NOM								
					25	NOM								
					50	NOM								
			75	75	0	NOM								
					25	NOM								
					50	NOM								
				20	0	NOM								
					25	NOM								
					50	NOM								
	15000	0	50	50	0	804.66	15000	12453	11916	2801	0	1025.9	1247.13	1468.37
					25	804.66	15000	12453	10175	3710	0	1025.9	1247.13	1468.37
					50	804.66	15000	12453	8912	4519	0	1025.9	1247.13	1468.37
				20	0	457.46	15000	11906	7697	4947	0	678.7	899.93	1121.17
					25	NOM								
					50	NOM								
			75	75	0	1138.96	15000	12470	12087	2772	0	1360.2	1581.43	1802.67
					25	1138.96	15000	12470	10771	3422	0	1360.2	1581.43	1802.67
					50	1138.96	15000	12470	9757	4020	0	1360.2	1581.43	1802.67
				20	0	NOM								
					25	NOM								
					50	NOM								
	7500	7500	50	50	0	669.63	13831	11134	10603	2801	0	890.87	1112.1	1333.34
					25	669.63	13831	11134	8913	3710	0	890.87	1112.1	1333.34
					50	669.63	13831	11134	7714	4519	0	890.87	1112.1	1333.34
				20	0	NOM								
					25	NOM								
					50	NOM								
			75	75	0	953.82	13834	11213	10835	2772	0	1175.06	1396.29	1617.53
					25	953.82	13834	11213	9548	3422	0	1175.06	1396.29	1617.53
					50	953.82	13834	11213	8553	4020	0	1175.06	1396.29	1617.53
				20	0	NOM								
					25	NOM								
					50	NOM								
	20000	0	50	50	0	2219.36	20000	16370	17937	2801	0	2440.6	2661.83	2883.07
					25	2219.36	20000	16370	16415	3710	0	2440.6	2661.83	2883.07
					50	2219.36	20000	16370	15182	4519	0	2440.6	2661.83	2883.07
				20	0	1144.68	20000	16242	14256	4947	0	1365.92	1587.15	1808.39
					25	1144.68	20000	16242	12509	6298	0	1365.92	1587.15	1808.39
					50	1144.68	20000	16242	11188	7430	0	1365.92	1587.15	1808.39

		75	75	0	3159.89	20000	18373	18068	2772	0	3381.13	3602.36	3823.6
				25	3159.89	20000	18373	16948	3422	0	3381.13	3602.36	3823.6
				50	3159.89	20000	18373	15990	4020	0	3381.13	3602.36	3823.6
			20	0	1189.65	20000	18143	12386	6298	0	1410.89	1632.12	1853.36
				25	1189.65	20000	18143	11087	7430	0	1410.89	1632.12	1853.36
				50	1189.65	20000	18143	10026	8398	0	1410.89	1632.12	1853.36
10000	10000	50	50	0	1274.32	17574	15432	14918	2801	0	1495.56	1716.79	1938.03
				25	1274.32	17574	15432	13189	3710	0	1495.56	1716.79	1938.03
				50	1274.32	17574	15432	11867	4519	0	1495.56	1716.79	1938.03
			20	0	664.12	17394	14916	10542	4947	0	885.36	1106.59	1327.83
				25	664.12	17394	14916	8855	6298	0	885.36	1106.59	1327.83
				50	664.12	17394	14916	7661	7430	0	885.36	1106.59	1327.83
		75	75	0	1827.79	17623	15499	15136	2772	0	2049.03	2270.26	2491.5
				25	1827.79	17623	15499	13847	3422	0	2049.03	2270.26	2491.5
				50	1827.79	17623	15499	12792	4020	0	2049.03	2270.26	2491.5
			20	0	709.09	17394	14675	8625	6298	0	930.33	1151.56	1372.8
				25	709.09	17394	14675	7445	7430	0	930.33	1151.56	1372.8
				50	709.09	17394	14675	6561	8398	0	930.33	1151.56	1372.8

Appendix B.3.1: 2014 minimum energy abort mass impacts - split fuel missions

Abort location	Abort insertion	ΔVs braking	Transfer nominal	Vehicles abort	Cargo payload	Samples	piloted	MLEOs cargo	TOTAL	ΔV available during mission phases: abort outbound	abort from Mars before cargo mission	abort from Mars after rendezvous	nominal from Mars	abort inbound
Inbound	5000	0	50	50	100	0	131.75	407.02	538.77	2687	0	6876	6652	5000
						25	131.75	420.67	552.42	2687	0	7240	5573	5000
						50	131.75	434.33	566.08	2687	0	7586	4900	5000
					200	0	131.75	617.2	748.95	2687	0	6876	6652	5000
						25	131.75	630.85	762.6	2687	0	7240	5573	5000
						50	131.75	644.5	776.25	2687	0	7586	4900	5000
					300	0	131.75	827.38	959.13	2687	0	6876	6652	5000
						25	131.75	841.03	972.78	2687	0	7240	5573	5000
						50	131.75	854.68	986.43	2687	0	7586	4900	5000
				20	100	0	131.75	341.07	472.82	4771	0	7785	4605	5000
						25	131.75	354.72	486.47	4771	0	8426	3927	5000
						50	131.75	368.37	500.12	4771	0	9010	3524	5000
					200	0	131.75	551.24	682.99	4771	0	7785	4605	5000
						25	131.75	564.9	696.65	4771	0	8426	3927	5000
						50	131.75	578.55	710.3	4771	0	9010	3524	5000
					300	0	131.75	761.42	893.17	4771	0	7785	4605	5000
						25	131.75	775.08	906.83	4771	0	8426	3927	5000
						50	131.75	788.73	920.48	4771	0	9010	3524	5000
			75	75	100	0	187.06	475.63	662.69	2719	0	6862	6704	5000
						25	187.06	489.29	676.35	2719	0	7120	5876	5000
						50	187.06	502.94	690	2719	0	7368	5296	5000
					200	0	187.06	685.81	872.87	2719	0	6862	6704	5000
						25	187.06	699.47	886.53	2719	0	7120	5876	5000
						50	187.06	713.12	900.18	2719	0	7368	5296	5000
					300	0	187.06	895.99	1083.05	2719	0	6862	6704	5000
						25	187.06	909.65	1096.71	2719	0	7120	5876	5000
						50	187.06	923.3	1110.36	2719	0	7368	5296	5000
				20	100	0	187.06	354.72	541.78	6202	0	8426	3927	5000
						25	187.06	368.37	555.43	6202	0	9010	3524	5000
						50	187.06	382.02	569.08	6202	0	9544	3258	5000
					200	0	187.06	564.9	751.96	6202	0	8426	3927	5000
						25	187.06	578.55	765.61	6202	0	9010	3524	5000
						50	187.06	592.2	779.26	6202	0	9544	3258	5000
					300	0	187.06	775.08	962.14	6202	0	8426	3927	5000
						25	187.06	788.73	975.79	6202	0	9010	3524	5000
						50	187.06	802.38	989.44	6202	0	9544	3258	5000
	2500	2500	50	50	100	0	131.75	401.51	533.26	2687	0	6723	6502	4842
						25	131.75	415.17	546.92	2687	0	7096	5449	4842
						50	131.75	428.82	560.57	2687	0	7449	4795	4842
					200	0	131.75	611.69	743.44	2687	0	6723	6502	4842
						25	131.75	625.34	757.09	2687	0	7096	5449	4842
						50	131.75	639	770.75	2687	0	7449	4795	4842
					300	0	131.75	821.87	953.62	2687	0	6723	6502	4842
						25	131.75	835.52	967.27	2687	0	7096	5449	4842
						50	131.75	849.18	980.93	2687	0	7449	4795	4842
				20	100	0	131.75	336.71	468.46	4771	0	7567	4447	4740
						25	131.75	350.36	482.11	4771	0	8229	3804	4740
						50	131.75	364.01	495.76	4771	0	8829	3424	4740
					200	0	131.75	546.89	678.64	4771	0	7567	4447	4740
						25	131.75	560.54	692.29	4771	0	8229	3804	4740
						50	131.75	574.19	705.94	4771	0	8829	3424	4740
					300	0	131.75	757.07	888.82	4771	0	7567	4447	4740
						25	131.75	770.72	902.47	4771	0	8229	3804	4740
						50	131.75	784.37	916.12	4771	0	8829	3424	4740
			75	75	100	0	187.06	469.17	656.23	2719	0	6737	6580	4870
						25	187.06	482.82	669.88	2719	0	6999	5768	4870
						50	187.06	496.48	683.54	2719	0	7252	5200	4870
					200	0	187.06	679.35	866.41	2719	0	6737	6580	4870
						25	187.06	693	880.06	2719	0	6999	5768	4870
						50	187.06	706.65	893.71	2719	0	7252	5200	4870
					300	0	187.06	889.53	1076.59	2719	0	6737	6580	4870
						25	187.06	903.18	1090.24	2719	0	6999	5768	4870
						50	187.06	916.83	1103.89	2719	0	7252	5200	4870
				20	100	0	187.06	350.36	537.42	6202	0	8229	3804	4740
						25	187.06	364.01	551.07	6202	0	8829	3424	4740
						50	187.06	377.67	564.73	6202	0	9379	3173	4740
					200	0	187.06	560.54	747.6	6202	0	8229	3804	4740
