Efficient Mission Design via EXPLORE

Employing EXPLORE for Rapid Trajectory Design and Analysis

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ABSTRACT

Designing spacecraft missions is often a difficult task of finding a needle in a haystack due to the high number of degrees of freedom, compounded by time constraints and computing resource limits. A typical approach is to perform a grid search with specific constraints. The software designed to do such searches, namely JPL's STOUR program, was originally designed for a very specific mission in a time with limited computing resources, forcing it to rely on costly file read/write operations. Since its inauguration during the design of the Galileo mission, several enhancements and spin-off programs have been developed for new mission design concepts. However, the core algorithms were still designed for computers of the 1980s and 90s. A new program, EXPLORE, was written with modern computing techniques and semi-automated search features that previous software did not employ, allowing broader searches to be accomplished in significantly shorter time. This paper uses the inner-planet flybys (without specifying details of the deep space maneuver) of the Cassini mission as a reference trajectory and "re-discovers" several Cassini-like trajectories, analyzes their characteristics, identifies the closest Cassini trajectory, then extends the mission to first include the asteroid Vesta, and then the dwarf planet Ceres, after a Saturn flyby. The elapsed time between the inexplicit design concept to obtaining several candidate trajectories and detailed data files for higher-level mission design was approximately 3 hours using a common consumer grade desktop computer.

Introduction

The initial step in designing a spacecraft mission with multiple celestial body encounters (departure, flyby, or rendezvous) is, at best, a difficult task to do manually. The geometry of trajectories become increasingly unstable as the number of encounters grows; small changes to dates, positions, velocities, and other trajectory parameters may not significantly affect the first several legs of a trajectory, but the effect amplifies after each encounter, potentially affecting the final several legs severely. For this reason programs that search through high numbers of potential trajectories are invaluable.

The Jet Propulsion Lab (JPL) developed a tool named the Satellite Tour Design Program (STOUR) to aid in the mission design of Galileo [5]. This was then modified to enable heliocentric planetary tours at Purdue and other spin-off programs have been developed with the same central concept: specify initial conditions and a sequence of encounters and use simplified dynamics such as two-body patched conics [6]. Though the programs have undoubtedly been updated and modified since their inception, their core structure was designed in the late 1980's and 1990's, in times when RAM was not largely available and large-scale grid searches depended on numerous file read/write operations which cause the programs to potentially take several days for a single trajectory.

Modern computers are much more capable than their earlier counterparts. Among other advancements, increased RAM storage, processing speed and parallel computing have helped to make previously infeasible tasks manageable. Exploiting these advancements, a new program, the Exploration Tool for Multi-Flyby Trajectories (EXPLORE), was developed to accomplish similar tasks to STOUR and its spin-offs with improved efficiency and enhanced capabilities. EXPLORE has the unique capability to include V_∞ Leveraging Maneuvers (VILMs) in the search, which allows for non-ballistic solutions to be found autonomously.

Approach

The original Cassini mission (not including the extended missions) can be divided into two main segments: the planetary tour to the Saturn system and the Saturn moon tour. This paper will use the first part as a design reference mission. The trajectory overview is shown below in Figure 1.

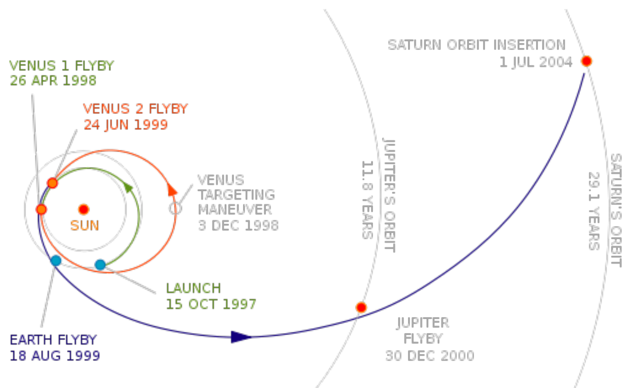

Figure 1. Cassini inter-planetary trajectory.

This mission is of particular interest because of its unique flyby configuration, which includes an intermediate VILM between Venus flybys. Because the Earth and Venus have an approximate 8:13 resonance (8 Earth periods to 13 Venus periods), similar trajectories could be utilized as an efficient means of travel to the outer planets and other bodies beyond Mars' orbit. Thus it could prove extremely valuable to have a tool that can search for both ballistic trajectories and those with VILMs in an automated manner.

The EXPLORE tool is first used to search for trajectories similar to one in Figure 1 by tightly bounding the inner-planet flyby dates, then leave the Jupiter and Saturn encounters free for up to 5,000 days past epoch, approximately 11 years after the Earth flyby. This was chosen via trial and error to yield multiple results for analysis and comparison. The trajectory closest to the actual Cassini mission will then be modified to include small bodies in the Main Asteroid Belt, namely Vesta and the dwarf planet Ceres, the focal bodies of the Dawn mission [4].

Procedure & Results

Detailed step-by-step instructions for creating a working input file for the EXPLORE program can be found in the EXPLORE User's Manual and will not be discussed in this paper. This paper will instead focus on specific features utilized to create and analyze Cassini-like trajectories. The original input file used to find the Cassini mission can be found in Appendix A. This file is first loaded into the EXPLORE input GUI as shown in Figure 2 below. With this file loaded, simply pressing *Run* in the lower-right hand corner will find the Cassini trajectory as shown in Figure 3. As expected with a tightly bound search space, only one resulting solution is left at the end of the search.

Figure 2. Loaded *Cassini_Mission.input* file in the EXPLORE Input GUI.

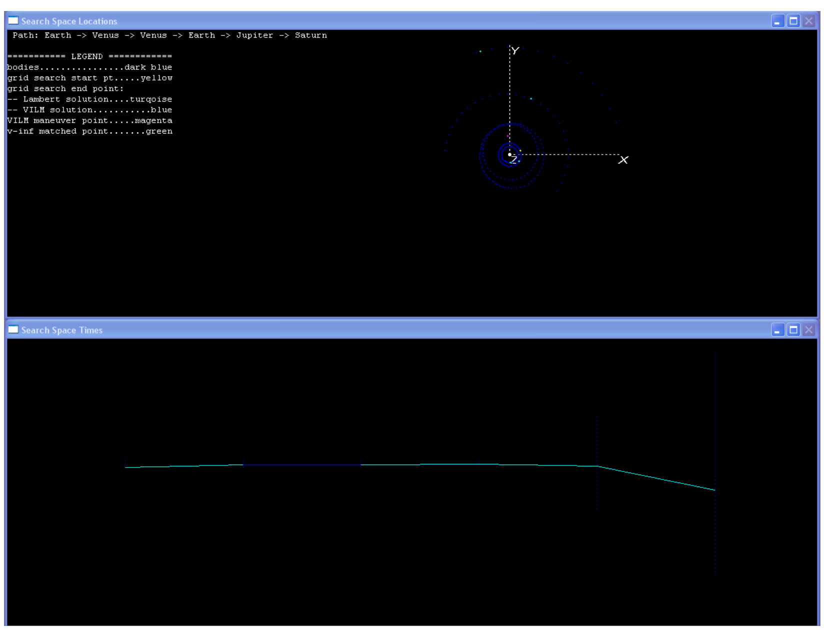

Figure 3. EXPLORE search result from provided *Cassini_Mission.input* file.

As mentioned, the constraints are then relaxed on the outer planet encounters and the mission time is set to 5,000 days past epoch. The launch C_3 constraints are removed to allow for more launch conditions as well. Because this greatly increases the search space for EXPLORE, the advanced options to generate .traj files for the bodies and the spacecraft are set to *False* using the *Advanced Inputs* menu as shown in Figure 4. Creating and running this modified input file (*Cassini_Mission_Relaxed.input*) results in 20 solutions, the EXPLORE search results shown in Figure 5. As expected the first leg has multiple options due to not having a launch C_3 constraint (minimum or maximum). The second and third legs remain tightly bound, but the last two legs are left without constraints allowing them to "fan out" to 20 distinct solutions.

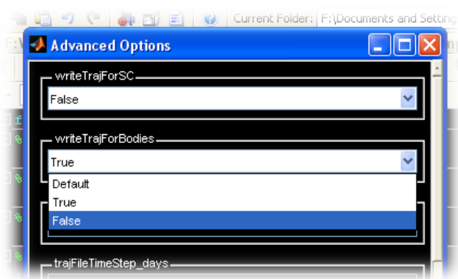

Figure 4. Setting .traj file writing to *False* for improved performance in the EXPLORE Advanced Inputs menu.

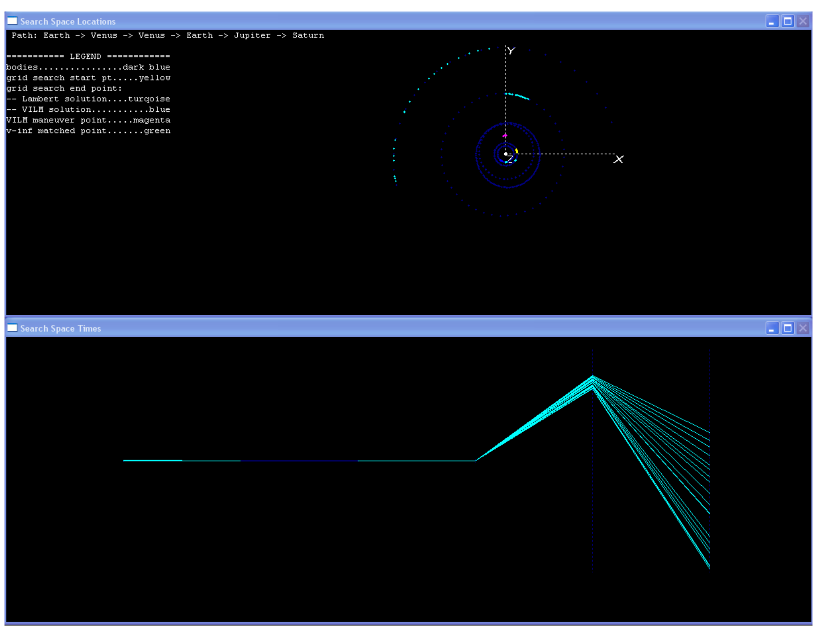

Figure 5. EXPLORE search result from the *Cassini_Mission_Relaxed.input* file.

If the .traj file generation were enabled, the trajectories could be directly visualized using the EXPLORE Trajectory GUI. The user would generate plots similar to Figure 6, which shows the 20 trajectories, the body orbits, VILM positions, and the positions of all encounters plotted in the EXPLORE Trajectory GUI.

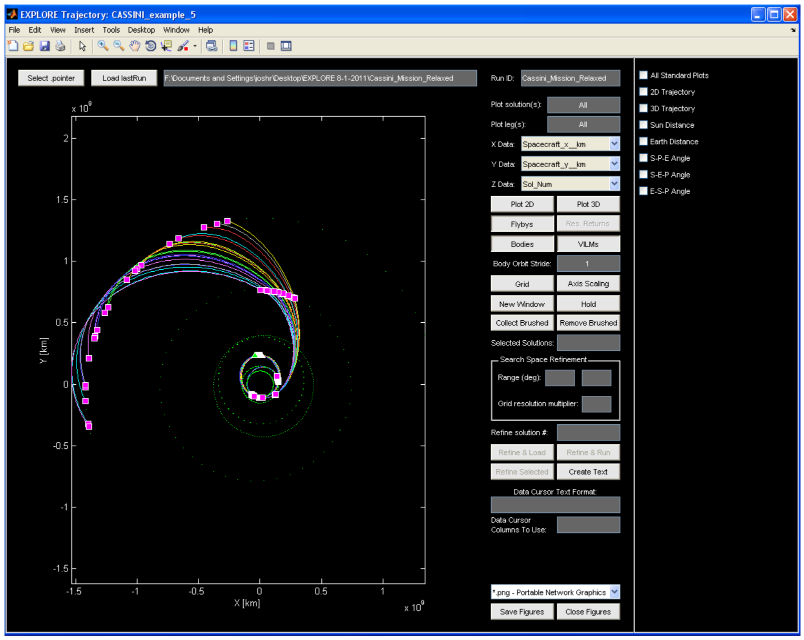

Figure 6. All 20 solutions found from the *Cassini_Mission_Relaxed.input* file.

With merely 20 solutions, this is a manageable task and perhaps more efficient than analyzing the trajectories prior to generating the .traj files. However, initial mission design rarely allows for such confined search spaces, resulting in potentially tens of thousands of solutions, in which case it is to the user's benefit to filter the solutions using the auto-generated .nodes files, then generate only a handful of .traj files for further analysis. For demonstrative purposes, this paper will go through the process of first filtering the results using the .nodes files, then generating the .traj files.

With the .traj file generation disabled, the .nodes files are the only output produced for visualization. Loading the results into the EXPLORE Nodes GUI and plotting the launch C_3 and arriving V_∞ quickly allows users to visualize the basic efficiency of each trajectory. Such a plot is shown below in Figure 7, plotted within the EXPLORE Nodes GUI. Because all trajectories found from a common input file will have the same sequence of bodies, it is typically preferred to have a low launch C_3 and a low arrival V_∞ to minimize the required fuel for the spacecraft.

