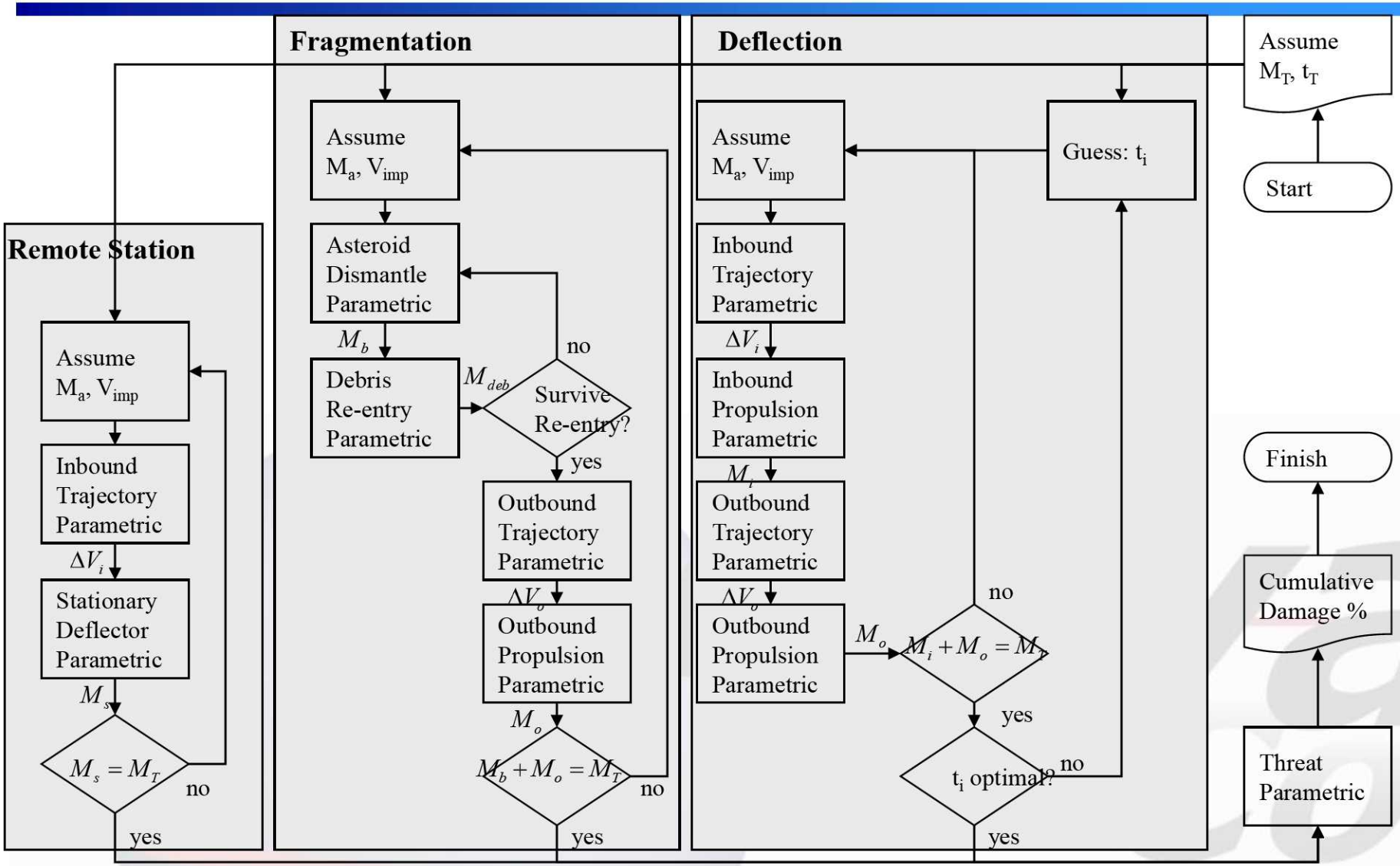
Toward Identifying Needed Investments in Modeling and Simulation Tools for NEO Deflection Planning