						25	187.06	574.19	761.25	6202	0	8829	3424	4740
						50	187.06	587.84	774.9	6202	0	9379	3173	4740
					300	0	187.06	770.72	957.78	6202	0	8229	3804	4740
						25	187.06	784.37	971.43	6202	0	8829	3424	4740
						50	187.06	798.02	985.08	6202	0	9379	3173	4740
	10000	0	50	50	100	0	131.75	661.21	792.96	2687	0	11662	11390	10000
						25	131.75	679.86	811.61	2687	0	11833	9758	10000
						50	131.75	693.51	825.26	2687	0	11999	8628	10000
					200	0	131.75	876.39	1008.14	2687	0	11662	11390	10000
						25	131.75	890.04	1021.79	2687	0	11833	9758	10000
						50	131.75	903.69	1035.44	2687	0	11999	8628	10000
					300	0	131.75	1086.57	1218.32	2687	0	11662	11390	10000
						25	131.75	1100.22	1231.97	2687	0	11833	9758	10000
						50	131.75	1113.87	1245.62	2687	0	11999	8628	10000
				20	100	0	131.75	466.97	598.72	4771	0	12096	8100	10000
						25	131.75	480.63	612.38	4771	0	12417	6798	10000
						50	131.75	494.28	626.03	4771	0	12720	5958	10000
					200	0	131.75	677.15	808.9	4771	0	12096	8100	10000

					25	131.75	690.8	822.55	4771	0	12417	6798	10000
					50	131.75	704.46	836.21	4771	0	12720	5958	10000
				300	0	131.75	887.33	1019.08	4771	0	12096	8100	10000
					25	131.75	900.98	1032.73	4771	0	12417	6798	10000
					50	131.75	914.64	1046.39	4771	0	12720	5958	10000
		75	75	100	0	187.06	845.89	1032.95	2719	0	11656	11464	10000
					25	187.06	859.54	1046.6	2719	0	11776	10236	10000
					50	187.06	873.2	1060.26	2719	0	11894	9303	10000
				200	0	187.06	1056.07	1243.13	2719	0	11656	11464	10000
					25	187.06	1069.72	1256.78	2719	0	11776	10236	10000
					50	187.06	1083.38	1270.44	2719	0	11894	9303	10000
				300	0	187.06	1266.25	1453.31	2719	0	11656	11464	10000
					25	187.06	1279.9	1466.96	2719	0	11776	10236	10000
					50	187.06	1293.55	1480.61	2719	0	11894	9303	10000
			20	100	0	187.06	480.63	667.69	6202	0	12417	6798	10000
					25	187.06	494.28	681.34	6202	0	12720	5958	10000
					50	187.06	507.93	694.99	6202	0	13006	5369	10000
				200	0	187.06	690.8	877.86	6202	0	12417	6798	10000
					25	187.06	704.46	891.52	6202	0	12720	5958	10000
					50	187.06	718.11	905.17	6202	0	13006	5369	10000
				300	0	187.06	900.98	1088.04	6202	0	12417	6798	10000
					25	187.06	914.64	1101.7	6202	0	12720	5958	10000
					50	187.06	928.29	1115.35	6202	0	13006	5369	10000
5000	5000	50	50	100	0	131.75	631.15	762.9	2687	0	11197	10926	9510
					25	131.75	644.8	776.55	2687	0	11383	9326	9510
					50	131.75	658.45	790.2	2687	0	11563	8229	9510
				200	0	131.75	841.33	973.08	2687	0	11197	10926	9510
					25	131.75	854.98	986.73	2687	0	11383	9326	9510
					50	131.75	868.63	1000.38	2687	0	11563	8229	9510
				300	0	131.75	1051.5	1183.25	2687	0	11197	10926	9510
					25	131.75	1065.16	1196.91	2687	0	11383	9326	9510
					50	131.75	1078.81	1210.56	2687	0	11563	8229	9510
			20	100	0	131.75	444.48	576.23	4771	0	11523	7593	9344
					25	131.75	458.13	589.88	4771	0	11878	6363	9344
					50	131.75	471.78	603.53	4771	0	12212	5579	9344
				200	0	131.75	654.66	786.41	4771	0	11523	7593	9344
					25	131.75	668.31	800.06	4771	0	11878	6363	9344
					50	131.75	681.96	813.71	4771	0	12212	5579	9344
				300	0	131.75	864.84	996.59	4771	0	11523	7593	9344
					25	131.75	878.49	1010.24	4771	0	11878	6363	9344
					50	131.75	892.14	1023.89	4771	0	12212	5579	9344
		75	75	100	0	187.06	800.36	987.42	2719	0	11234	11043	9556
					25	187.06	814.01	1001.07	2719	0	11364	9835	9556
					50	187.06	827.66	1014.72	2719	0	11491	8923	9556
				200	0	187.06	1010.53	1197.59	2719	0	11234	11043	9556
					25	187.06	1024.19	1211.25	2719	0	11364	9835	9556
					50	187.06	1037.84	1224.9	2719	0	11491	8923	9556
				300	0	187.06	1220.71	1407.77	2719	0	11234	11043	9556
					25	187.06	1234.37	1421.43	2719	0	11364	9835	9556
					50	187.06	1248.02	1435.08	2719	0	11491	8923	9556
			20	100	0	187.06	458.13	645.19	6202	0	11878	6363	9344
					25	187.06	471.78	658.84	6202	0	12212	5579	9344
					50	187.06	485.44	672.5	6202	0	12526	5034	9344
				200	0	187.06	668.31	855.37	6202	0	11878	6363	9344
					25	187.06	681.96	869.02	6202	0	12212	5579	9344
					50	187.06	695.61	882.67	6202	0	12526	5034	9344
				300	0	187.06	878.49	1065.55	6202	0	11878	6363	9344
					25	187.06	892.14	1079.2	6202	0	12212	5579	9344
					50	187.06	905.79	1092.85	6202	0	12526	5034	9344
15000	0	50	50	100	0	131.75	1272.59	1404.34	2687	0	16329	16079	15000
					25	131.75	1286.25	1418	2687	0	16394	14400	15000
					50	131.75	1299.9	1431.65	2687	0	16457	13120	15000
				200	0	131.75	1482.77	1614.52	2687	0	16329	16079	15000
					25	131.75	1496.42	1628.17	2687	0	16394	14400	15000
					50	131.75	1510.08	1641.83	2687	0	16457	13120	15000
				300	0	131.75	1692.95	1824.7	2687	0	16329	16079	15000
					25	131.75	1706.6	1838.35	2687	0	16394	14400	15000
					50	131.75	1720.26	1852.01	2687	0	16457	13120	15000
			20	100	0	131.75	761.54	893.29	4771	0	16495	12485	15000
					25	131.75	775.19	906.94	4771	0	16621	10797	15000
					50	131.75	788.84	920.59	4771	0	16743	9601	15000
				200	0	131.75	971.72	1103.47	4771	0	16495	12485	15000
					25	131.75	985.37	1117.12	4771	0	16621	10797	15000
					50	131.75	999.02	1130.77	4771	0	16743	9601	15000
				300	0	131.75	1181.9	1313.65	4771	0	16495	12485	15000
					25	131.75	1195.55	1327.3	4771	0	16621	10797	15000
					50	131.75	1209.2	1340.95	4771	0	16743	9601	15000
		75	75	100	0	187.06	1712.12	1899.18	2719	0	16327	16151	15000
					25	187.06	1725.78	1912.84	2719	0	16372	14911	15000
					50	187.06	1739.43	1926.49	2719	0	16417	13898	15000
				200	0	187.06	1922.3	2109.36	2719	0	16327	16151	15000
					25	187.06	1935.96	2123.02	2719	0	16372	14911	15000
					50	187.06	1949.61	2136.67	2719	0	16417	13898	15000
				300	0	187.06	2132.48	2319.54	2719	0	16327	16151	15000
					25	187.06	2146.13	2333.19	2719	0	16372	14911	15000
					50	187.06	2159.79	2346.85	2719	0	16417	13898	15000
			20	100	0	187.06	775.19	962.25	6202	0	16621	10797	15000
					25	187.06	788.84	975.9	6202	0	16743	9601	15000
					50	187.06	802.5	989.56	6202	0	16861	8703	15000
				200	0	187.06	985.37	1172.43	6202	0	16621	10797	15000
					25	187.06	999.02	1186.08	6202	0	16743	9601	15000
					50	187.06	1012.67	1199.73	6202	0	16861	8703	15000
				300	0	187.06	1195.55	1382.61	6202	0	16621	10797	15000

						25	187.06	1209.2	1396.26	6202	0	16743	9601	15000
						50	187.06	1222.85	1409.91	6202	0	16861	8703	15000
	7500	7500	50	50	100	0	131.75	1073.84	1205.59	2687	0	15253	14991	13831
						25	131.75	1087.5	1219.25	2687	0	15336	13277	13831
						50	131.75	1101.15	1232.9	2687	0	15418	11999	13831
					200	0	131.75	1284.02	1415.77	2687	0	15253	14991	13831
						25	131.75	1297.68	1429.43	2687	0	15336	13277	13831
						50	131.75	1311.33	1443.08	2687	0	15418	11999	13831
					300	0	131.75	1494.2	1625.95	2687	0	15253	14991	13831
						25	131.75	1507.86	1639.61	2687	0	15336	13277	13831
						50	131.75	1521.51	1653.26	2687	0	15418	11999	13831