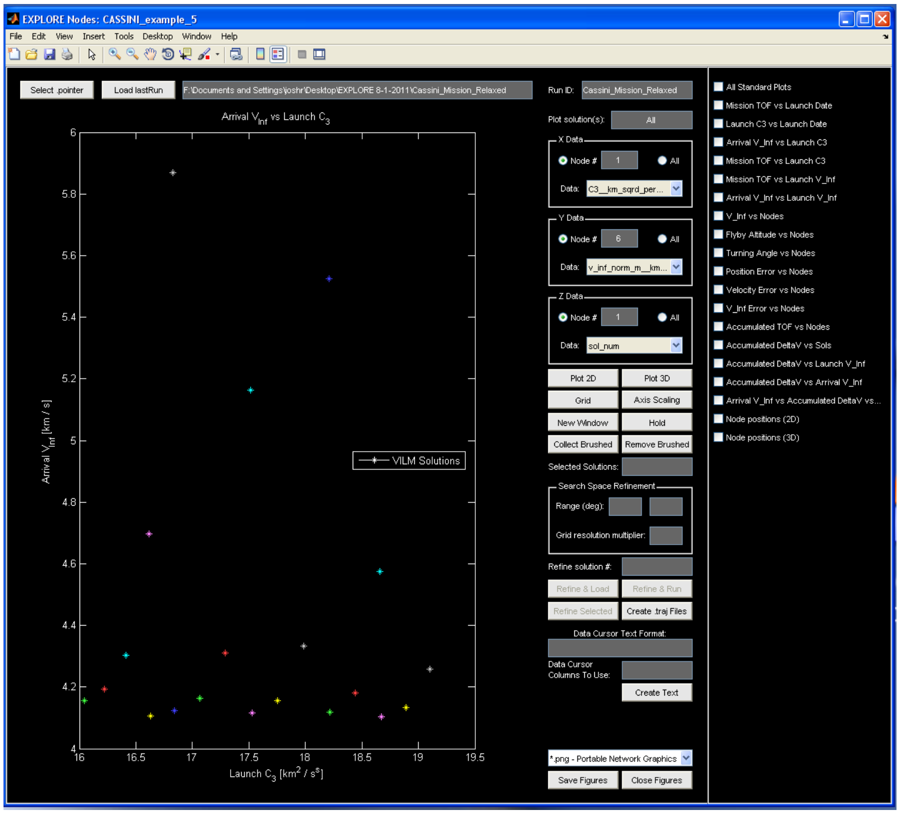

Figure 7. Arrival V_∞ vs. Launch C_3 for solutions found from the *Cassini_Mission_Relaxed.input* file.

This maps to the lower left-hand corner of the plot shown in Figure 7. The user does not need to know which solutions these correspond to because EXPLORE utilizes the built-in MATLAB *Brush* function. By selecting the *Brush* icon () the user draws a box around the points with the desired characteristics, in this case the points in the lower left-hand corner, as shown in Figure 8. The user then presses the *Collect Brushed* button to create an array of solution numbers associated with the selected data points. More solutions may be added to this array from this or other plots, or solutions may be removed in a similar manner using the *Remove Brushed* button; the user may also add or remove solutions by manually typing in the *Selected Solutions* edit box.

Once satisfied with the solution array, the user may then press *Create .traj Files*, which prompts the user with the window shown in Figure 9, which clarifies which files to generate. The first input is auto-generated from the EXPLORE pointer files, and typically does not require user modification.

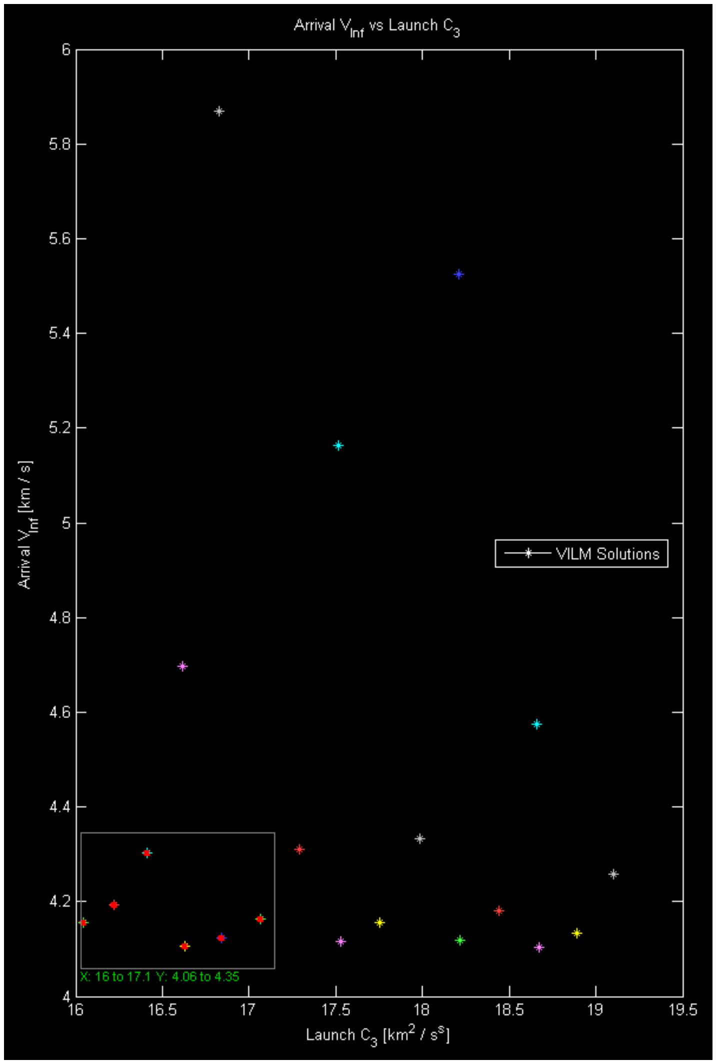

Figure 8. Highlighting the desired solutions using the MATLAB *Brush* function.

Figure 9. EXPLORE menu prompt for generating .traj files from EXPLORE Nodes GUI.

The second input in this menu, *previousDataMode*, allows the user to specify to generate the .traj file for the selected solutions (default), or for all solutions. The user may also specify to create .traj files for the spacecraft and/or the bodies, as well as to generate .bsp files. From this menu, the selected solutions (13, 14, 16, 18, 19, and 20) will be recreated and their .traj files will be generated, as well as the .traj files for the bodies. The resulting solutions from EXPLORE are shown below in Figure 10. Clearly the number of solutions decreased from the original *Cassini_Mission_Relaxed.input* results. The resulting .traj files are then loaded into the EXPLORE Trajectory GUI and the 2D trajectory plots are generated in a similar fashion as in Figure 6, shown below in Figure 11.

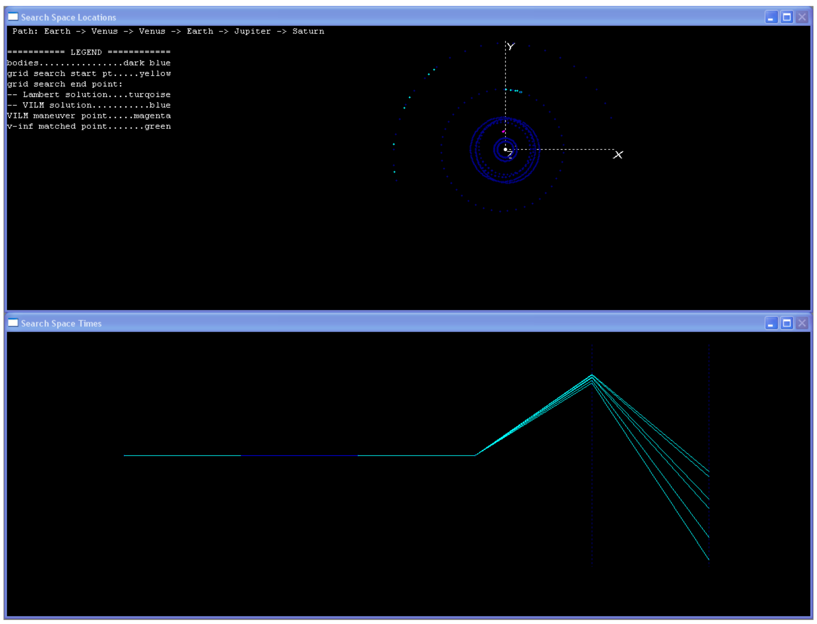

Figure 10. Filtered solutions from EXPLORE Nodes GUI.

In the case that the user is specifically interested in the solution number as well as the solution data, there is a manual data cursor format editor that allows users to display any available information, independent of the plot axes. Because the Cassini mission dates are well known, examining the accumulated time-of-flight vs. nodes plot shows only one candidate solution that matches the constraints: solution number 7. This is shown below in Figure 12a with the modified data cursor. Figure 12b highlights the corresponding point from the arrival V_∞ vs. launch C_3 plot, which is interestingly not among the more attractive solutions. In fact, it is arguably the worst solution by this plot alone. Clearly other factors contributed to its selection for the Cassini mission, such as a significantly shorter TOF.

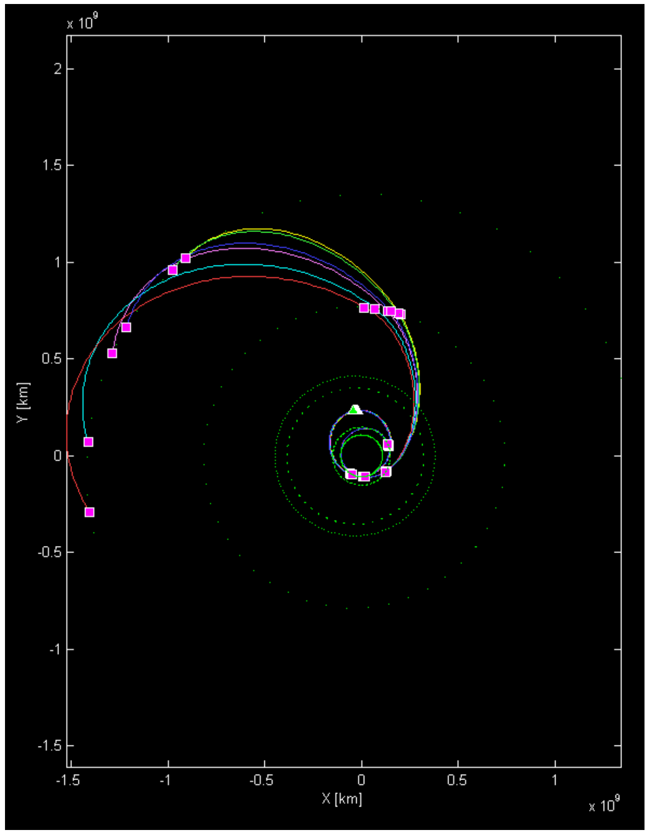

Figure 11. Filtered solution trajectories using EXPLORE Trajectory GUI.

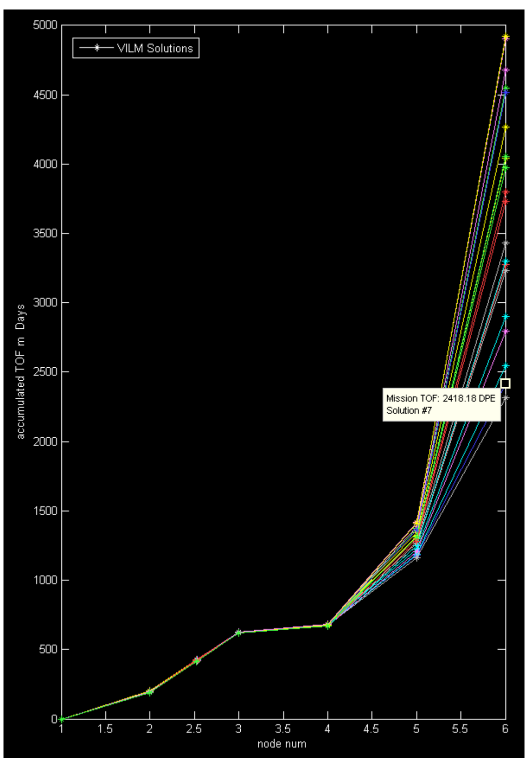

Figure 12a. Identifying Cassini trajectory using EXPLORE Nodes GUI.

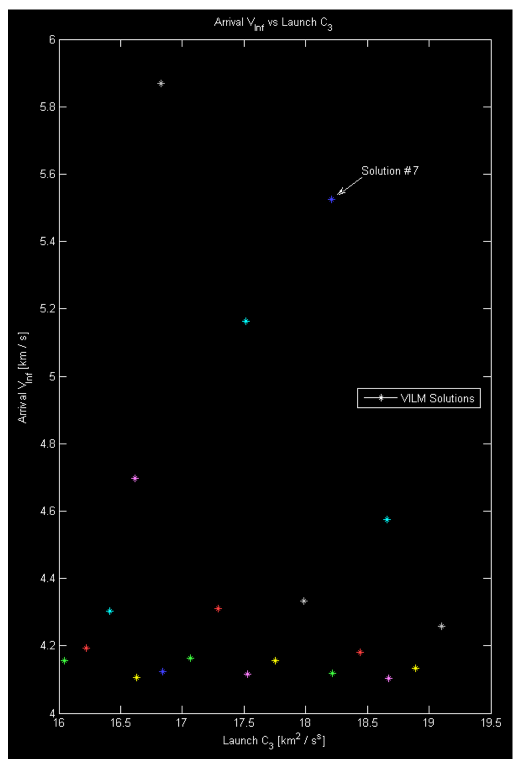

Figure 12b. Highlighting Cassini trajectory from Figure 7.