October 21, 2009

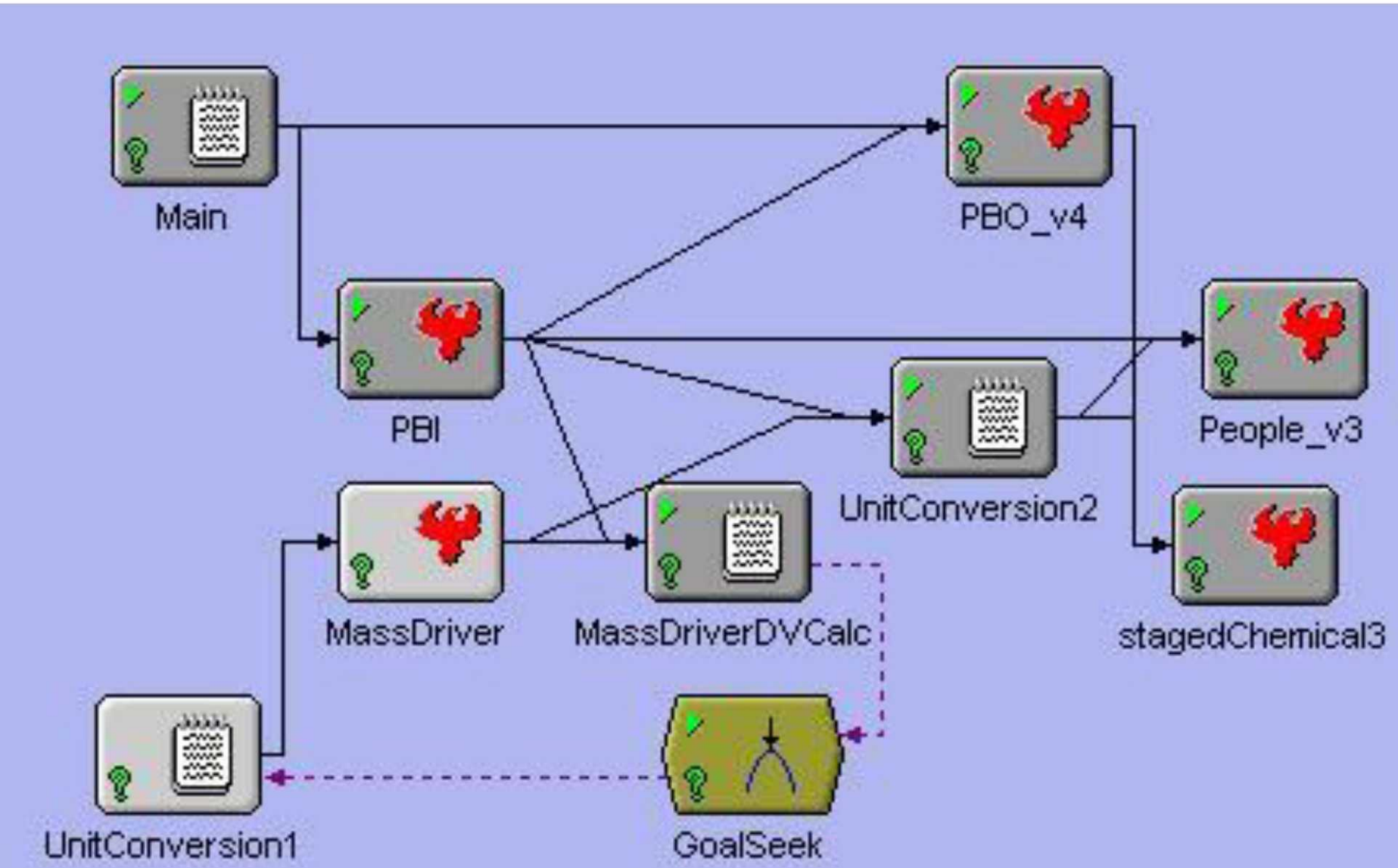
Outline

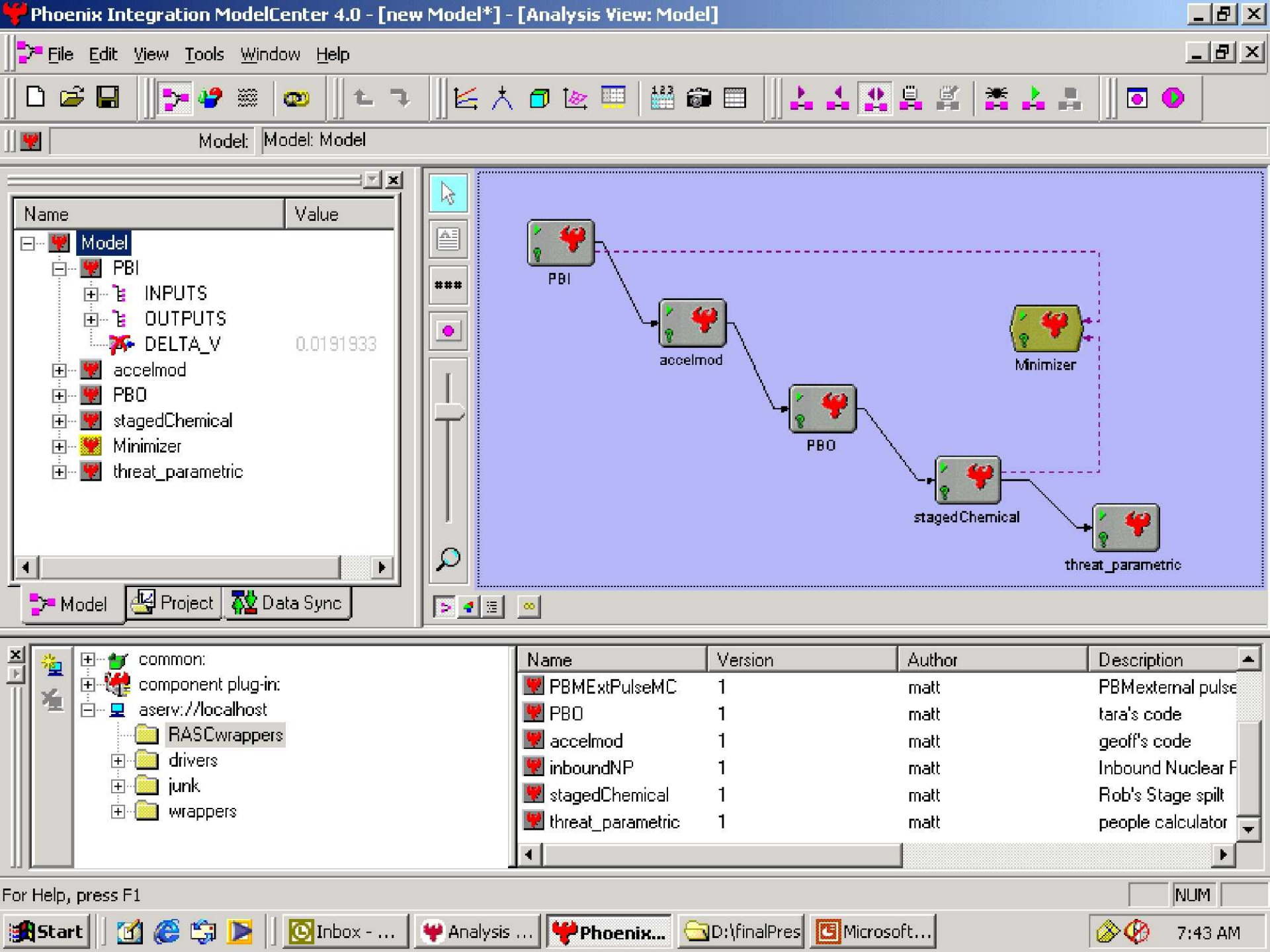
- Early Design Process
- Needed Tool Development
- Synergy with Other Missions
- Proposal for New Design Process
- Team Integration
- Conclusion

Early Design Process



Early Design Process

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Early Design Process

- Modified version of existing Monte Carlo code used to estimate number of deaths caused by asteroid impact
- Given maximum size and energy of deflectable NEO's calculates number of deaths prevented per century

•Chapman, C. R, and Morrison, D., "Impacts on the Earth by Asteroids and Comets: Assessing the Hazard," *Nature*, 6 January 1994.

•Gold, R. E., "SHIELD – A Comprehensive Earth Protection System: A Phase I Report to the NASA Institute for Advanced Concepts," 28 May 1999.