				20	100	0	131.75	651.31	783.06	4771	0	15298	11197	13639
						25	131.75	664.96	796.71	4771	0	15466	9578	13639
						50	131.75	678.62	810.37	4771	0	15628	8461	13639
					200	0	131.75	861.49	993.24	4771	0	15298	11197	13639
						25	131.75	875.14	1006.89	4771	0	15466	9578	13639
						50	131.75	888.8	1020.55	4771	0	15628	8461	13639
					300	0	131.75	1071.67	1203.42	4771	0	15298	11197	13639
						25	131.75	1085.32	1217.07	4771	0	15466	9578	13639
						50	131.75	1098.98	1230.73	4771	0	15628	8461	13639
			75	75	100	0	187.06	1439.61	1626.67	2719	0	15299	15114	13884
						25	187.06	1453.26	1640.32	2719	0	15357	13844	13884
						50	187.06	1466.91	1653.97	2719	0	15414	12823	13884
					200	0	187.06	1649.79	1836.85	2719	0	15299	15114	13884
						25	187.06	1663.44	1850.5	2719	0	15357	13844	13884
						50	187.06	1677.09	1864.15	2719	0	15414	12823	13884
					300	0	187.06	1859.97	2047.03	2719	0	15299	15114	13884
						25	187.06	1873.62	2060.68	2719	0	15357	13844	13884
						50	187.06	1887.27	2074.33	2719	0	15414	12823	13884
				20	100	0	187.06	664.96	852.02	6202	0	15466	9578	13639
						25	187.06	678.62	865.68	6202	0	15628	8461	13639
						50	187.06	692.27	879.33	6202	0	15784	7639	13639
					200	0	187.06	875.14	1062.2	6202	0	15466	9578	13639
						25	187.06	888.8	1075.86	6202	0	15628	8461	13639
						50	187.06	902.45	1089.51	6202	0	15784	7639	13639
					300	0	187.06	1085.32	1272.38	6202	0	15466	9578	13639
						25	187.06	1098.98	1286.04	6202	0	15628	8461	13639
						50	187.06	1112.63	1299.69	6202	0	15784	7639	13639
From Mars	5000	0	50	50	100	0	131.75	347.04	478.79	2687	0	5000	4817	0
						25	131.75	347.04	478.79	2687	0	5000	3709	0
						50	131.75	347.04	478.79	2687	0	5000	3019	0
					200	0	131.75	557.22	688.97	2687	0	5000	4817	0
						25	131.75	557.22	688.97	2687	0	5000	3709	0
						50	131.75	557.22	688.97	2687	0	5000	3019	0
					300	0	131.75	767.4	899.15	2687	0	5000	4817	0
						25	131.75	767.4	899.15	2687	0	5000	3709	0
						50	131.75	767.4	899.15	2687	0	5000	3019	0
				20	100	0	131.75	294.69	426.44	4771	0	5000	2717	0
						25	131.75	294.69	426.44	4771	0	5000	2024	0
						50	131.75	NOM				5793	1941	0
					200	0	131.75	504.87	636.62	4771	0	5000	2717	0
						25	131.75	504.87	636.62	4771	0	5000	2024	0
						50	131.75	NOM				5793	1941	0
					300	0	131.75	715.05	846.8	4771	0	5000	2717	0
						25	131.75	715.05	846.8	4771	0	5000	2024	0
						50	131.75	NOM				5793	1941	0
			75	75	100	0	187.06	390.67	577.73	2719	0	5000	4870	0
						25	187.06	390.67	577.73	2719	0	5000	4019	0
						50	187.06	390.67	577.73	2719	0	5000	3424	0
					200	0	187.06	600.85	787.91	2719	0	5000	4870	0
						25	187.06	600.85	787.91	2719	0	5000	4019	0
						50	187.06	600.85	787.91	2719	0	5000	3424	0
					300	0	187.06	811.03	998.09	2719	0	5000	4870	0
						25	187.06	811.03	998.09	2719	0	5000	4019	0
						50	187.06	811.03	998.09	2719	0	5000	3424	0
				20	100	0	187.06	294.69	481.75	6202	0	5000	2024	0
						25	187.06	NOM						
						50	187.06	NOM						
					200	0	187.06	504.87	691.93	6202	0	5000	2024	0
						25	187.06	NOM						
						50	187.06	NOM						
					300	0	187.06	715.05	902.11	6202	0	5000	2024	0
						25	187.06	NOM						
						50	187.06	NOM						
	2500	2500	50	50	100	0	131.75	342.67	474.42	2687	0	4842	4663	0
						25	131.75	342.67	474.42	2687	0	4842	3581	0
						50	131.75	342.67	474.42	2687	0	4842	2911	0
					200	0	131.75	552.85	684.6	2687	0	4842	4663	0
						25	131.75	552.85	684.6	2687	0	4842	3581	0
						50	131.75	552.85	684.6	2687	0	4842	2911	0
					300	0	131.75	763.03	894.78	2687	0	4842	4663	0
						25	131.75	763.03	894.78	2687	0	4842	3581	0
						50	131.75	763.03	894.78	2687	0	4842	2911	0
				20	100	0	131.75	291.23	422.98	4771	0	4740	2555	0
						25	131.75	NOM						
						50	131.75	NOM						
					200	0	131.75	501.41	633.16	4771	0	4740	2555	0
						25	131.75	NOM						
						50	131.75	NOM						
					300	0	131.75	711.59	843.34	4771	0	4740	2555	0
						25	131.75	NOM						
						50	131.75	NOM						
			75	75	100	0	187.06	385.54	572.6	2719	0	4870	4743	0

					25	187.06	385.54	572.6	2719	0	4870	3908	0
					50	187.06	385.54	572.6	2719	0	4870	3326	0
				200	0	187.06	595.72	782.78	2719	0	4870	4743	0
					25	187.06	595.72	782.78	2719	0	4870	3908	0
					50	187.06	595.72	782.78	2719	0	4870	3326	0
				300	0	187.06	805.9	992.96	2719	0	4870	4743	0
					25	187.06	805.9	992.96	2719	0	4870	3908	0
					50	187.06	805.9	992.96	2719	0	4870	3326	0
			20	100	0	187.06	NOM						
					25	187.06	NOM						
					50	187.06	NOM						
				200	0	187.06	NOM						
					25	187.06	NOM						
					50	187.06	NOM						
				300	0	187.06	NOM						
					25	187.06	NOM						
					50	187.06	NOM						
10000	0	50	50	100	0	131.75	552.78	684.53	2687	0	10000	9736	0
					25	131.75	552.78	684.53	2687	0	10000	8030	0
					50	131.75	552.78	684.53	2687	0	10000	6857	0
				200	0	131.75	762.96	894.71	2687	0	10000	9736	0
					25	131.75	762.96	894.71	2687	0	10000	8030	0
					50	131.75	762.96	894.71	2687	0	10000	6857	0
				300	0	131.75	973.13	1104.88	2687	0	10000	9736	0
					25	131.75	973.13	1104.88	2687	0	10000	8030	0
					50	131.75	973.13	1104.88	2687	0	10000	6857	0
			20	100	0	131.75	394.63	526.38	4771	0	10000	6310	0
					25	131.75	394.63	526.38	4771	0	10000	4967	0
					50	131.75	394.63	526.38	4771	0	10000	4103	0
				200	0	131.75	604.81	736.56	4771	0	10000	6310	0
					25	131.75	604.81	736.56	4771	0	10000	4967	0
					50	131.75	604.81	736.56	4771	0	10000	4103	0
				300	0	131.75	814.99	946.74	4771	0	10000	6310	0
					25	131.75	814.99	946.74	4771	0	10000	4967	0
					50	131.75	814.99	946.74	4771	0	10000	4103	0
		75	75	100	0	187.06	684.56	871.62	2719	0	10000	9814	0
					25	187.06	684.56	871.62	2719	0	10000	8528	0
					50	187.06	684.56	871.62	2719	0	10000	7557	0
				200	0	187.06	894.74	1081.8	2719	0	10000	9814	0
					25	187.06	894.74	1081.8	2719	0	10000	8528	0
					50	187.06	894.74	1081.8	2719	0	10000	7557	0
				300	0	187.06	1104.92	1291.98	2719	0	10000	9814	0
					25	187.06	1104.92	1291.98	2719	0	10000	8528	0
					50	187.06	1104.92	1291.98	2719	0	10000	7557	0
			20	100	0	187.06	394.63	581.69	6202	0	10000	4967	0
					25	187.06	394.63	581.69	6202	0	10000	4103	0
					50	187.06	394.63	581.69	6202	0	10000	3499	0
				200	0	187.06	604.81	791.87	6202	0	10000	4967	0
					25	187.06	604.81	791.87	6202	0	10000	4103	0
					50	187.06	604.81	791.87	6202	0	10000	3499	0
				300	0	187.06	814.99	1002.05	6202	0	10000	4967	0
					25	187.06	814.99	1002.05	6202	0	10000	4103	0
					50	187.06	814.99	1002.05	6202	0	10000	3499	0
5000	5000	50	50	100	0	131.75	524.95	656.7	2687	0	9510	9520	0
					25	131.75	524.95	656.7	2687	0	9510	7581	0
					50	131.75	524.95	656.7	2687	0	9510	6444	0
				200	0	131.75	735.12	866.87	2687	0	9510	9520	0
					25	131.75	735.12	866.87	2687	0	9510	7581	0
					50	131.75	735.12	866.87	2687	0	9510	6444	0