Solution number 7 is manually selected to generate the .traj file and the resulting Cassini trajectory is show below in Figure 13, which should be compared to Figure 1 above to verify that EXPLORE accurately found the Cassini trajectory.

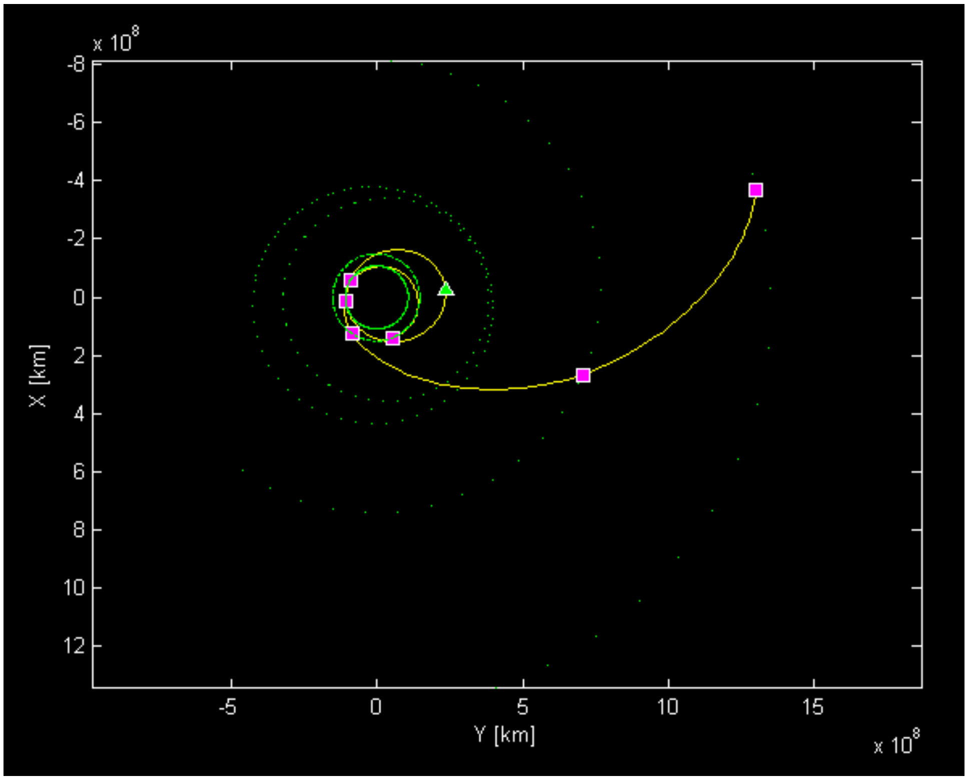

Figure 13. Recreation of the Cassini trajectory using EXPLORE. Squares indicate flybys and the triangle indicates a VILM.

With the Cassini trajectory accurately found using EXPLORE, the next step was to extend it to include small bodies. This was accomplished by first loading the *Cassini_Mission.input* file into the EXPLORE Input GUI again, then pressing the *Load Small Bodies* which launches the Small Body Browser (SBB). This prompts the user to select a .csv file either downloaded from the Internet or created by a user. See the EXPLORE User's Manual for details about the .csv file requirements. The loaded files can be arbitrarily large, limited only by the computer's available memory. The file used in this paper had 65,535 bodies, the limit of Microsoft Excel 2003, as shown in Figure 14.

For typical computers, modeling several thousand bodies in the EXPLORE search is not a viable option, thus the SBB is designed to aid the users in down selecting to a reasonable number, though no upper limit is enforced. Using known bounds on the MJD epoch and orbit inclination, the 65,535 bodies were filtered to just two, the desired Ceres and Vesta. It is important to note that there are two sorting methods, numeric and ASCII. By pressing the *Column Formats* button a window pops up prompting the user to specify which columns need to be sorted numerically, and which as strings (ASCII). This is shown in Figure 15. By default, the epoch and orbital elements are the only columns that sort numerically.

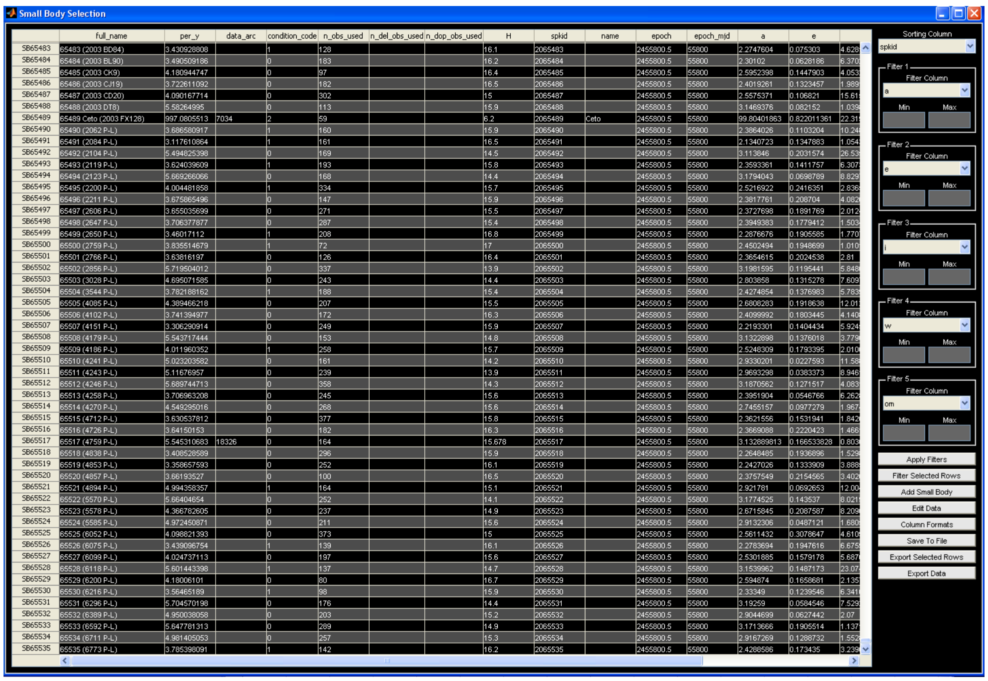

Figure 14. EXPLORE Small Body Browser window.

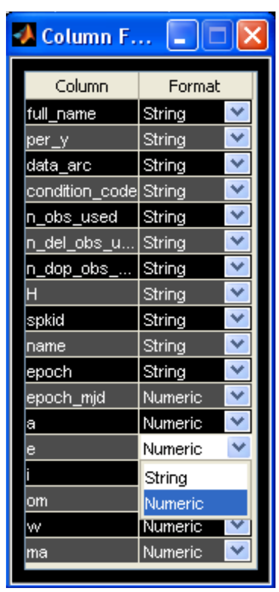

Figure 15. EXPLORE Small Body Browser column sorting specification window.

Two filters may often not be enough to reduce the bodies to the desired subset. Up to five filters may be used and the user has the ability to filter individual bodies if these are not enough. Users may also add a new body to the set or edit existing bodies, giving the user complete control of the data exported from the SBB to the EXPLORE Input GUI. Figure 16 shows the results of the sorting, as well as the prompt users see when exporting the small body data from the SBB to the EXPLORE Input GUI.

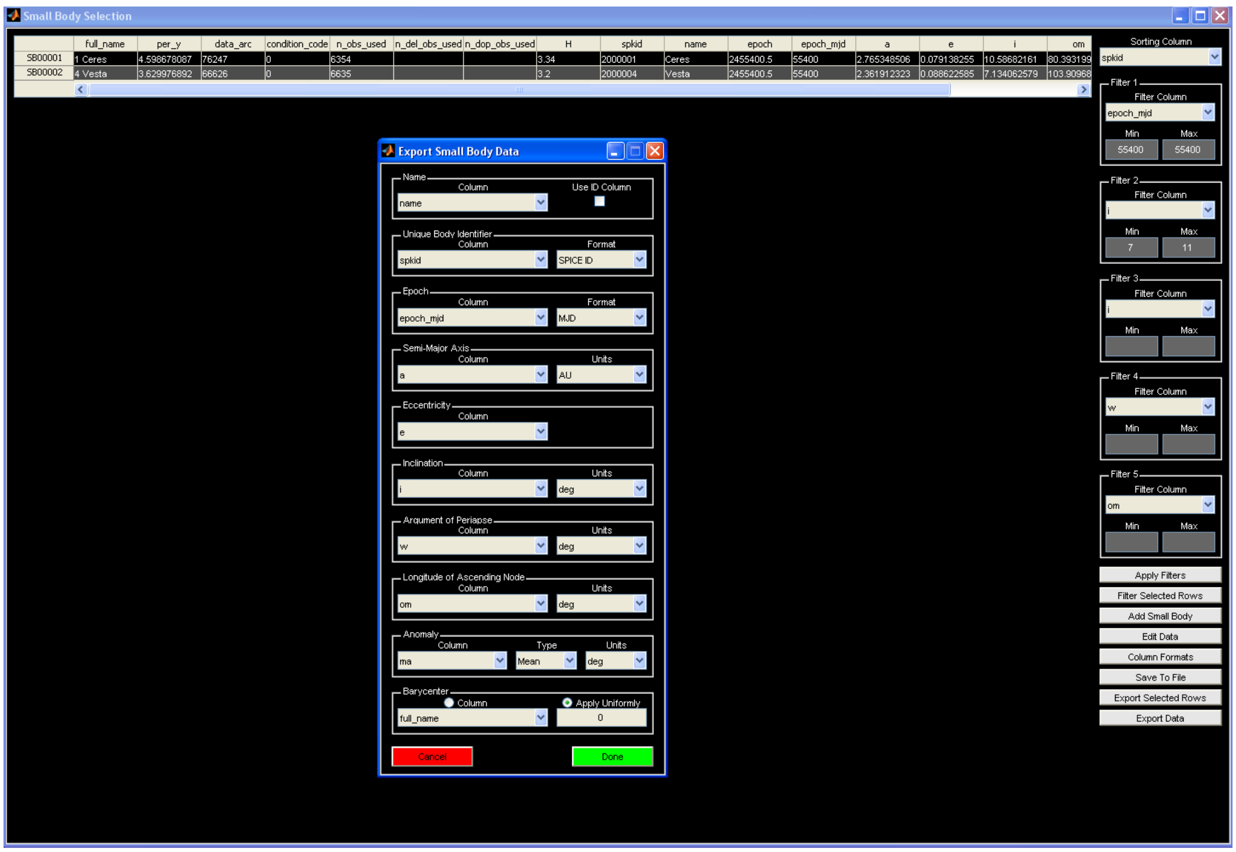

Figure 16. Filtered small body data and export prompt window.

Once the small bodies are exported from the SBB to the EXPLORE Input GUI, the program cannot differentiate standard bodies loaded at startup from small bodies loaded from he SBB. Figure 17a shows the body properties menu for Earth and Figure 17b shows the body properties for the asteroid Vesta. Because the small bodies are not guaranteed to have ephemeris files, two Kepler propagator methods are available to calculate the position of the small bodies for the EXPLORE grid search, both of which require six orbital elements and an epoch. The first uses a cubic spline interpolation based on a precalculated table of data points calculated using a Kepler propagator. The other uses a direct Kepler propagator call each time a new point is needed. Each of these provides several times speedup over SPICE calls for bodies using ephemeris files, the cubic spline being the most efficient method. For this reason it may be desirable to reduce the accuracy of the standard bodies and use two-body orbit approximations via a Kepler propagator rather than ephemeris files. In this case the user simply needs to specify the approximate orbital elements and an epoch for the standard bodies, then switch the propagator from the *Ephemeris* option to either the *Interpolation* or *Kepler* method.