•Lewis, John S., *Comet and Asteroid Impact Hazards on a Populated Earth*, Academic Press, 1999.

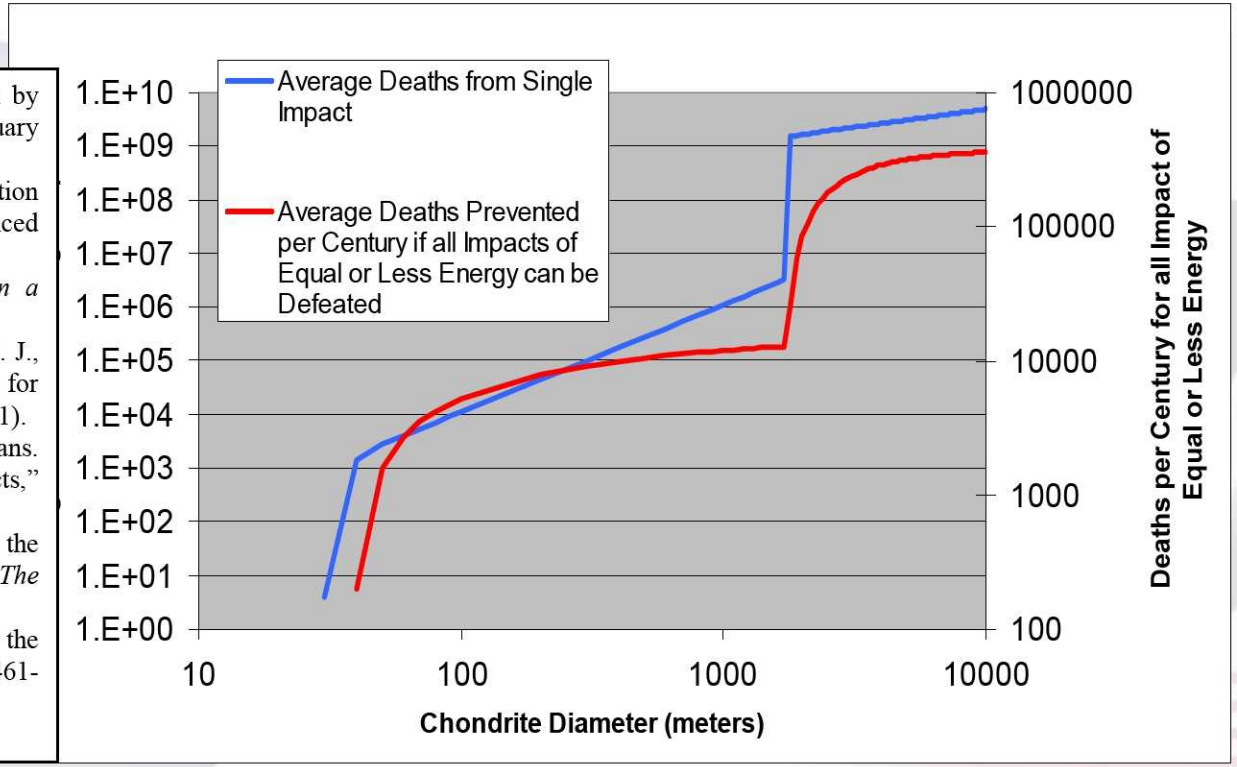
•Jeffers, S. V., Manley, S. P., Bailey, M. E., and Asher, D. J., "Near-Earth Object Velocity Distributions and Consequences for the Chicxulub Impactor," *Mon. Not. R. Astron. Soc.*, 327 (2001).

•Chesley, S, Chodas, P, Milani,, A., Valsecchi, G., Yeomans. D., "Quantifying the risk posed by Potential Earth impacts," *Icarus Asteroids*, 2001.

•Ivezic, Zeljko, *et al*, "Solar System Objects Observed in the Sloan Digital Sky Survey Commissioning Data," *The Astronomical Journal*, November 2001.

•Shoemaker, E. M., "Asteroid and Comet Bombardment of the Earth," *Annual Review of Earth and Planetary Sciences*, 11: 461-494.