				300	0	131.75	945.3	1077.05	2687	0	9510	9520	0
					25	131.75	945.3	1077.05	2687	0	9510	7581	0
					50	131.75	945.3	1077.05	2687	0	9510	6444	0
			20	100	0	131.75	376.78	508.53	4771	0	9344	5786	0
					25	131.75	376.78	508.53	4771	0	9344	4520	0
					50	131.75	376.78	508.53	4771	0	9344	3715	0
				200	0	131.75	586.95	718.7	4771	0	9344	5786	0
					25	131.75	586.95	718.7	4771	0	9344	4520	0
					50	131.75	586.95	718.7	4771	0	9344	3715	0
				300	0	131.75	797.13	928.88	4771	0	9344	5786	0
					25	131.75	797.13	928.88	4771	0	9344	4520	0
					50	131.75	797.13	928.88	4771	0	9344	3715	0
		75	75	100	0	187.06	648.42	835.48	2719	0	9556	9372	0
					25	187.06	648.42	835.48	2719	0	9556	8110	0
					50	187.06	648.42	835.48	2719	0	9556	7163	0
				200	0	187.06	858.6	1045.66	2719	0	9556	9372	0
					25	187.06	858.6	1045.66	2719	0	9556	8110	0
					50	187.06	858.6	1045.66	2719	0	9556	7163	0
				300	0	187.06	1068.78	1255.84	2719	0	9556	9372	0
					25	187.06	1068.78	1255.84	2719	0	9556	8110	0
					50	187.06	1068.78	1255.84	2719	0	9556	7163	0
			20	100	0	187.06	376.78	563.84	6202	0	9344	4520	0
					25	187.06	376.78	563.84	6202	0	9344	3715	0
					50	187.06	376.78	563.84	6202	0	9344	3155	0
				200	0	187.06	586.95	774.01	6202	0	9344	4520	0
					25	187.06	586.95	774.01	6202	0	9344	3715	0
					50	187.06	586.95	774.01	6202	0	9344	3155	0
				300	0	187.06	797.13	984.19	6202	0	9344	4520	0
					25	187.06	797.13	984.19	6202	0	9344	3715	0
					50	187.06	797.13	984.19	6202	0	9344	3155	0
15000	0	50	50	100	0	131.75	1034.1	1165.85	2687	0	15000	14736	0
					25	131.75	1034.1	1165.85	2687	0	15000	12926	0
					50	131.75	1034.1	1165.85	2687	0	15000	11562	0
				200	0	131.75	1244.28	1376.03	2687	0	15000	14736	0

					25	131.75	1244.28	1376.03	2687	0	15000	12926	0
					50	131.75	1244.28	1376.03	2687	0	15000	11562	0
				300	0	131.75	1454.46	1586.21	2687	0	15000	14736	0
					25	131.75	1454.46	1586.21	2687	0	15000	12926	0
					50	131.75	1454.46	1586.21	2687	0	15000	11562	0
			20	100	0	131.75	628.44	760.19	4771	0	15000	10889	0
					25	131.75	628.44	760.19	4771	0	15000	9114	0
					50	131.75	628.44	760.19	4771	0	15000	7867	0
				200	0	131.75	838.62	970.37	4771	0	15000	10889	0
					25	131.75	838.62	970.37	4771	0	15000	9114	0
					50	131.75	838.62	970.37	4771	0	15000	7867	0
				300	0	131.75	1048.8	1180.55	4771	0	15000	10889	0
					25	131.75	1048.8	1180.55	4771	0	15000	9114	0
					50	131.75	1048.8	1180.55	4771	0	15000	7867	0
		75	75	100	0	187.06	1372.14	1559.2	2719	0	15000	14814	0
					25	187.06	1372.14	1559.2	2719	0	15000	13474	0
					50	187.06	1372.14	1559.2	2719	0	15000	12389	0
				200	0	187.06	1582.32	1769.38	2719	0	15000	14814	0
					25	187.06	1582.32	1769.38	2719	0	15000	13474	0
					50	187.06	1582.32	1769.38	2719	0	15000	12389	0
				300	0	187.06	1792.5	1979.56	2719	0	15000	14814	0
					25	187.06	1792.5	1979.56	2719	0	15000	13474	0
					50	187.06	1792.5	1979.56	2719	0	15000	12389	0
			20	100	0	187.06	628.44	815.5	6202	0	15000	9114	0
					25	187.06	628.44	815.5	6202	0	15000	7867	0
					50	187.06	628.44	815.5	6202	0	15000	6934	0
				200	0	187.06	838.62	1025.68	6202	0	15000	9114	0
					25	187.06	838.62	1025.68	6202	0	15000	7867	0
					50	187.06	838.62	1025.68	6202	0	15000	6934	0
				300	0	187.06	1048.8	1235.86	6202	0	15000	9114	0
					25	187.06	1048.8	1235.86	6202	0	15000	7867	0
					50	187.06	1048.8	1235.86	6202	0	15000	6934	0
7500	7500	50	50	100	0	131.75	876.34	1008.09	2687	0	13831	13560	0
					25	131.75	876.34	1008.09	2687	0	13831	11728	0
					50	131.75	876.34	1008.09	2687	0	13831	10377	0
				200	0	131.75	1086.52	1218.27	2687	0	13831	13560	0
					25	131.75	1086.52	1218.27	2687	0	13831	11728	0
					50	131.75	1086.52	1218.27	2687	0	13831	10377	0
				300	0	131.75	1296.7	1428.45	2687	0	13831	13560	0
					25	131.75	1296.7	1428.45	2687	0	13831	11728	0
					50	131.75	1296.7	1428.45	2687	0	13831	10377	0
			20	100	0	131.75	540.95	672.7	4771	0	13639	9534	0
					25	131.75	540.95	672.7	4771	0	13639	7843	0
					50	131.75	540.95	672.7	4771	0	13639	6684	0
				200	0	131.75	751.13	882.88	4771	0	13639	9534	0
					25	131.75	751.13	882.88	4771	0	13639	7843	0
					50	131.75	751.13	882.88	4771	0	13639	6684	0
				300	0	131.75	961.31	1093.06	4771	0	13639	9534	0
					25	131.75	961.31	1093.06	4771	0	13639	7843	0
					50	131.75	961.31	1093.06	4771	0	13639	6684	0
		75	75	100	0	187.06	1155.83	1342.89	2719	0	13884	13693	0
					25	187.06	1155.83	1342.89	2719	0	13884	12332	0
					50	187.06	1155.83	1342.89	2719	0	13884	11247	0
				200	0	187.06	1366.01	1553.07	2719	0	13884	13693	0
					25	187.06	1366.01	1553.07	2719	0	13884	12332	0
					50	187.06	1366.01	1553.07	2719	0	13884	11247	0
				300	0	187.06	1576.19	1763.25	2719	0	13884	13693	0
					25	187.06	1576.19	1763.25	2719	0	13884	12332	0
					50	187.06	1576.19	1763.25	2719	0	13884	11247	0
			20	100	0	187.06	540.95	728.01	6202	0	13639	7843	0
					25	187.06	540.95	728.01	6202	0	13639	6684	0
					50	187.06	540.95	728.01	6202	0	13639	5833	0
				200	0	187.06	751.13	938.19	6202	0	13639	7843	0
					25	187.06	751.13	938.19	6202	0	13639	6684	0
					50	187.06	751.13	938.19	6202	0	13639	5833	0
				300	0	187.06	961.31	1148.37	6202	0	13639	7843	0
					25	187.06	961.31	1148.37	6202	0	13639	6684	0
					50	187.06	961.31	1148.37	6202	0	13639	5833	0
20000	0	50	50	100	0	131.75	2686.99	2818.74	2687	0	20000	19819	0
					25	131.75	2686.99	2818.74	2687	0	20000	18487	0
					50	131.75	2686.99	2818.74	2687	0	20000	17369	0
				200	0	131.75	2897.17	3028.92	2687	0	20000	19819	0
					25	131.75	2897.17	3028.92	2687	0	20000	18487	0
					50	131.75	2897.17	3028.92	2687	0	20000	17369	0
				300	0	131.75	3107.34	3239.09	2687	0	20000	19819	0
					25	131.75	3107.34	3239.09	2687	0	20000	18487	0
					50	131.75	3107.34	3239.09	2687	0	20000	17369	0
			20	100	0	131.75	1431.37	1563.12	4771	0	20000	16778	0
					25	131.75	1431.37	1563.12	4771	0	20000	15079	0
					50	131.75	1431.37	1563.12	4771	0	20000	13747	0
				200	0	131.75	1641.55	1773.3	4771	0	20000	16778	0
					25	131.75	1641.55	1773.3	4771	0	20000	15079	0
					50	131.75	1641.55	1773.3	4771	0	20000	13747	0
				300	0	131.75	1851.73	1983.48	4771	0	20000	16778	0
					25	131.75	1851.73	1983.48	4771	0	20000	15079	0
					50	131.75	1851.73	1983.48	4771	0	20000	13747	0
		75	75	100	0	187.06	3733.33	3920.39	2719	0	20000	19873	0
					25	187.06	3733.33	3920.39	2719	0	20000	18908	0
					50	187.06	3733.33	3920.39	2719	0	20000	18059	0
				200	0	187.06	3943.51	4130.57	2719	0	20000	19873	0
					25	187.06	3943.51	4130.57	2719	0	20000	18908	0
					50	187.06	3943.51	4130.57	2719	0	20000	18059	0
				300	0	187.06	4153.69	4340.75	2719	0	20000	19873	0

						25	187.06	4153.69	4340.75	2719	0	20000	18908	0
						50	187.06	4153.69	4340.75	2719	0	20000	18059	0
				20	100	0	187.06	1431.37	1618.43	6202	0	20000	15079	0
						25	187.06	1431.37	1618.43	6202	0	20000	13747	0