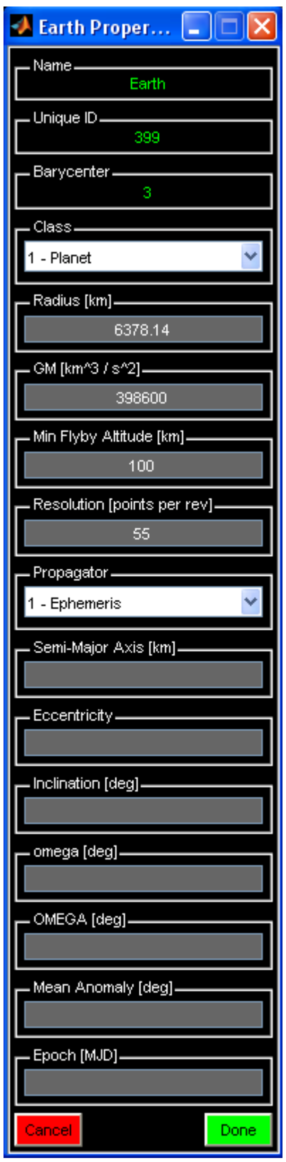

Figure 17a. Earth properties menu

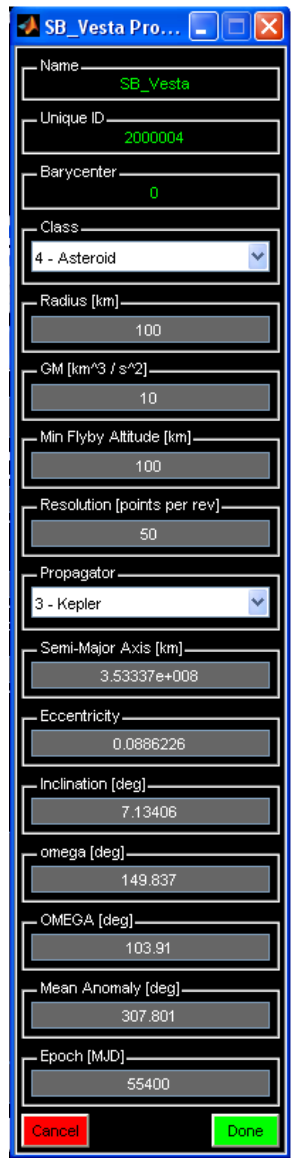

Figure 17b. Vesta properties menu

The input file *Cassini_Mission.input* was loaded into the EXPLORE Input GUI, thus all of the constraints and settings were set already. Modifying the trajectory sequence clears the trajectory constraints, such as the node time constraints, thus by adding the small bodies Ceres and Vesta to the trajectory, these constraints must be re-entered. The first modified sequence appended Vesta after Saturn, and the emptied EXPLORE Trajectory Constraints window is shown in Figure 18. For details about using this window, please refer to the EXPLORE User's manual. Figure 19 below shows the only trajectory constraints required for this search, the initial and final time bounds for each node.

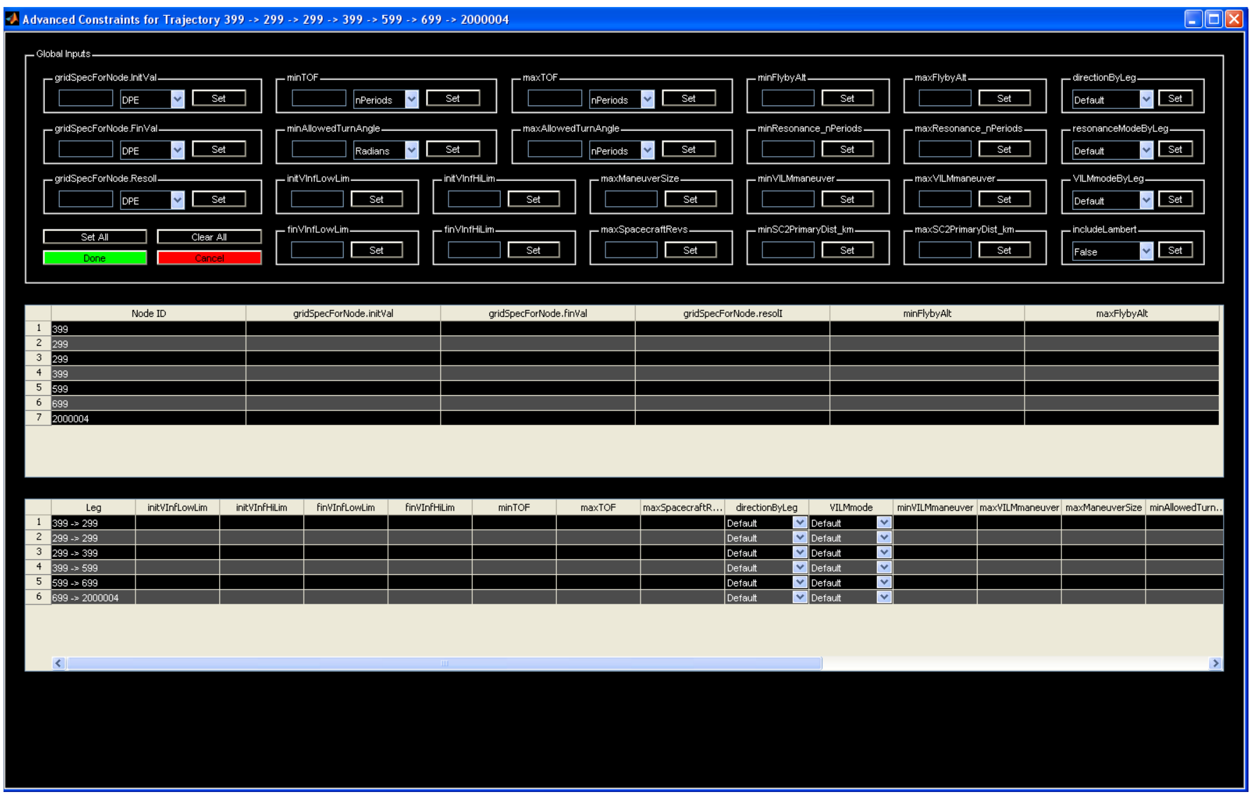

Figure 18. Emptied EXPLORE Trajectory Constraints window.

	Node ID	gridSpecForNode.initVal	gridSpecForNode.finVal
1	399		
2	299	185	205
3	299	600	650
4	399	660	720
5	599	1130	1230
6	699	2400	2500
7	2000004	4800	5000

Figure 19. Trajectory constraints for Cassini-to-Vesta trajectory.

Typically the search space should be left broad to capture as many candidate solutions as possible, which can then be filtered and analyzed using methods described above. This search kept the 5,000 days past epoch limit for the mission TOF, and initially the final leg (Saturn to Vesta) was left free. Only one solution was found in this time range, and for speed and improved appearance during the search, appropriate time bounds for the single solution were honed in to be between 4,800 and 5,000 days past epoch. With these constraints defined, the new input file, *Cassini_Vesta.input*, was generated and run. As mentioned, exactly one solution was found, as shown in Figure 20.

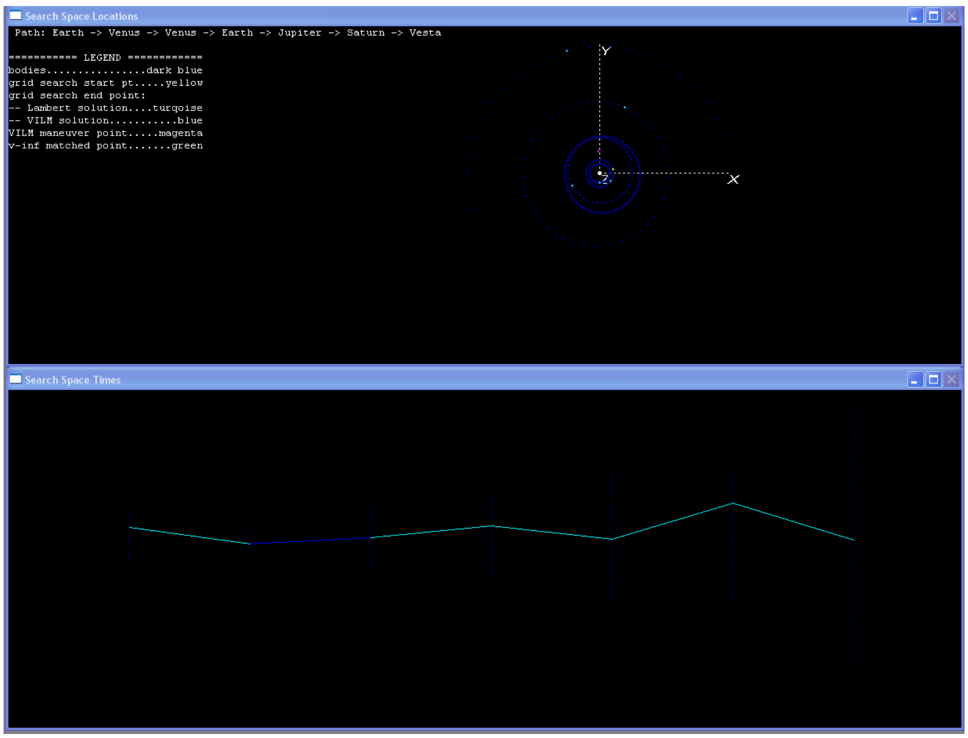

Figure 20. EXPLORE search result from the *Cassini_Vesta.input* file.

Because only one solution was found, there was no need to filter using the EXPLORE Nodes GUI. The .traj files were generated for the bodies and spacecraft and loaded into the EXPLORE Trajectory GUI. The 2D trajectory with flyby and VILM locations marked, shown below in Figure 21. It is interesting to note the shape of the trajectory from the Earth flyby to the Vesta arrival, which approximates a continuous, smooth ellipse. This implies low turning angles from the Jupiter and Saturn flybys, which consequently indicates good feasibility and low risk due to high-altitude flybys.

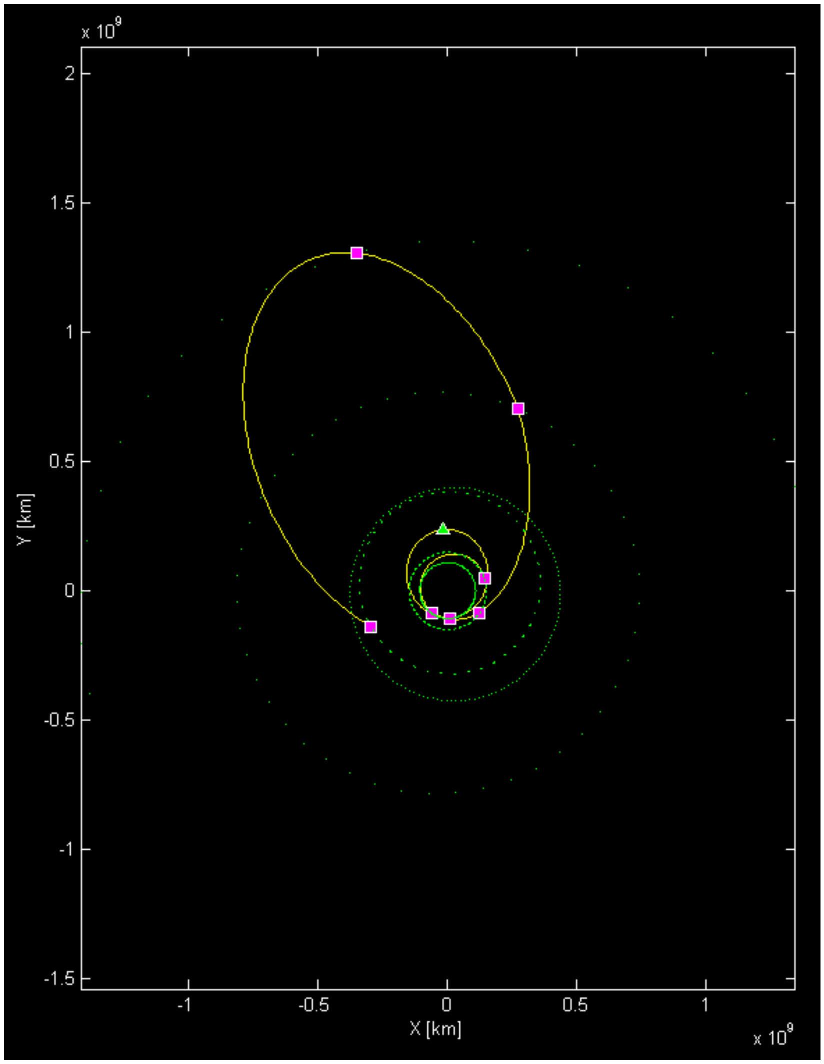

Figure 21. 2D trajectory from the *Cassini_Vesta.input* file.

With only one solution there is little to be done for analyzing and selecting the best trajectory. Rather than broadening the search space to capture more solutions, the user has the capability to refine the search space around solutions, limiting the search to a small region with high resolution to find neighboring solutions. Because only one solution was found, this solution is manually selected and the grid refinement properties are entered, as shown in Figure 22. The angle inputs define a true anomaly window centered about each node in the solution, and the grid resolution multiplier will increase the resolution of each body by the input factor. With the inputs in Figure 22, the search will center with ±5° around each node and increase the resolution by a factor of 3 for each body.

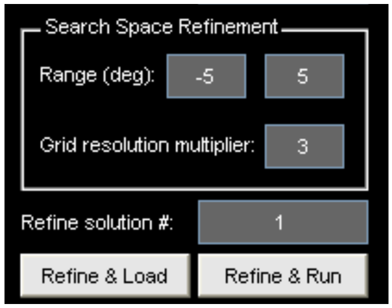

Figure 22. EXPLORE search grid refinement inputs.