						50	187.06	1431.37	1618.43	6202	0	20000	12664	0
					200	0	187.06	1641.55	1828.61	6202	0	20000	15079	0
						25	187.06	1641.55	1828.61	6202	0	20000	13747	0
						50	187.06	1641.55	1828.61	6202	0	20000	12664	0
					300	0	187.06	1851.73	2038.79	6202	0	20000	15079	0
						25	187.06	1851.73	2038.79	6202	0	20000	13747	0
						50	187.06	1851.73	2038.79	6202	0	20000	12664	0
	10000	10000	50	50	100	0	131.75	1582.84	1714.59	2687	0	17574	17341	0
						25	131.75	1582.84	1714.59	2687	0	17574	15691	0
						50	131.75	1582.84	1714.59	2687	0	17574	14382	0
					200	0	131.75	1793.02	1924.77	2687	0	17574	17341	0
						25	131.75	1793.02	1924.77	2687	0	17574	15691	0
						50	131.75	1793.02	1924.77	2687	0	17574	14382	0
					300	0	131.75	2003.2	2134.95	2687	0	17574	17341	0
						25	131.75	2003.2	2134.95	2687	0	17574	15691	0
						50	131.75	2003.2	2134.95	2687	0	17574	14382	0
				20	100	0	131.75	869.9	1001.65	4771	0	17394	13505	0
						25	131.75	869.9	1001.65	4771	0	17394	11673	0
						50	131.75	869.9	1001.65	4771	0	17394	10323	0
					200	0	131.75	1080.08	1211.83	4771	0	17394	13505	0
						25	131.75	1080.08	1211.83	4771	0	17394	11673	0
						50	131.75	1080.08	1211.83	4771	0	17394	10323	0
					300	0	131.75	1290.26	1422.01	4771	0	17394	13505	0
						25	131.75	1290.26	1422.01	4771	0	17394	11673	0
						50	131.75	1290.26	1422.01	4771	0	17394	10323	0
			75	75	100	0	187.06	2176.95	2364.01	2719	0	17623	17460	0
						25	187.06	2176.95	2364.01	2719	0	17623	16254	0
						50	187.06	2176.95	2364.01	2719	0	17623	15238	0
					200	0	187.06	2387.13	2574.19	2719	0	17623	17460	0
						25	187.06	2387.13	2574.19	2719	0	17623	16254	0
						50	187.06	2387.13	2574.19	2719	0	17623	15238	0
					300	0	187.06	2597.31	2784.37	2719	0	17623	17460	0
						25	187.06	2597.31	2784.37	2719	0	17623	16254	0
						50	187.06	2597.31	2784.37	2719	0	17623	15238	0
				20	100	0	187.06	869.9	1056.96	6202	0	17394	11673	0
						25	187.06	869.9	1056.96	6202	0	17394	10323	0
						50	187.06	869.9	1056.96	6202	0	17394	9277	0
					200	0	187.06	1080.08	1267.14	6202	0	17394	11673	0
						25	187.06	1080.08	1267.14	6202	0	17394	10323	0
						50	187.06	1080.08	1267.14	6202	0	17394	9277	0
					300	0	187.06	1290.26	1477.32	6202	0	17394	11673	0
						25	187.06	1290.26	1477.32	6202	0	17394	10323	0
						50	187.06	1290.26	1477.32	6202	0	17394	9277	0
Piloted	5000	0	50	50	100	0	244.75	239.69	484.44	7627	5000	5000	4817	0
						25	244.75	239.69	484.44	7627	5000	5000	3709	0
						50	244.75	239.69	484.44	7627	5000	5000	3019	0
					200	0	244.75	449.87	694.62	7627	5000	5000	4817	0
						25	244.75	449.87	694.62	7627	5000	5000	3709	0
						50	244.75	449.87	694.62	7627	5000	5000	3019	0
					300	0	244.75	660.05	904.8	7627	5000	5000	4817	0
						25	244.75	660.05	904.8	7627	5000	5000	3709	0
						50	244.75	660.05	904.8	7627	5000	5000	3019	0
				20	100	0	189.64	239.69	429.33	8782	5000	5000	2717	0
						25	189.64	239.69	429.33	8782	5000	5000	2024	0
						50	189.64	251.06	440.7	8782	5000	5000	1941	0
					200	0	189.64	449.87	639.51	8782	5000	5000	2717	0
						25	189.64	449.87	639.51	8782	5000	5000	2024	0
						50	189.64	461.24	650.88	8782	5000	5000	1941	0
					300	0	189.64	660.05	849.69	8782	5000	5000	2717	0
						25	189.64	660.05	849.69	8782	5000	5000	2024	0
						50	189.64	671.42	861.06	8782	5000	5000	1941	0
			75	75	100	0	345.98	239.69	585.67	7627	5000	5000	4870	0
						25	345.98	239.69	585.67	7627	5000	5000	4019	0
						50	345.98	239.69	585.67	7627	5000	5000	3424	0
					200	0	345.98	449.87	795.85	7627	5000	5000	4870	0
						25	345.98	449.87	795.85	7627	5000	5000	4019	0
						50	345.98	449.87	795.85	7627	5000	5000	3424	0
					300	0	345.98	660.05	1006.03	7627	5000	5000	4870	0
						25	345.98	660.05	1006.03	7627	5000	5000	4019	0
						50	345.98	660.05	1006.03	7627	5000	5000	3424	0
				20	100	0	244.95	239.69	484.64	9607	5000	5000	2024	0
						25	244.95	251.06	496.01	9607	5000	5793	1941	0
						50	244.95	264.71	509.66	9607	5000	6640	1941	0
					200	0	244.95	449.87	694.82	9607	5000	5000	2024	0
						25	244.95	461.24	706.19	9607	5000	5793	1941	0
						50	244.95	474.89	719.84	9607	5000	6640	1941	0
					300	0	244.95	660.05	905	9607	5000	5000	2024	0
						25	244.95	671.42	916.37	9607	5000	5793	1941	0
						50	244.95	685.07	930.02	9607	5000	6640	1941	0
	2500	2500	50	50	100	0	240.15	239.69	479.84	7475	4842	4842	4663	0
						25	240.15	239.69	479.84	7475	4842	4842	3581	0
						50	240.15	239.69	479.84	7475	4842	4842	2911	0
					200	0	240.15	449.87	690.02	7475	4842	4842	4663	0
						25	240.15	449.87	690.02	7475	4842	4842	3581	0
						50	240.15	449.87	690.02	7475	4842	4842	2911	0
					300	0	240.15	660.05	900.2	7475	4842	4842	4663	0
						25	240.15	660.05	900.2	7475	4842	4842	3581	0
						50	240.15	660.05	900.2	7475	4842	4842	2911	0
				20	100	0	186	239.69	425.69	8574	4740	4740	2555	0

					25	186	240.87	426.87	8574	4740	4830	1941	0
					50	186	254.52	440.52	8574	4740	5793	1941	0
				200	0	186	449.87	635.87	8574	4740	4740	2555	0
					25	186	451.05	637.05	8574	4740	4830	1941	0
					50	186	464.7	650.7	8574	4740	5793	1941	0
				300	0	186	660.05	846.05	8574	4740	4740	2555	0
					25	186	661.23	847.23	8574	4740	4830	1941	0
					50	186	674.88	860.88	8574	4740	5793	1941	0
		75	75	100	0	340.58	239.69	580.27	7503	4870	4870	4743	0
					25	340.58	239.69	580.27	7503	4870	4870	3908	0
					50	340.58	239.69	580.27	7503	4870	4870	3326	0
				200	0	340.58	449.87	790.45	7503	4870	4870	4743	0
					25	340.58	449.87	790.45	7503	4870	4870	3908	0
					50	340.58	449.87	790.45	7503	4870	4870	3326	0
				300	0	340.58	660.05	1000.63	7503	4870	4870	4743	0
					25	340.58	660.05	1000.63	7503	4870	4870	3908	0
					50	340.58	660.05	1000.63	7503	4870	4870	3326	0
			20	100	0	241.31	240.87	482.18	9425	4740	4830	1941	0
					25	241.31	254.52	495.83	9425	4740	5793	1941	0
					50	241.31	268.18	509.49	9425	4740	6640	1941	0
				200	0	241.31	451.05	692.36	9425	4740	4830	1941	0
					25	241.31	464.7	706.01	9425	4740	5793	1941	0
					50	241.31	478.35	719.66	9425	4740	6640	1941	0
				300	0	241.31	661.23	902.54	9425	4740	4830	1941	0
					25	241.31	674.88	916.19	9425	4740	5793	1941	0
					50	241.31	688.53	929.84	9425	4740	6640	1941	0
10000	0	50	50	100	0	461.31	239.69	701	12344	10000	10000	9736	0
					25	461.31	239.69	701	12344	10000	10000	8030	0
					50	461.31	239.69	701	12344	10000	10000	6857	0
				200	0	461.31	449.87	911.18	12344	10000	10000	9736	0
					25	461.31	449.87	911.18	12344	10000	10000	8030	0
					50	461.31	449.87	911.18	12344	10000	10000	6857	0
				300	0	461.31	660.05	1121.36	12344	10000	10000	9736	0
					25	461.31	660.05	1121.36	12344	10000	10000	8030	0
					50	461.31	660.05	1121.36	12344	10000	10000	6857	0
			20	100	0	294.84	239.69	534.53	12893	10000	10000	6310	0
					25	294.84	239.69	534.53	12893	10000	10000	4967	0
					50	294.84	239.69	534.53	12893	10000	10000	4103	0
				200	0	294.84	449.87	744.71	12893	10000	10000	6310	0
					25	294.84	449.87	744.71	12893	10000	10000	4967	0
					50	294.84	449.87	744.71	12893	10000	10000	4103	0
				300	0	294.84	660.05	954.89	12893	10000	10000	6310	0
					25	294.84	660.05	954.89	12893	10000	10000	4967	0
					50	294.84	660.05	954.89	12893	10000	10000	4103	0
		75	75	100	0	655.34	239.69	895.03	12344	10000	10000	9814	0
					25	655.34	239.69	895.03	12344	10000	10000	8528	0
					50	655.34	239.69	895.03	12344	10000	10000	7557	0
				200	0	655.34	449.87	1105.21	12344	10000	10000	9814	0
					25	655.34	449.87	1105.21	12344	10000	10000	8528	0
					50	655.34	449.87	1105.21	12344	10000	10000	7557	0
				300	0	655.34	660.05	1315.39	12344	10000	10000	9814	0
					25	655.34	660.05	1315.39	12344	10000	10000	8528	0
					50	655.34	660.05	1315.39	12344	10000	10000	7557	0
			20	100	0	350.15	239.69	589.84	13310	10000	10000	4967	0
					25	350.15	239.69	589.84	13310	10000	10000	4103	0
					50	350.15	239.69	589.84	13310	10000	10000	3499	0
				200	0	350.15	449.87	800.02	13310	10000	10000	4967	0
					25	350.15	449.87	800.02	13310	10000	10000	4103	0
					50	350.15	449.87	800.02	13310	10000	10000	3499	0
				300	0	350.15	660.05	1010.2	13310	10000	10000	4967	0
					25	350.15	660.05	1010.2	13310	10000	10000	4103	0
					50	350.15	660.05	1010.2	13310	10000	10000	3499	0
5000	5000	50	50	100	0	432.01	239.69	671.7	11889	9510	9510	9250	0
					25	432.01	239.69	671.7	11889	9510	9510	7581	0
					50	432.01	239.69	671.7	11889	9510	9510	6444	0
				200	0	432.01	449.87	881.88	11889	9510	9510	9250	0
					25	432.01	449.87	881.88	11889	9510	9510	7581	0
					50	432.01	449.87	881.88	11889	9510	9510	6444	0
				300	0	432.01	660.05	1092.06	11889	9510	9510	9250	0
					25	432.01	660.05	1092.06	11889	9510	9510	7581	0
					50	432.01	660.05	1092.06	11889	9510	9510	6444	0
			20	100	0	276.05	239.69	515.74	12345	9344	9344	5786	0
					25	276.05	239.69	515.74	12345	9344	9344	4520	0
					50	276.05	239.69	515.74	12345	9344	9344	3715	0
				200	0	276.05	449.87	725.92	12345	9344	9344	5786	0
					25	276.05	449.87	725.92	12345	9344	9344	4520	0
					50	276.05	449.87	725.92	12345	9344	9344	3715	0
				300	0	276.05	660.05	936.1	12345	9344	9344	5786	0
					25	276.05	660.05	936.1	12345	9344	9344	4520	0
					50	276.05	660.05	936.1	12345	9344	9344	3715	0
		75	75	100	0	617.29	239.69	856.98	11932	9556	9556	9372	0
					25	617.29	239.69	856.98	11932	9556	9556	8110	0
					50	617.29	239.69	856.98	11932	9556	9556	7163	0
				200	0	617.29	449.87	1067.16	11932	9556	9556	9372	0
					25	617.29	449.87	1067.16	11932	9556	9556	8110	0
					50	617.29	449.87	1067.16	11932	9556	9556	7163	0
				300	0	617.29	660.05	1277.34	11932	9556	9556	9372	0
					25	617.29	660.05	1277.34	11932	9556	9556	8110	0
					50	617.29	660.05	1277.34	11932	9556	9556	7163	0
			20	100	0	331.36	239.69	571.05	12806	9344	9344	4520	0
					25	331.36	239.69	571.05	12806	9344	9344	3715	0
					50	331.36	239.69	571.05	12806	9344	9344	3155	0
				200	0	331.36	449.87	781.23	12806	9344	9344	4520	0

					25	331.36	449.87	781.23	12806	9344	9344	3715	0
					50	331.36	449.87	781.23	12806	9344	9344	3155	0
				300	0	331.36	660.05	991.41	12806	9344	9344	4520	0
					25	331.36	660.05	991.41	12806	9344	9344	3715	0
					50	331.36	660.05	991.41	12806	9344	9344	3155	0
15000	0	50	50	100	0	967.95	239.69	1207.64	16873	15000	15000	14736	0
					25	967.95	239.69	1207.64	16873	15000	15000	12926	0
					50	967.95	239.69	1207.64	16873	15000	15000	11562	0
				200	0	967.95	449.87	1417.82	16873	15000	15000	14736	0
					25	967.95	449.87	1417.82	16873	15000	15000	12926	0
					50	967.95	449.87	1417.82	16873	15000	15000	11562	0
				300	0	967.95	660.05	1628	16873	15000	15000	14736	0
					25	967.95	660.05	1628	16873	15000	15000	12926	0
					50	967.95	660.05	1628	16873	15000	15000	11562	0
			20	100	0	540.96	239.69	780.65	17079	15000	15000	10889	0
					25	540.96	239.69	780.65	17079	15000	15000	9114	0
					50	540.96	239.69	780.65	17079	15000	15000	7867	0
				200	0	540.96	449.87	990.83	17079	15000	15000	10889	0
					25	540.96	449.87	990.83	17079	15000	15000	9114	0
					50	540.96	449.87	990.83	17079	15000	15000	7867	0
				300	0	540.96	660.05	1201.01	17079	15000	15000	10889	0
					25	540.96	660.05	1201.01	17079	15000	15000	9114	0
					50	540.96	660.05	1201.01	17079	15000	15000	7867	0
		75	75	100	0	1379.09	239.69	1618.78	16873	15000	15000	14814	
					25	1379.09	239.69	1618.78	16873	15000	15000	13474	0
					50	1379.09	239.69	1618.78	16873	15000	15000	12389	0
				200	0	1379.09	449.87	1828.96	16873	15000	15000	14814	0
					25	1379.09	449.87	1828.96	16873	15000	15000	13474	0
					50	1379.09	449.87	1828.96	16873	15000	15000	12389	0
				300	0	1379.09	660.05	2039.14	16873	15000	15000	14814	0
					25	1379.09	660.05	2039.14	16873	15000	15000	13474	0
					50	1379.09	660.05	2039.14	16873	15000	15000	12389	0
			20	100	0	596.26	239.69	835.95	17243	15000	15000	9114	0
					25	596.26	239.69	835.95	17243	15000	15000	7867	0
					50	596.26	239.69	835.95	17243	15000	15000	6934	0
				200	0	596.26	449.87	1046.13	17243	15000	15000	9114	0
					25	596.26	449.87	1046.13	17243	15000	15000	7867	0
					50	596.26	449.87	1046.13	17243	15000	15000	6934	0
				300	0	596.26	660.05	1256.31	17243	15000	15000	9114	0
					25	596.26	660.05	1256.31	17243	15000	15000	7867	0
					50	596.26	660.05	1256.31	17243	15000	15000	6934	0
7500	7500	50	50	100	0	801.89	239.69	1041.58	15836	13831	13831	13560	0
					25	801.89	239.69	1041.58	15836	13831	13831	11728	0
					50	801.89	239.69	1041.58	15836	13831	13831	10377	0
				200	0	801.89	449.87	1251.76	15836	13831	13831	13560	0
					25	801.89	449.87	1251.76	15836	13831	13831	11728	0
					50	801.89	449.87	1251.76	15836	13831	13831	10377	0
				300	0	801.89	660.05	1461.94	15836	13831	13831	13560	0
					25	801.89	660.05	1461.94	15836	13831	13831	11728	0
					50	801.89	660.05	1461.94	15836	13831	13831	10377	0
			20	100	0	448.86	239.69	688.55	15943	13639	13639	9534	0
					25	448.86	239.69	688.55	15943	13639	13639	7843	0
					50	448.86	239.69	688.55	15943	13639	13639	6684	0
				200	0	448.86	449.87	898.73	15943	13639	13639	9534	0
					25	448.86	449.87	898.73	15943	13639	13639	7843	0
					50	448.86	449.87	898.73	15943	13639	13639	6684	0
				300	0	448.86	660.05	1108.91	15943	13639	13639	9534	0
					25	448.86	660.05	1108.91	15943	13639	13639	7843	0
					50	448.86	660.05	1108.91	15943	13639	13639	6684	0
		75	75	100	0	1151.4	239.69	1391.09	15883	13884	13884	13693	0
					25	1151.4	239.69	1391.09	15883	13884	13884	12332	0
					50	1151.4	239.69	1391.09	15883	13884	13884	11247	0
				200	0	1151.4	449.87	1601.27	15883	13884	13884	13693	0
					25	1151.4	449.87	1601.27	15883	13884	13884	12332	0
					50	1151.4	449.87	1601.27	15883	13884	13884	11247	0