With the grid refinement parameters entered, the user can generate a new input file and load it into the EXPLORE Input GUI or generate it and run it directly. Because no other changes are required besides the grid refinement, there is no need to load the new input file. The input file, *Cassini_Vesta_T006_S001.input*, is generated and run, the name indicating that it is derived from *Cassini_Vesta.input*, refined using the EXPLORE Trajectory GUI, using output files generated after leg 6 of the trajectory, and using solution 1 as the reference trajectory. The refined input resulted in three solutions, as shown in Figure 23.

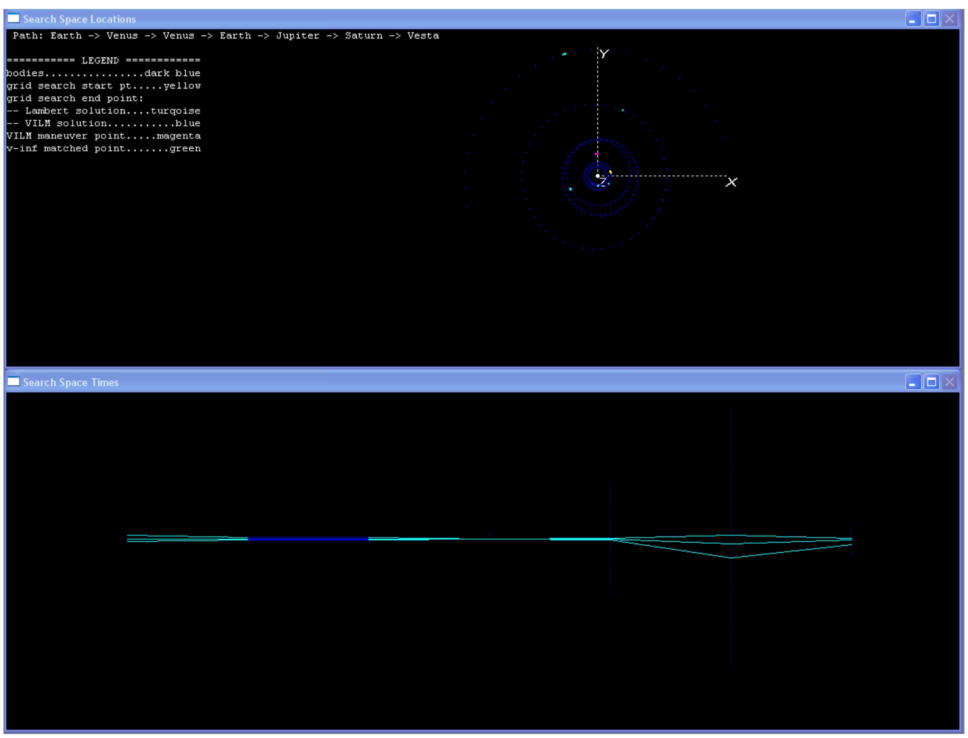

Figure 23. EXPLORE search results from the *Cassini_Vesta_T006_S001.input* file.

It appears that the three neighboring solutions are quite similar, which is verified using the EXPLORE Nodes GUI. The launch V_∞ values have a range of about 0.14 km/s, and the arrival V_∞ values have a range of about 0.20 km/s, as shown in Figure 24. Because there are only three solutions, .traj files are generated for all solutions and bodies. Figure 25a shows the 2D trajectories for all three solutions overlaid, and as expected there is little difference between them. Because these three solutions were found by examining the search space immediately surrounding a single solution, it is expected that they will exhibit very similar characteristics. If the refined search included grid points at ±10°, for example, the resulting solutions may exhibit a wider range of variation. As the search space is increased, the refined solutions may include trajectories from distinct families of solutions, in which case the characteristics could vary widely. To see the individual solutions more clearly, plotting the solution number along the z-axis and plotting in 3D effectively "pulls apart" the individual solutions, as shown in Figure 25b.

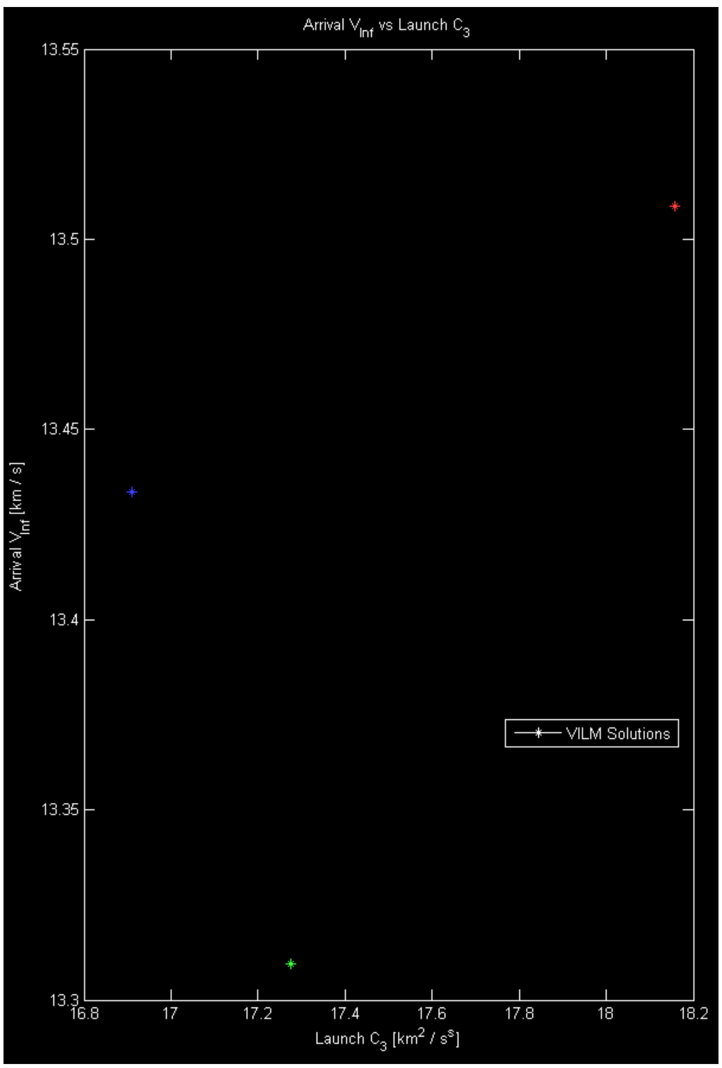

Figure 24. Arrival V_∞ vs. launch C_3 for solutions from the *Cassini_Vesta_T006_S001.input* file.

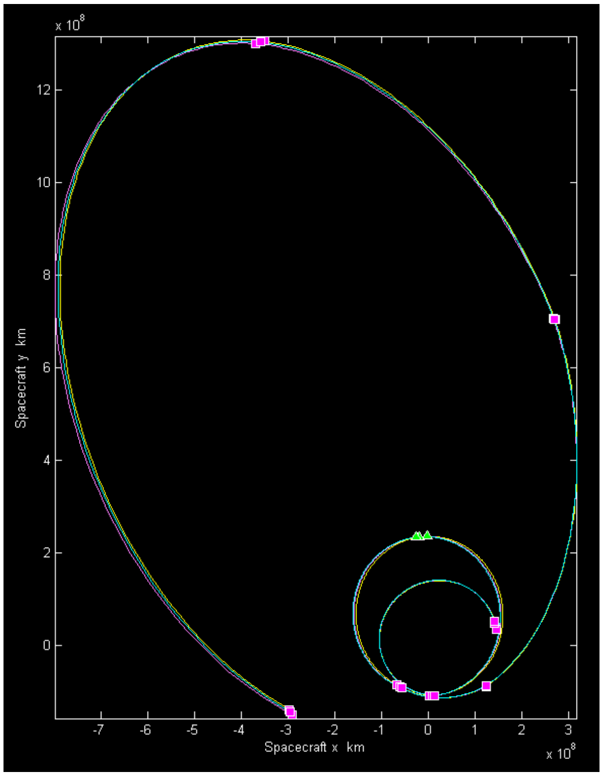

Figure 25a. Overlaid 2D trajectories for solutions from the *Cassini_Vesta_T006_S001.input* file.

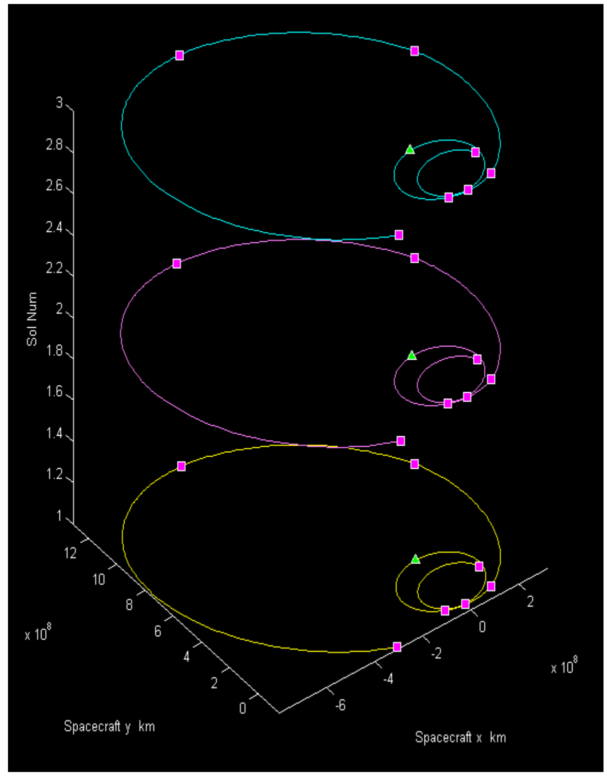

Figure 25a. Individual 2D trajectories for solutions from the *Cassini_Vesta_T006_S001.input* file.

Using the EXPLORE Nodes and Trajectory GUIs, much more in-depth analysis can be used to determine the ideal trajectory for the Cassini-plus-Vesta mission design. Further grid refinement can be done to find yet even more solutions, or the dates can be modified to find entirely new sets. The focus will now shift, however, from the Cassini-plus-Vesta mission design to the Cassini-plus-Ceres mission design. The initial steps were identical to the Vesta mission design, constraining the first six nodes to remain close to the Cassini mission dates, then allowing the seventh (Ceres) to be free up to 5,000 days past epoch. Three distinct solutions were found within a time range of 4,000 to 4,500 days past epoch for the seventh node, as shown below in Figure 26, unlike the Vesta case in which only one solution was found in the time range of about 2,300 to 5,000 days past epoch.

The three solutions were loaded into the EXPLORE Nodes GUI and analyzed. In the original Cassini search, only one solution remained within the constraints and grid discretization. Because these same parameters were used in this search, it was expected that the only variation between the three solutions existed on the last node, Ceres. This was clearly noticeable when plotting in the EXPLORE Nodes GUI, an example shown in Figure 27 below, in which each of the three solutions has exactly the same launch C_3. Unlike in Figure 24, where the three solutions were found by refining the search space about a single solution, Figure 27 has arrival V_∞ values with a range of about 1.2 km/s. This variation allows users to quickly identify attractive candidate solutions to refine the search grid about. Because this process was chronicled using the Cassini-plus-Vesta mission design, it will not be repeated for the Cassini-plus-Ceres mission design. Again with only three solutions, all .traj files are generated and visualized using the EXPLORE Trajectory GUI.

Similar to Figures 25a and 25b, Figure 28a shows the overlaid trajectories for all three solutions and Figure 28b shows the three solutions "pulled apart" by plotting solution number along the z-axis. Unlike the Vesta trajectories, the Ceres trajectories do not have a smooth appearance at the Saturn node. All three solutions have a sharp turning angle, indicating low-altitude flybys. Though this increases the risk associated with the mission, a lower-altitude flyby could allow for higher scientific return value.

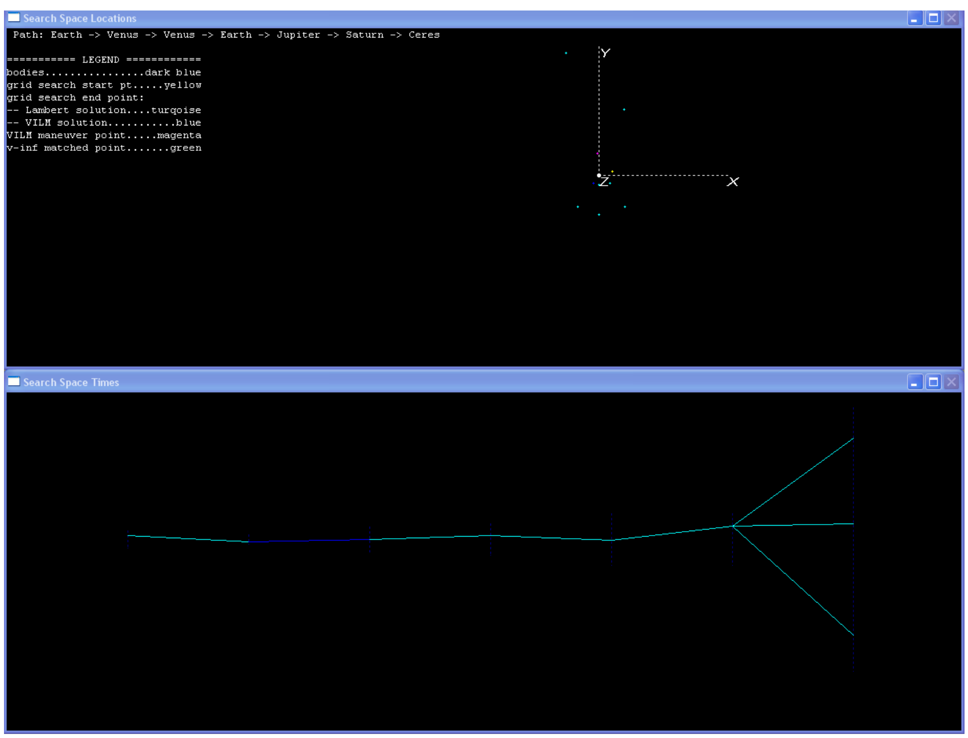

Figure 26. EXPLORE search result from the *Cassini_Ceres.input* file.