				300	0	1151.4	660.05	1811.45	15883	13884	13884	13693	0
					25	1151.4	660.05	1811.45	15883	13884	13884	12332	0
					50	1151.4	660.05	1811.45	15883	13884	13884	11247	0
			20	100	0	504.17	239.69	743.86	16162	13639	13639	7843	0
					25	504.17	239.69	743.86	16162	13639	13639	6684	0
					50	504.17	239.69	743.86	16162	13639	13639	5833	0
				200	0	504.17	449.87	954.04	16162	13639	13639	7843	0
					25	504.17	449.87	954.04	16162	13639	13639	6684	0
					50	504.17	449.87	954.04	16162	13639	13639	5833	0
				300	0	504.17	660.05	1164.22	16162	13639	13639	7843	0
					25	504.17	660.05	1164.22	16162	13639	13639	6684	0
					50	504.17	660.05	1164.22	16162	13639	13639	5833	0

Appendix B.3.2: 2014 minimum energy abort mass impacts - all fuel piloted missions

Abort location	Abort insertion	ΔVs breking	Transfer nominal	Vehicles abort	Samples	Piloted IMLEO	ΔV available during mission phases: abort outbound	abort from Mars	nominal from Mars	abort inbound	TOTAL IMLEO Cargo payload = 100	200	300
Inbound	5000	0	50	50	0	333.1	9588	6876	6652	5000	543.28	753.46	963.64
					25	347.47	9923	7240	5573	5000	557.65	767.83	978.01
					50	361.84	10242	7586	4900	5000	572.02	782.2	992.38
				20	0	263.68	11322	7785	4605	5000	473.86	684.04	894.22
					25	278.05	11829	8426	3927	5000	488.23	698.41	908.59
					50	292.42	12293	9010	3524	5000	502.6	712.78	922.96
			75	75	0	460.64	9523	6862	6704	5000	670.82	881	1091.18
					25	475.01	9763	7120	5876	5000	685.19	895.37	1105.55
					50	489.38	9993	7368	5296	5000	699.56	909.74	1119.92
				20	0	333.36	12334	8426	3927	5000	543.54	753.72	963.9
					25	347.73	12759	9010	3524	5000	557.91	768.09	978.27
					50	362.1	13151	9544	3258	5000	572.28	782.46	992.64
	2500	2500	50	50	0	327.31	9447	6723	6502	4842	537.49	747.67	957.85
					25	341.68	9790	7096	5449	4842	551.86	762.04	972.22
					50	356.05	10115	7449	4795	4842	566.23	776.41	986.59
				20	0	259.09	11150	7567	4447	4740	469.27	679.45	889.63
					25	273.46	11672	8229	3804	4740	483.64	693.82	904
					50	287.83	12149	8829	3424	4740	498.01	708.19	918.37
			75	75	0	453.83	9407	6737	6580	4870	664.01	874.19	1084.37
					25	468.2	9650	6999	5768	4870	678.38	888.56	1098.74
					50	482.57	9885	7252	5200	4870	692.75	902.93	1113.11
				20	0	328.77	12191	8229	3804	4740	538.95	749.13	959.31
					25	343.14	12627	8829	3424	4740	553.32	763.5	973.68
					50	357.51	13029	9379	3173	4740	567.69	777.87	988.05
	10000	0	50	50	0	605.93	13953	11662	11390	10000	816.11	1026.29	1236.47
					25	620.3	14107	11833	9758	10000	830.48	1040.66	1250.84
					50	634.67	14256	11999	8268	10000	844.85	1055.03	1265.21
				20	0	396.21	14786	12096	8100	10000	606.39	816.57	1026.75
					25	410.58	15048	12417	6798	10000	620.76	830.94	1041.12
					50	424.95	15294	12720	5958	10000	635.13	845.31	1055.49
			75	75	0	850.37	13924	11656	11464	10000	1060.55	1270.73	1480.91
					25	864.74	14033	11776	10236	10000	1074.92	1285.1	1495.28
					50	879.11	14140	11894	9303	10000	1089.29	1299.47	1509.65
				20	0	465.89	15317	12417	6798	10000	676.07	886.25	1096.43
					25	480.26	15549	12720	5958	10000	690.44	900.62	1110.8
					50	494.63	15769	13006	5369	10000	704.81	914.99	1125.17
	5000	5000	50	50	0	569.02	13535	11197	10926	9510	779.2	989.38	1199.56
					25	583.39	13702	11383	9326	9510	793.57	1003.75	1213.93
					50	597.76	13864	11563	8229	9510	807.94	1018.12	1228.3
				20	0	372.53	14319	11523	7593	9344	582.71	792.89	1003.07
					25	386.9	14608	11878	6363	9344	597.08	807.26	1017.44
					50	401.27	14880	12212	5579	9344	611.45	821.63	1031.81
			75	75	0	802.44	13543	11234	11043	9556	1012.62	1222.8	1432.98
					25	816.81	13660	11364	9835	9556	1026.99	1237.17	1447.35
					50	831.18	13775	11491	8923	9556	1041.36	1251.54	1461.72
				20	0	442.21	14904	11878	6363	9344	652.39	862.57	1072.75
					25	456.58	15159	12212	5579	9344	666.76	876.94	1087.12
					50	470.95	15400	12526	5036	9344	681.13	891.31	1101.49
	15000	0	50	50	0	1244.21	18061	16329	16079	15000	1454.39	1664.57	1874.75
					25	1258.58	18116	16394	14400	15000	1468.76	1678.94	1889.12
					50	1272.95	18170	16457	13120	15000	1483.13	1693.31	1903.49
				20	0	706.27	18370	16495	12485	15000	916.45	1126.63	1336.81
					25	720.64	18472	16621	10797	15000	930.82	1141	1351.18
					50	735.01	18570	16743	9601	15000	945.19	1155.37	1365.55
			75	75	0	1762.18	18051	16327	16151	15000	1972.36	2182.54	2392.72
					25	1776.55	18089	16372	14911	15000	1986.73	2196.91	2407.09
					50	1790.92	18128	16417	13898	15000	2001.1	2211.28	2421.46
				20	0	775.95	18579	16621	10797	15000	986.13	1196.31	1406.49
					25	790.32	18674	16743	9601	15000	1000.5	1210.68	1420.86
					50	804.69	18767	16861	8703	15000	1014.87	1225.05	1435.23
	7500	7500	50	50	0	1035.01	17132	15253	14991	13831	1245.19	1455.37	1665.55
					25	1049.38	17204	15336	13277	13831	1259.56	1469.74	1679.92
					50	1063.75	17275	15418	11999	13831	1273.93	1484.11	1694.29
				20	0	590.25	17397	15298	11197	13639	800.43	1010.61	1220.79
					25	604.62	17534	15466	9578	13639	814.8	1024.98	1235.16
					50	618.99	17666	15628	8461	13639	829.17	1039.35	1249.53
			75	75	0	1475.32	17161	15299	15114	13844	1685.5	1895.68	2105.86
					25	1489.69	17211	15357	13844	13844	1699.87	1910.05	2120.23
					50	1504.06	17261	15414	12823	13844	1714.24	1924.42	2134.6
				20	0	659.93	17678	15466	9578	13639	870.11	1080.29	1290.47
					25	674.3	17804	15628	8461	13639	884.48	1094.66	1304.84
					50	688.67	17926	15784	7639	13639	898.85	1109.03	1319.21
From Mars	5000	0	50	50	0	275.81	7908	5000	4817	0	485.99	696.17	906.35
					25	275.81	7908	5000	3709	0	485.99	696.17	906.35
					50	275.81	7908	5000	3019	0	485.99	696.17	906.35
				20	0	220.71	9258	5000	2717	0	430.89	641.07	851.25
					25	220.71	9258	5000	2024	0	430.89	641.07	851.25
					50	NOM				0			
			75	75	0	377.04	7825	5000	4870	0	587.22	797.4	1007.58
					25	377.04	7825	5000	4019	0	587.22	797.4	1007.58
					50	377.04	7825	5000	3424	0	587.22	797.4	1007.58
				20	0	276.01	10027	5000	2024	0	486.19	696.37	906.55
					25	NOM				0			
					50	NOM				0			
	2500	2500	50	50	0	271.21	7762	4842	4663	0	481.39	691.57	901.75

					25	271.21	7762	4842	3581	0	481.39	691.57	901.75
					50	271.21	7762	4842	2911	0	481.39	691.57	901.75
				20	0	217.06	9066	4740	2555	0	427.24	637.42	847.6
					25	NOM				0			
					50	NOM				0			
			75	75	0	371.64	7704	4870	4743	0	581.82	792	1002.18
					25	371.64	7704	4870	3908	0	581.82	792	1002.18
					50	371.64	7704	4870	3326	0	581.82	792	1002.18
				20	0	NOM				0			
					25	NOM				0			
					50	NOM				0			
	10000	0	50	50	0	492.37	12474	10000	9736	0	702.55	912.73	1122.91
					25	492.37	12474	10000	8030	0	702.55	912.73	1122.91
					50	492.37	12474	10000	6857	0	702.55	912.73	1122.91
				20	0	325.9	13131	10000	6310	0	536.08	746.26	956.44
					25	325.9	13131	10000	4967	0	536.08	746.26	956.44
					50	325.9	13131	10000	4103	0	536.08	746.26	956.44