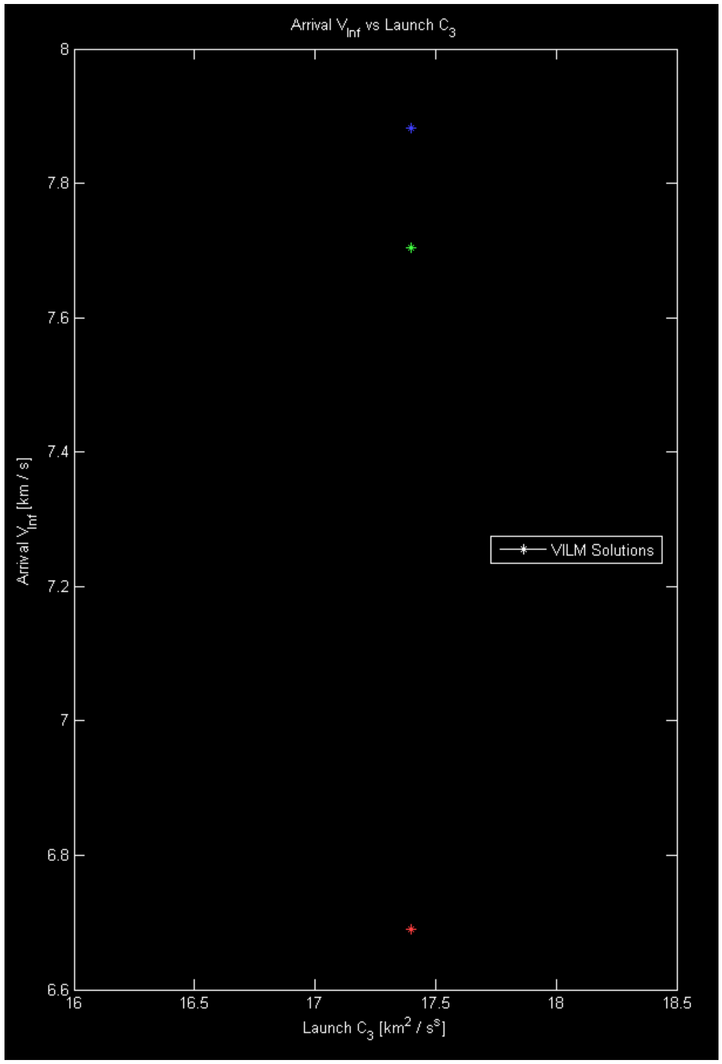

Figure 27. Arrival V_∞ vs. launch C_3 for solutions from the *Cassini_Ceres.input* file.

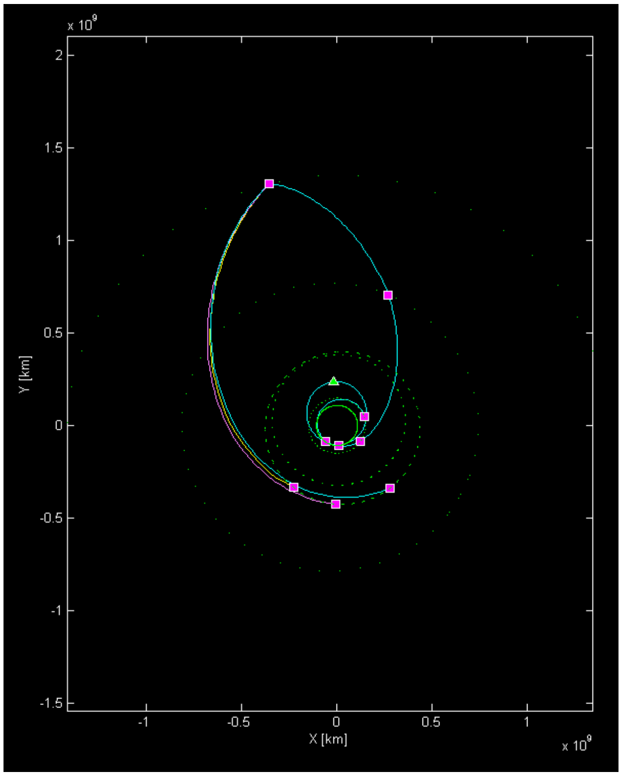

Figure 28a. Overlaid 2D trajectories for solutions from the *Cassini_Ceres.input* file.

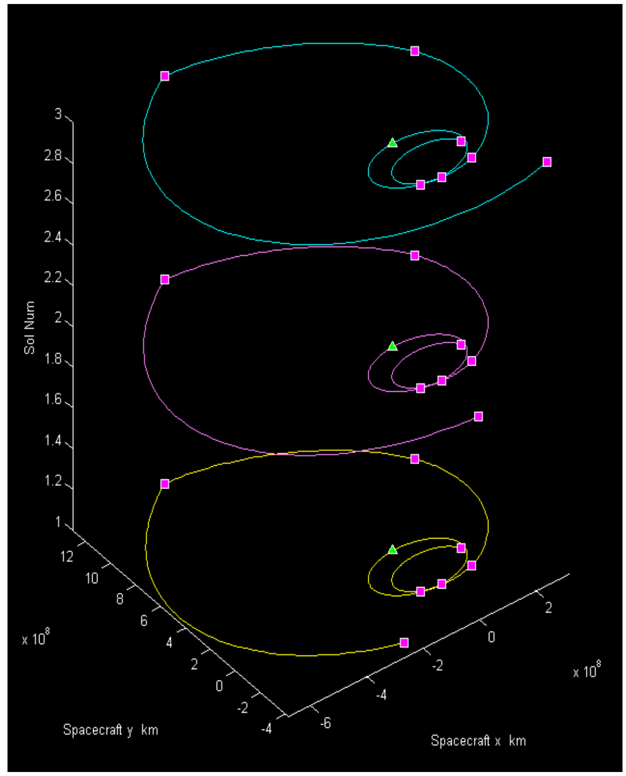

Figure 28a. Individual 2D trajectories for solutions from the *Cassini_Ceres.input* file.

Conclusion

From the Cassini mission data provided by NASA [2], it was known that a trajectory could be designed to depart Earth, fly by Venus twice with a VILM in between, then flyby Earth on a slingshot trajectory to the outer planets. Using the provided Cassini mission as a reference design mission, 20 trajectories were found with similar dates and trajectory paths. From this, further analysis could be done within the EXPLORE Nodes and Trajectory GUIs, and sufficient data is provided for further post-processing. With EXPLORE's solution filtering and grid refinement capabilities, users can quickly focus on candidate solutions of interest, saving time and resources by discarding extraneous solutions. The Cassini mission was reproduced within 3 hours starting with only the inner-planetary flybys and VILM on a common desktop computer.

Without ephemeris files, EXPLORE's small-body modules include the capability of calculating two-body orbits using basic orbital elements and an epoch, and EXPLORE's small body browser allows users to edit existing bodies or define new ones, extending the search space to virtually any known body and allowing for new classes of missions to be designed beyond the capability of existing software. The Cassini trajectory was modified to include two small bodies, the asteroid Vesta and the dwarf planet Ceres. This required only an additional hour and resulted in 6 trajectories, 3 each for Vesta and Ceres, potentially bridging the Cassini and Dawn missions.

Using well-known trajectories as a base, EXPLORE is an efficient tool for searching for neighboring trajectories and/or extending the trajectory to include new bodies. Its GUIs allow users to quickly create and run input files, analyze and filter the results, and refine the search space. Its automated VILM search and small body capabilities, as well as its efficient memory structure and limited file read/write operations, set it apart from other mission design software. Within mere hours, opposed to days or weeks, users may begin from nebulous mission constraints and develop well-defined mission trajectories with ideal characteristics.

References

[1] Heaton, Andrew F., et al. "Automated Design of the Europa Orbiter Tour." Purdue University, West Lafayette, IN. 2000.

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[3] NASA. "The Cassini Mission to Saturn." Jet Propulsion Laboratory, Pasadena, CA. JPL 400-843, October 1999. Web. July 25 2011. <http://saturn.jpl.nasa.gov/multimedia/products/pdfs/cassini_msn.pdf>.

[4] Rayman, Marc D., et al. "Dawn: A mission in development for exploration of main belt asteroids Vesta and Ceres." *Acta Astronautica* 58 (2006): 605-616. Web. 25 July 2011. <http://dawn.jpl.nasa.gov/mission/Dawn_overview.pdf>.

[5] Rinderle, E. A. "Galileo User's Guide, Mission Design System, Satellite Tour Analysis and Design Subsystem." Jet Propulsion Laboratory, Pasadena, CA. JPL D-263, 1986.

[6] Williams, S. N., and J. M. Longuski. "Low Energy Trajectories to Mars via Gravity Assist from Venus to Earth." *Engineering Notes* Jul. - Aug. 1991: 486-488. Print.

Appendix A: Original Cassini-like mission input file

Cassini_Mission.input

```
!================================================
&inputDeckNL
!================================================
  runID              = 'Cassini_Mission'
  numEphemFiles      = 4
  ephemFile(1)       = 'de421.bsp'
  ephemFile(2)       = 'jup230l.bsp'
  ephemFile(3)       = 'sat291.bsp'
  ephemFile(4)       = 'sat299.bsp'
!------------------------------------------------------------
  masterEpochStr     = '06-Oct-1997 00:00:00.000'
  earliestLaunchDate_DPE = -5
  latestLaunchDate_DPE   = 30
  maxMissionEndDate_DPE  = 2600
!------------------------------------------------------------
  masterRefFrame     = 'ECLIPJ2000'
  origin_ID          = 10
  sequenceByNumber   = 399,299,299,399,599,699
  numLegs            = 5
!------------------------------------------------------------
  launchVinfRange(1) = 4
  launchVinfRange(2) = 4.472136e+000
!------------------------------------------------------------
  gridSpecForNode_DPE(2)%initVal = 185
  gridSpecForNode_DPE(2)%finVal  = 205
  gridSpecForNode_DPE(3)%initVal = 600
  gridSpecForNode_DPE(3)%finVal  = 650
  gridSpecForNode_DPE(4)%initVal = 660
  gridSpecForNode_DPE(4)%finVal  = 720
  gridSpecForNode_DPE(5)%initVal = 1130
  gridSpecForNode_DPE(5)%finVal  = 1230
  gridSpecForNode_DPE(6)%initVal = 2400
  gridSpecForNode_DPE(6)%finVal  = 2500
  globalResolMultiplier  = 18
!------------------------------------------------------------
  body(0)%name       = 'Sun'
  body(0)%ID         = 10
  body(0)%barycenter = 0
  body(0)%GM         = 1.32712e+011
  body(0)%Radius     = 696000
!------------------------------------------------------------
  body(1)%name       = 'Earth'
  body(1)%ID         = 399
  body(1)%barycenter = 3
  body(1)%defResolI  = 55
  body(1)%GM         = 398600
  body(1)%radius     = 6378.14
  body(1)%minAlt     = 100
  body(1)%propagator = 1
!------------------------------------------------------------
  body(2)%name       = 'Venus'
  body(2)%ID         = 299
  body(2)%barycenter = 2
  body(2)%defResolI  = 45
  body(2)%GM         = 324859
  body(2)%radius     = 6052
  body(2)%minAlt     = 100
  body(2)%propagator = 1
!------------------------------------------------------------
  body(3)%name       = 'Jupiter'
  body(3)%ID         = 599
  body(3)%barycenter = 5
  body(3)%defResolI  = 150
  body(3)%GM         = 1.26687e+008
  body(3)%radius     = 71492
  body(3)%minAlt     = 100
  body(3)%propagator = 1
!------------------------------------------------------------
  body(4)%name       = 'Saturn'
  body(4)%ID         = 699
  body(4)%barycenter = 6
  body(4)%defResolI  = 300
  body(4)%GM         = 3.79312e+007
  body(4)%radius     = 60330
  body(4)%minAlt     = 100
  body(4)%propagator = 1
!------------------------------------------------------------
  writeTrajForSC     = F
  writeTrajForBodies = F
  debugMode          = 3
  extraRevs          = 2
  trajFileSCResolMult  = 10
  solverPreFilterLevel = 0
  previousDataFile     = '*'
  writeTrajForSCThreshold = 10
  writeIntermedBinFiles  = T
  bspGen_active      = F
  bspGen_verify      = F
  bspGen_verify_posThreshold = 100000
  bspGen_verify_velThreshold = 0.1
  bspGen_polynom_degree  = 15
  useGPU             = F
  normalizationBalance   = 100
  VILMmodeOverride       = 2
!================================================
/ End of file
!================================================
```

Appendix B: Relaxed Cassini-like mission input file

Cassini_Mission_Relaxed.input

```
!=================================================
&inputDeckNL
!=================================================
   runID               = 'Cassini_Mission_Relaxed'
   numEphemFiles       = 4
   ephemFile(1)        = 'de421.bsp'
   ephemFile(2)        = 'jup230l.bsp'
   ephemFile(3)        = 'sat291.bsp'
   ephemFile(4)        = 'sat299.bsp'
!-----------------------------------------------------------
   masterEpochStr      = '06-Oct-1997 00:00:00.000'
   earliestLaunchDate_DPE  = -5
   latestLaunchDate_DPE    = 30
   maxMissionEndDate_DPE   = 5000
!-----------------------------------------------------------
   masterRefFrame      = 'ECLIPJ2000'
   origin_ID           = 10
   sequenceByNumber    = 399,299,299,399,599,699
   numLegs             = 5
!-----------------------------------------------------------
   gridSpecForNode_DPE(2)%initVal   = 185
   gridSpecForNode_DPE(2)%finVal    = 205
   gridSpecForNode_DPE(3)%initVal   = 600
   gridSpecForNode_DPE(3)%finVal    = 650
   gridSpecForNode_DPE(4)%initVal   = 660
   gridSpecForNode_DPE(4)%finVal    = 720
   globalResolMultiplier   = 18
!-----------------------------------------------------------
   body(0)%name          = 'Sun'
   body(0)%ID            = 10
   body(0)%barycenter    = 0
   body(0)%GM            = 1.32712e+011
   body(0)%Radius        = 696000
!-----------------------------------------------------------
   body(1)%name          = 'Earth'
   body(1)%ID            = 399
   body(1)%barycenter    = 3
   body(1)%defResolI     = 55
   body(1)%GM            = 398600
   body(1)%radius        = 6378.14
   body(1)%minAlt        = 100
   body(1)%propagator    = 1
!-----------------------------------------------------------
   body(2)%name          = 'Venus'
   body(2)%ID            = 299
   body(2)%barycenter    = 2
   body(2)%defResolI     = 45
   body(2)%GM            = 324859
   body(2)%radius        = 6052
   body(2)%minAlt        = 100
   body(2)%propagator    = 1
!-----------------------------------------------------------
   body(3)%name          = 'Jupiter'
   body(3)%ID            = 599
   body(3)%barycenter    = 5
   body(3)%defResolI     = 150
   body(3)%GM            = 1.26687e+008
   body(3)%radius        = 71492
   body(3)%minAlt        = 100
   body(3)%propagator    = 1
!-----------------------------------------------------------
   body(4)%name          = 'Saturn'
   body(4)%ID            = 699
   body(4)%barycenter    = 6
   body(4)%defResolI     = 300
   body(4)%GM            = 3.79312e+007
   body(4)%radius        = 60330
   body(4)%minAlt        = 100
   body(4)%propagator    = 1
!-----------------------------------------------------------
   body(5)%name          = 'Ceres'
   body(5)%ID            = 2000001
   body(5)%barycenter    = 0
   body(5)%defResolI     = 100
   body(5)%GM            = 100
   body(5)%radius        = 100
   body(5)%minAlt        = 100
   body(5)%propagator    = 3
   anaEphem(1,5)         = 4.1369e+008
   anaEphem(2,5)         = 0.0791383
   anaEphem(3,5)         = 10.5868
   anaEphem(4,5)         = 72.5898
   anaEphem(5,5)         = 80.3932
   anaEphem(6,5)         = 113.41
   anaEphem(7,5)         = 55400
!-----------------------------------------------------------
   body(6)%name          = 'Vesta'
   body(6)%ID            = 2000004
   body(6)%barycenter    = 0
   body(6)%defResolI     = 100
   body(6)%GM            = 100
   body(6)%radius        = 100
   body(6)%minAlt        = 100
   body(6)%propagator    = 3
   anaEphem(1,6)         = 3.53337e+008
   anaEphem(2,6)         = 0.0886226
   anaEphem(3,6)         = 7.13406
   anaEphem(4,6)         = 149.837
   anaEphem(5,6)         = 103.91
   anaEphem(6,6)         = 307.801
   anaEphem(7,6)         = 55400
!-----------------------------------------------------------
   writeTrajForSC        = F
   writeTrajForBodies    = F
   debugMode             = 3
   extraRevs             = 2
   trajFileSCResolMult   = 10
   solverPreFilterLevel  = 0
   previousDataFile      = '*'
   writeTrajForSCThreshold = 100
   writeIntermedBinFiles  = T
   bspGen_active         = F
   bspGen_verify         = F
   bspGen_verify_posThreshold = 100000
   bspGen_verify_velThreshold = 0.1
   bspGen_polynom_degree  = 15
   useGPU                = F
   normalizationBalance  = 100
   VILMmodeOverride      = 2
!=================================================
/ End of file
!=================================================
```

Appendix C: Cassini-like mission input file, refined from Appendix B

Cassini_Mission_Relaxed_N005_S007.input

```
!================================================
&inputDeckNL
!================================================
  runID          = 'Cassini_Mission_Relaxed_N005_S007'
  numEphemFiles        = 4
  ephemFile(1)         = 'de421.bsp'
  ephemFile(2)         = 'jup230l.bsp'
  ephemFile(3)         = 'sat291.bsp'
  ephemFile(4)         = 'sat299.bsp'
!------------------------------------------------------------
  masterEpochStr       = '06-Oct-1997 00:00:00.000'
  earliestLaunchDate_DPE  = 2
  latestLaunchDate_DPE    = 8
  maxMissionEndDate_DPE   = 2505
!------------------------------------------------------------
  masterRefFrame       = 'ECLIPJ2000'
  origin_ID            = 10
  sequenceByNumber     = 399,299,299,399,599,699
  numLegs              = 5
!------------------------------------------------------------
  globalResolMultiplier   = 18.000000
!------------------------------------------------------------
  body(0)%name         = 'Sun'
  body(0)%ID           = 10
  body(0)%barycenter   = 0
  body(0)%GM           = 1.32712e+011
  body(0)%Radius       = 696000
!------------------------------------------------------------
  body(1)%name         = 'Earth'
  body(1)%ID           = 399
  body(1)%barycenter   = 3
  body(1)%defResolI    = 55
  body(1)%GM           = 398600
  body(1)%radius       = 6378.14
  body(1)%minAlt       = 100
  body(1)%propagator   = 1
!------------------------------------------------------------
  body(2)%name         = 'Venus'
  body(2)%ID           = 299
  body(2)%barycenter   = 2
  body(2)%defResolI    = 45
  body(2)%GM           = 324859
  body(2)%radius       = 6052
  body(2)%minAlt       = 100
  body(2)%propagator   = 1
!------------------------------------------------------------
  body(3)%name         = 'Jupiter'
  body(3)%ID           = 599
  body(3)%barycenter   = 5
  body(3)%defResolI    = 150
  body(3)%GM           = 1.26687e+008
  body(3)%radius       = 71492
  body(3)%minAlt       = 100
  body(3)%propagator   = 1
!------------------------------------------------------------
  body(4)%name         = 'Saturn'
  body(4)%ID           = 699
  body(4)%barycenter   = 6
  body(4)%defResolI    = 300
  body(4)%GM           = 3.79312e+007
  body(4)%radius       = 60330
  body(4)%minAlt       = 100
  body(4)%propagator   = 1
!------------------------------------------------------------
  body(5)%name         = 'Ceres'
  body(5)%ID           = 2000001
  body(5)%barycenter   = 0
  body(5)%defResolI    = 100
  body(5)%GM           = 100
  body(5)%radius       = 100
  body(5)%minAlt       = 100
  body(5)%propagator   = 3
  anaEphem(1,5)        = 4.1369e+008
  anaEphem(2,5)        = 0.0791383
  anaEphem(3,5)        = 10.5868
  anaEphem(4,5)        = 72.5898
  anaEphem(5,5)        = 80.3932
  anaEphem(6,5)        = 113.41
  anaEphem(7,5)        = 55400
!------------------------------------------------------------
  body(6)%name         = 'Vesta'
  body(6)%ID           = 2000004
  body(6)%barycenter   = 0
  body(6)%defResolI    = 100
  body(6)%GM           = 100
  body(6)%radius       = 100
  body(6)%minAlt       = 100
  body(6)%propagator   = 3
  anaEphem(1,6)        = 3.53337e+008
  anaEphem(2,6)        = 0.0886226
  anaEphem(3,6)        = 7.13406
  anaEphem(4,6)        = 149.837
  anaEphem(5,6)        = 103.91
  anaEphem(6,6)        = 307.801
  anaEphem(7,6)        = 55400
!------------------------------------------------------------
  writeTrajForSC       = T
  writeTrajForBodies   = T
  debugMode            = 3
  extraRevs            = 2
  trajFileSCResolMult  = 10
  solverPreFilterLevel = 0
  writeTrajForSCThreshold = 100
  writeIntermedBinFiles   = T
  bspGen_active        = F
  bspGen_verify        = F
  bspGen_verify_posThreshold = 100000
  bspGen_verify_velThreshold = 0.1
  bspGen_polynom_degree   = 15
  useGPU               = F
  normalizationBalance = 100
  VILMmodeOverride     = 2
!================================================
  gridSpecForNode_DPE(2)%initVal = 199
  gridSpecForNode_DPE(2)%finVal  = 203
!------------------------------------------------------------
  gridSpecForNode_DPE(3)%initVal = 624
  gridSpecForNode_DPE(3)%finVal  = 628
!------------------------------------------------------------
  gridSpecForNode_DPE(4)%initVal = 678
  gridSpecForNode_DPE(4)%finVal  = 684
!------------------------------------------------------------
  gridSpecForNode_DPE(5)%initVal = 1148
  gridSpecForNode_DPE(5)%finVal  = 1216
!------------------------------------------------------------
  gridSpecForNode_DPE(6)%initVal = 2344
!================================================
/ End of file
!================================================
```

Appendix D: Cassini-plus-Vesta mission input file

Cassini_Vesta.input

```
!===============================================
&inputDeckNL
!===============================================
  runID              = 'Cassini_Vesta'
  numEphemFiles         = 4
  ephemFile(1)          = 'de421.bsp'
  ephemFile(2)          = 'jup230l.bsp'
  ephemFile(3)          = 'sat291.bsp'
  ephemFile(4)          = 'sat299.bsp'
!-----------------------------------------------------------
  masterEpochStr        = '06-Oct-1997 00:00:00.000'
  earliestLaunchDate_DPE  = -5
  latestLaunchDate_DPE    = 30
  maxMissionEndDate_DPE   = 5000
!-----------------------------------------------------------
  masterRefFrame        = 'ECLIPJ2000'
  origin_ID             = 10
  sequenceByNumber      =
399,299,299,399,599,699,2000004
  numLegs               = 6
!-----------------------------------------------------------
  launchVinfRange(1)    = 4
  launchVinfRange(2)    = 4.472136e+000
!-----------------------------------------------------------
  gridSpecForNode_DPE(2)%initVal    = 185
  gridSpecForNode_DPE(2)%finVal     = 205
  gridSpecForNode_DPE(3)%initVal    = 600
  gridSpecForNode_DPE(3)%finVal     = 650
  gridSpecForNode_DPE(4)%initVal    = 660
  gridSpecForNode_DPE(4)%finVal     = 720
  gridSpecForNode_DPE(5)%initVal    = 1130
  gridSpecForNode_DPE(5)%finVal     = 1230
  gridSpecForNode_DPE(6)%initVal    = 2400
  gridSpecForNode_DPE(6)%finVal     = 2500
  gridSpecForNode_DPE(7)%initVal    = 4800
  gridSpecForNode_DPE(7)%finVal     = 5000
  globalResolMultiplier   = 18
!-----------------------------------------------------------
  body(0)%name          = 'Sun'
  body(0)%ID            = 10
  body(0)%barycenter     = 0
  body(0)%GM            = 1.32712e+011
  body(0)%Radius        = 696000
!-----------------------------------------------------------
  body(1)%name          = 'Earth'
  body(1)%ID            = 399
  body(1)%barycenter     = 3
  body(1)%defResolI      = 55
  body(1)%GM            = 398600
  body(1)%radius        = 6378.14
  body(1)%minAlt        = 100
  body(1)%propagator     = 1
!-----------------------------------------------------------
  body(2)%name          = 'Venus'
  body(2)%ID            = 299
  body(2)%barycenter     = 2
  body(2)%defResolI      = 45
  body(2)%GM            = 324859
  body(2)%radius        = 6052
  body(2)%minAlt        = 100
  body(2)%propagator     = 1
!-----------------------------------------------------------
  body(3)%name          = 'Jupiter'
  body(3)%ID            = 599
  body(3)%barycenter     = 5
  body(3)%defResolI      = 150
  body(3)%GM            = 1.26687e+008
  body(3)%radius        = 71492
  body(3)%minAlt        = 100
  body(3)%propagator     = 1
!-----------------------------------------------------------
  body(4)%name          = 'Saturn'
  body(4)%ID            = 699
  body(4)%barycenter     = 6
  body(4)%defResolI      = 300
  body(4)%GM            = 3.79312e+007
  body(4)%radius        = 60330
  body(4)%minAlt        = 100
  body(4)%propagator     = 1
!-----------------------------------------------------------
  body(5)%name          = 'Ceres'
  body(5)%ID            = 2000001
  body(5)%barycenter     = 0
  body(5)%defResolI      = 100
  body(5)%GM            = 100
  body(5)%radius        = 100
  body(5)%minAlt        = 100
  body(5)%propagator     = 3
  anaEphem(1,5)         = 4.1369e+008
  anaEphem(2,5)         = 0.0791383
  anaEphem(3,5)         = 10.5868
  anaEphem(4,5)         = 72.5898
  anaEphem(5,5)         = 80.3932
  anaEphem(6,5)         = 113.41
  anaEphem(7,5)         = 55400
!-----------------------------------------------------------
  body(6)%name          = 'Vesta'
  body(6)%ID            = 2000004
  body(6)%barycenter     = 0
  body(6)%defResolI      = 100
  body(6)%GM            = 100
  body(6)%radius        = 100
  body(6)%minAlt        = 100
  body(6)%propagator     = 3
  anaEphem(1,6)         = 3.53337e+008
  anaEphem(2,6)         = 0.0886226
  anaEphem(3,6)         = 7.13406
  anaEphem(4,6)         = 149.837
  anaEphem(5,6)         = 103.91
  anaEphem(6,6)         = 307.801
  anaEphem(7,6)         = 55400
!-----------------------------------------------------------
  writeTrajForSC        = F
  writeTrajForBodies     = F
  debugMode             = 3
  extraRevs             = 2
  trajFileSCResolMult    = 10
  solverPreFilterLevel   = 0
  previousDataFile       = '*'
  writeTrajForSCThreshold = 10
  writeIntermedBinFiles   = T
  bspGen_active          = F
  bspGen_verify          = F
  bspGen_verify_posThreshold = 100000
  bspGen_verify_velThreshold = 0.1
  bspGen_polynom_degree   = 15
  useGPU                = F
  normalizationBalance    = 100
  VILMmodeOverride       = 2
!===============================================
/ End of file
!===============================================
```