			75	75	0	686.4	12435	10000	9814	0	896.58	1106.76	1316.94
					25	686.4	12435	10000	8528	0	896.58	1106.76	1316.94
					50	686.4	12435	10000	7557	0	896.58	1106.76	1316.94
				20	0	381.21	13530	10000	4967	0	591.39	801.57	1011.75
					25	381.21	13530	10000	4103	0	591.39	801.57	1011.75
					50	381.21	13530	10000	3499	0	591.39	801.57	1011.75
	5000	5000	50	50	0	463.07	12030	9510	9250	0	673.25	883.43	1093.61
					25	463.07	12030	9510	7581	0	673.25	883.43	1093.61
					50	463.07	12030	9510	6444	0	673.25	883.43	1093.61
				20	0	307.11	12609	9344	5786	0	517.29	727.47	937.65
					25	307.11	12609	9344	4520	0	517.29	727.47	937.65
					50	307.11	12609	9344	3715	0	517.29	727.47	937.65
			75	75	0	648.35	12030	9556	9372	0	858.53	1068.71	1278.89
					25	648.35	12030	9556	8110	0	858.53	1068.71	1278.89
					50	648.35	12030	9556	7163	0	858.53	1068.71	1278.89
				20	0	362.42	13049	9344	4520	0	572.6	782.78	992.96
					25	362.42	13049	9344	3715	0	572.6	782.78	992.96
					50	362.42	13049	9344	3155	0	572.6	782.78	992.96
	15000	0	50	50	0	999.01	16921	15000	14736	0	1209.19	1419.37	1629.55
					25	999.01	16921	15000	12926	0	1209.19	1419.37	1629.55
					50	999.01	16921	15000	11562	0	1209.19	1419.37	1629.55
				20	0	572.02	17172	15000	10889	0	782.2	992.38	1202.56
					25	572.02	17172	15000	9114	0	782.2	992.38	1202.56
					50	572.02	17172	15000	7867	0	782.2	992.38	1202.56
			75	75	0	1410.15	16907	15000	14814	0	1620.33	1830.51	2040.69
					25	1410.15	16907	15000	13474	0	1620.33	1830.51	2040.69
					50	1410.15	16907	15000	12389	0	1620.33	1830.51	2040.69
				20	0	627.33	17331	15000	9114	0	837.51	1047.69	1257.87
					25	627.33	17331	15000	7867	0	837.51	1047.69	1257.87
					50	627.33	17331	15000	6934	0	837.51	1047.69	1257.87
	7500	7500	50	50	0	832.96	15898	13831	13560	0	1043.14	1253.32	1463.5
					25	832.96	15898	13831	11728	0	1043.14	1253.32	1463.5
					50	832.96	15898	13831	10377	0	1043.14	1253.32	1463.5
				20	0	479.92	16067	13639	9534	0	690.1	900.28	1110.46
					25	479.92	16067	13639	7843	0	690.1	900.28	1110.46
					50	479.92	16067	13639	6684	0	690.1	900.28	1110.46
			75	75	0	1182.46	15926	13884	13693	0	1392.64	1602.82	1813
					25	1182.46	15926	13884	12332	0	1392.64	1602.82	1813
					50	1182.46	15926	13884	11247	0	1392.64	1602.82	1813
				20	0	535.23	16280	13639	7843	0	745.41	955.59	1165.77
					25	535.23	16280	13639	6684	0	745.41	955.59	1165.77
					50	535.23	16280	13639	5833	0	745.41	955.59	1165.77
Outbound	5000	0	50	50	0	NOM							
					25	NOM							
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
			75	75	0	NOM							
					25	NOM							
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
	2500	2500	50	50	0	NOM							
					25	NOM							
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
			75	75	0	NOM							
					25	NOM							
					50	NOM							
				20	0	NOM							
					25	NOM							
					50	NOM							
	10000	0	50	50	0	355.05	10000	7283		0	565.23	775.41	985.59
					25	355.05	10000	7283	5610	0	565.23	775.41	985.59
					50	355.05	10000	7283	4668	0	565.23	775.41	985.59
				20	0	235.83	10000	5987	3354	0	446.01	656.19	866.37
					25	235.83	10000	5987	2524	0	446.01	656.19	866.37
					50	235.83	10000	5987	2025	0	446.01	656.19	866.37
			75	75	0	494.01	10000	7348	7184	0	704.19	914.37	1124.55
					25	494.01	10000	7348	6080	0	704.19	914.37	1124.55
					50	494.01	10000	7348	5279	0	704.19	914.37	1124.55
				20	0	275.44	10000	4959	2004	0	485.62	695.8	905.98

				25	NOM								
				50	NOM								
5000	5000	50	50	0	334.06	9510	6748	6526	0	544.24	754.42	964.6
				25	334.06	9510	6748	5153	0	544.24	754.42	964.6
				50	334.06	9510	6748	4266	0	544.24	754.42	964.6
			20	0	222.36	9344	5115	2789	0	432.54	642.72	852.9
				25	222.36	9344	5115	2080	0	432.54	642.72	852.9
				50	NOM							
		75	75	0	466.76	9556	6867	6709	0	676.94	887.12	1097.3
				25	466.76	9556	6867	5650	0	676.94	887.12	1097.3
				50	466.76	9556	6867	4887	0	676.94	887.12	1097.3
			20	0	NOM							
				25	NOM							
				50	NOM							
15000	0	50	50	0	717.9	15000	12815	12541	0	928.08	1138.26	1348.44
				25	717.9	15000	12815	10715	0	928.08	1138.26	1348.44
				50	717.9	15000	12815	9391	0	928.08	1138.26	1348.44
			20	0	412.09	15000	12323	8304	0	622.27	832.45	1042.63
				25	412.09	15000	12323	6721	0	622.27	832.45	1042.63
				50	412.09	15000	12323	5661	0	622.27	832.45	1042.63
		75	75	0	1012.35	15000	12841	12648	0	1222.53	1432.71	1642.89
				25	1012.35	15000	12841	11285	0	1222.53	1432.71	1642.89
				50	1012.35	15000	12841	10213	0	1222.53	1432.71	1642.89
			20	0	451.7	15000	11965	6432	0	661.88	872.06	1082.24
				25	451.7	15000	11965	5401	0	661.88	872.06	1082.24
				50	451.7	15000	11965	4661	0	661.88	872.06	1082.24
7500	7500	50	50	0	598.97	13831	11505	11233	0	809.15	1019.33	1229.51
				25	598.97	13831	11505	9443	0	809.15	1019.33	1229.51
				50	598.97	13831	11505	8177	0	809.15	1019.33	1229.51
			20	0	346.13	13639	10635	6834	0	556.31	766.49	976.67
				25	346.13	13639	10635	5419	0	556.31	766.49	976.67
				50	346.13	13639	10635	4500	0	556.31	766.49	976.67
		75	75	0	849.28	13884	11597	11405	0	1059.46	1269.64	1479.82
				25	849.28	13884	11597	10061	0	1059.46	1269.64	1479.82
				50	849.28	13884	11597	9023	0	1059.46	1269.64	1479.82
			20	0	385.74	13639	10148	5071	0	595.92	806.1	1016.28
				25	385.74	13639	10148	4194	0	595.92	806.1	1016.28
				50	385.74	13639	10148	3579	0	595.92	806.1	1016.28
20000	0	50	50	0	1963.95	20000	18628	18415	0	2174.13	2384.31	2594.49
				25	1963.95	20000	18628	16880	0	2174.13	2384.31	2594.49
				50	1963.95	20000	18628	15635	0	2174.13	2384.31	2594.49
			20	0	1017.39	20000	18515	14850	0	1227.57	1437.75	1647.93
				25	1017.39	20000	18515	13044	0	1227.57	1437.75	1647.93
				50	1017.39	20000	18515	11679	0	1227.57	1437.75	1647.93
		75	75	0	2792.37	20000	18634	18484	0	3002.55	3212.73	3422.91
				25	2792.37	20000	18634	17366	0	3002.55	3212.73	3422.91
				50	2792.37	20000	18634	16407	0	3002.55	3212.73	3422.91
			20	0	1057	20000	18436	12943	0	1267.18	1477.36	1687.54
				25	1057	20000	18436	11579	0	1267.18	1477.36	1687.54
				50	1057	20000	18436	10503	0	1267.18	1477.36	1687.54
10000	10000	50	50	0	1131.57	17574	15754	15497	0	1341.75	1551.93	1762.11
				25	1131.57	17574	15754	13717	0	1341.75	1551.93	1762.11
				50	1131.57	17574	15754	12357	0	1341.75	1551.93	1762.11
			20	0	594.12	17394	15274	11173	0	804.3	1014.48	1224.66
				25	594.12	17394	15274	9385	0	804.3	1014.48	1224.66
				50	594.12	17394	15274	8122	0	804.3	1014.48	1224.66
		75	75	0	1619.07	17623	15825	15645	0	1829.25	2039.43	2249.61
				25	1619.07	17623	15825	14334	0	1829.25	2039.43	2249.61
				50	1619.07	17623	15825	13259	0	1829.25	2039.43	2249.61
			20	0	633.73	17394	15081	9194	0	843.91	1054.09	1264.27
				25	633.73	17394	15081	7942	0	843.91	1054.09	1264.27
				50	633.73	17394	15081	7005	0	843.91	1054.09	1264.27