Appendix E: Refined Cassini-plus-Vesta mission input file

Cassini_Vesta_T006_S001.input

```
!==================================================
&inputDeckNL
!==================================================
   runID                = 'Cassini_Vesta_T006_S001'
   numEphemFiles        = 4
   ephemFile(1)         = 'de421.bsp'
   ephemFile(2)         = 'jup230l.bsp'
   ephemFile(3)         = 'sat291.bsp'
   ephemFile(4)         = 'sat299.bsp'
!-----------------------------------------------------------
   masterEpochStr       = '06-Oct-1997 00:00:00.000'
   earliestLaunchDate_DPE  = 0
   latestLaunchDate_DPE    = 10
   maxMissionEndDate_DPE   = 4919
!-----------------------------------------------------------
   masterRefFrame       = 'ECLIPJ2000'
   origin_ID            = 10
   sequenceByNumber     =
399,299,299,399,599,699,2000004
   numLegs              = 6
!-----------------------------------------------------------
   launchVinfRange(1)     = 4
   launchVinfRange(2)     = 4.472136e+000
   globalResolMultiplier  = 54.000000
!-----------------------------------------------------------
   body(0)%name         = 'Sun'
   body(0)%ID           = 10
   body(0)%barycenter   = 0
   body(0)%GM           = 1.32712e+011
   body(0)%Radius       = 696000
!-----------------------------------------------------------
   body(1)%name         = 'Earth'
   body(1)%ID           = 399
   body(1)%barycenter   = 3
   body(1)%defResolI    = 55
   body(1)%GM           = 398600
   body(1)%radius       = 6378.14
   body(1)%minAlt       = 100
   body(1)%propagator   = 1
!-----------------------------------------------------------
   body(2)%name         = 'Venus'
   body(2)%ID           = 299
   body(2)%barycenter   = 2
   body(2)%defResolI    = 45
   body(2)%GM           = 324859
   body(2)%radius       = 6052
   body(2)%minAlt       = 100
   body(2)%propagator   = 1
!-----------------------------------------------------------
   body(3)%name         = 'Jupiter'
   body(3)%ID           = 599
   body(3)%barycenter   = 5
   body(3)%defResolI    = 150
   body(3)%GM           = 1.26687e+008
   body(3)%radius       = 71492
   body(3)%minAlt       = 100
   body(3)%propagator   = 1
!-----------------------------------------------------------
   body(4)%name         = 'Saturn'
   body(4)%ID           = 699
   body(4)%barycenter   = 6
   body(4)%defResolI    = 300
   body(4)%GM           = 3.79312e+007
   body(4)%radius       = 60330
   body(4)%minAlt       = 100
   body(4)%propagator   = 1
!-----------------------------------------------------------
   body(5)%name         = 'Ceres'
   body(5)%ID           = 2000001
   body(5)%barycenter   = 0
   body(5)%defResolI    = 100
   body(5)%GM           = 100
   body(5)%radius       = 100
   body(5)%minAlt       = 100
   body(5)%propagator   = 3
   anaEphem(1,5)        = 4.1369e+008
   anaEphem(2,5)        = 0.0791383
   anaEphem(3,5)        = 10.5868
   anaEphem(4,5)        = 72.5898
   anaEphem(5,5)        = 80.3932
   anaEphem(6,5)        = 113.41
   anaEphem(7,5)        = 55400
!-----------------------------------------------------------
   body(6)%name         = 'Vesta'
   body(6)%ID           = 2000004
   body(6)%barycenter   = 0
   body(6)%defResolI    = 100
   body(6)%GM           = 100
   body(6)%radius       = 100
   body(6)%minAlt       = 100
   body(6)%propagator   = 3
   anaEphem(1,6)        = 3.53337e+008
   anaEphem(2,6)        = 0.0886226
   anaEphem(3,6)        = 7.13406
   anaEphem(4,6)        = 149.837
   anaEphem(5,6)        = 103.91
   anaEphem(6,6)        = 307.801
   anaEphem(7,6)        = 55400
!-----------------------------------------------------------
   writeTrajForSC       = F
   writeTrajForBodies   = F
   debugMode            = 3
   extraRevs            = 2
   trajFileSCResolMult  = 10
   solverPreFilterLevel = 0
   previousDataFile     = '*'
   writeTrajForSCThreshold = 10
   writeIntermedBinFiles   = T
   normalizationBalance    = 100
   VILMmodeOverride        = 2
!==================================================
   gridSpecForNode_DPE(2)%initVal = 197
   gridSpecForNode_DPE(2)%finVal  = 204
!-----------------------------------------------------------
   gridSpecForNode_DPE(3)%initVal = 622
   gridSpecForNode_DPE(3)%finVal  = 629
!-----------------------------------------------------------
   gridSpecForNode_DPE(4)%initVal = 676
   gridSpecForNode_DPE(4)%finVal  = 686
!-----------------------------------------------------------
   gridSpecForNode_DPE(5)%initVal = 1126
   gridSpecForNode_DPE(5)%finVal  = 1239
!-----------------------------------------------------------
   gridSpecForNode_DPE(6)%initVal = 2290
   gridSpecForNode_DPE(6)%finVal  = 2559
!-----------------------------------------------------------
   gridSpecForNode_DPE(7)%initVal = 4886
!==================================================
/ End of file
!==================================================
```

Appendix F: Cassini-plus-Ceres mission input file

Cassini_Ceres.input

```
!==================================================
&inputDeckNL
!==================================================
   runID                = 'Cassini_Ceres'
   numEphemFiles        = 4
   ephemFile(1)         = 'de421.bsp'
   ephemFile(2)         = 'jup230l.bsp'
   ephemFile(3)         = 'sat291.bsp'
   ephemFile(4)         = 'sat299.bsp'
!------------------------------------------------------------
   masterEpochStr       = '06-Oct-1997 00:00:00.000'
   earliestLaunchDate_DPE  = -5
   latestLaunchDate_DPE    = 30
   maxMissionEndDate_DPE   = 5000
!------------------------------------------------------------
   masterRefFrame       = 'ECLIPJ2000'
   origin_ID            = 10
   sequenceByNumber     =
399,299,299,399,599,699,2000001
   numLegs              = 6
!------------------------------------------------------------
   launchVinfRange(1)     = 4
   launchVinfRange(2)     = 4.472136e+000
!------------------------------------------------------------
   gridSpecForNode_DPE(2)%initVal    = 185
   gridSpecForNode_DPE(2)%finVal     = 205
   gridSpecForNode_DPE(3)%initVal    = 600
   gridSpecForNode_DPE(3)%finVal     = 650
   gridSpecForNode_DPE(4)%initVal    = 660
   gridSpecForNode_DPE(4)%finVal     = 720
   gridSpecForNode_DPE(5)%initVal    = 1130
   gridSpecForNode_DPE(5)%finVal     = 1230
   gridSpecForNode_DPE(6)%initVal    = 2400
   gridSpecForNode_DPE(6)%finVal     = 2500
   gridSpecForNode_DPE(7)%initVal    = 4000
   gridSpecForNode_DPE(7)%finVal     = 4500
   globalResolMultiplier   = 18
!------------------------------------------------------------
   body(0)%name          = 'Sun'
   body(0)%ID            = 10
   body(0)%barycenter     = 0
   body(0)%GM            = 1.32712e+011
   body(0)%Radius        = 696000
!------------------------------------------------------------
   body(1)%name          = 'Earth'
   body(1)%ID            = 399
   body(1)%barycenter     = 3
   body(1)%defResolI      = 55
   body(1)%GM            = 398600
   body(1)%radius        = 6378.14
   body(1)%minAlt        = 100
   body(1)%propagator     = 1
!------------------------------------------------------------
   body(2)%name          = 'Venus'
   body(2)%ID            = 299
   body(2)%barycenter     = 2
   body(2)%defResolI      = 45
   body(2)%GM            = 324859
   body(2)%radius        = 6052
   body(2)%minAlt        = 100
   body(2)%propagator     = 1
!------------------------------------------------------------
   body(3)%name          = 'Jupiter'
   body(3)%ID            = 599
   body(3)%barycenter     = 5
   body(3)%defResolI      = 150
   body(3)%GM            = 1.26687e+008
   body(3)%radius        = 71492
   body(3)%minAlt        = 100
   body(3)%propagator     = 1
!------------------------------------------------------------
   body(4)%name          = 'Saturn'
   body(4)%ID            = 699
   body(4)%barycenter     = 6
   body(4)%defResolI      = 300
   body(4)%GM            = 3.79312e+007
   body(4)%radius        = 60330
   body(4)%minAlt        = 100
   body(4)%propagator     = 1
!------------------------------------------------------------
   body(5)%name          = 'Ceres'
   body(5)%ID            = 2000001
   body(5)%barycenter     = 0
   body(5)%defResolI      = 100
   body(5)%GM            = 100
   body(5)%radius        = 100
   body(5)%minAlt        = 100
   body(5)%propagator     = 3
   anaEphem(1,5)         = 4.1369e+008
   anaEphem(2,5)         = 0.0791383
   anaEphem(3,5)         = 10.5868
   anaEphem(4,5)         = 72.5898
   anaEphem(5,5)         = 80.3932
   anaEphem(6,5)         = 113.41
   anaEphem(7,5)         = 55400
!------------------------------------------------------------
   body(6)%name          = 'Vesta'
   body(6)%ID            = 2000004
   body(6)%barycenter     = 0
   body(6)%defResolI      = 100
   body(6)%GM            = 100
   body(6)%radius        = 100
   body(6)%minAlt        = 100
   body(6)%propagator     = 3
   anaEphem(1,6)         = 3.53337e+008
   anaEphem(2,6)         = 0.0886226
   anaEphem(3,6)         = 7.13406
   anaEphem(4,6)         = 149.837
   anaEphem(5,6)         = 103.91
   anaEphem(6,6)         = 307.801
   anaEphem(7,6)         = 55400
!------------------------------------------------------------
   writeTrajForSC        = F
   writeTrajForBodies     = F
   debugMode             = 3
   extraRevs             = 2
   trajFileSCResolMult    = 10
   solverPreFilterLevel   = 0
   previousDataFile       = '*'
   writeTrajForSCThreshold = 10
   writeIntermedBinFiles   = T
   bspGen_active          = F
   bspGen_verify          = F
   bspGen_verify_posThreshold = 100000
   bspGen_verify_velThreshold = 0.1
   bspGen_polynom_degree   = 15
   useGPU                = F
   normalizationBalance    = 100
   VILMmodeOverride       = 2
!==================================================
/ End of file
!==================================================
```