•Chapman, C.R. & Morrison, D., 1994, Nature 367, 33-40

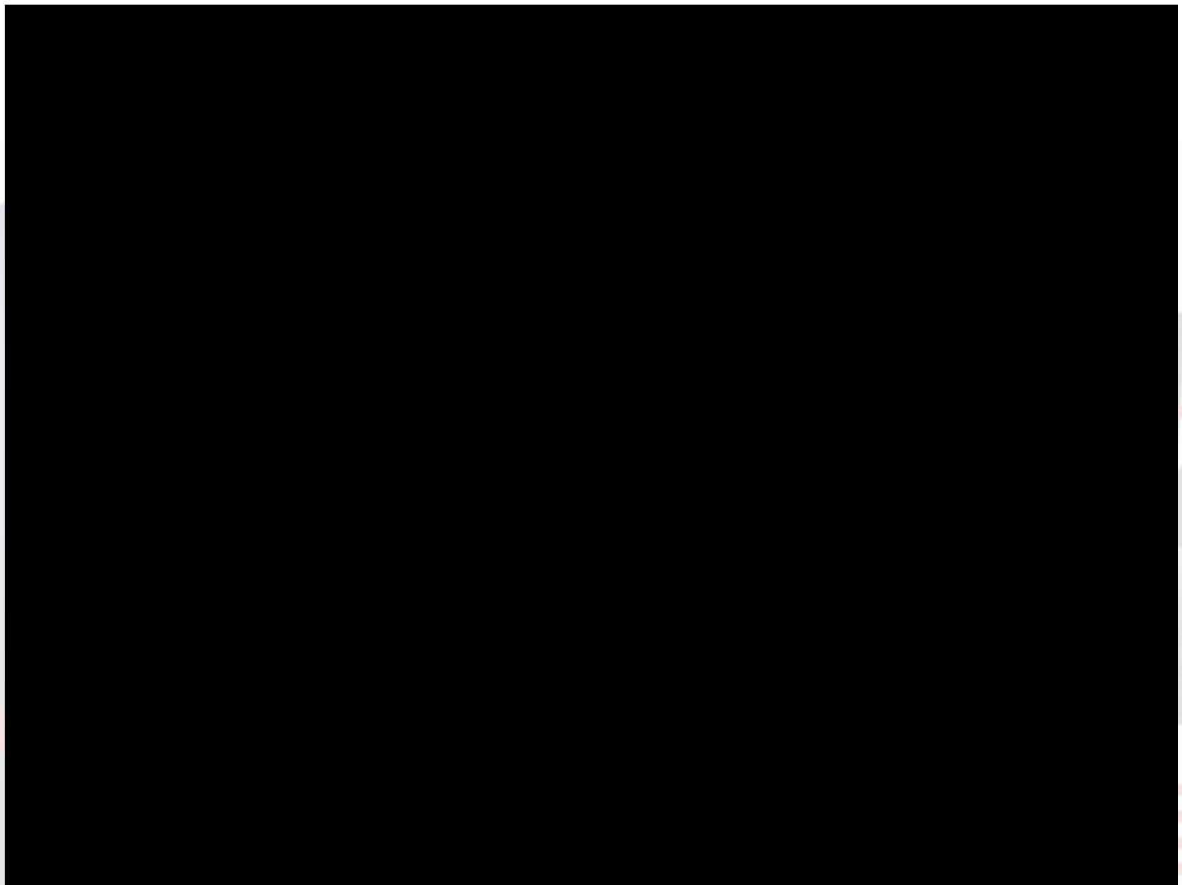


Needed Tool Development

- Points to address
  - Deflection system models
    - Nuclear Stand-Off, Kinetic Interceptor, Gravity Tractor, Solar Collector
    - Quantification of infrastructure requirements
    - Sizing, performance, cost, reliability analysis at several levels of fidelity
  - People
    - Better handle of NEO population
    - Quantification of statistical variance
  - Astrodynamics
    - Targeting issues endemic to NEO orbits
    - Quick evaluation of parametric trade space
  - Terminal intercept package
    - Propulsion trades
    - Target Acquisition
    - Deep space communications
  - Instrumentation
    - More comprehensive look at potential scientific instruments

Needed Tool Development

- Use of mission visualization facilitates communication
  - To decision makers
  - To general public
  - Between researchers and vehicle designers



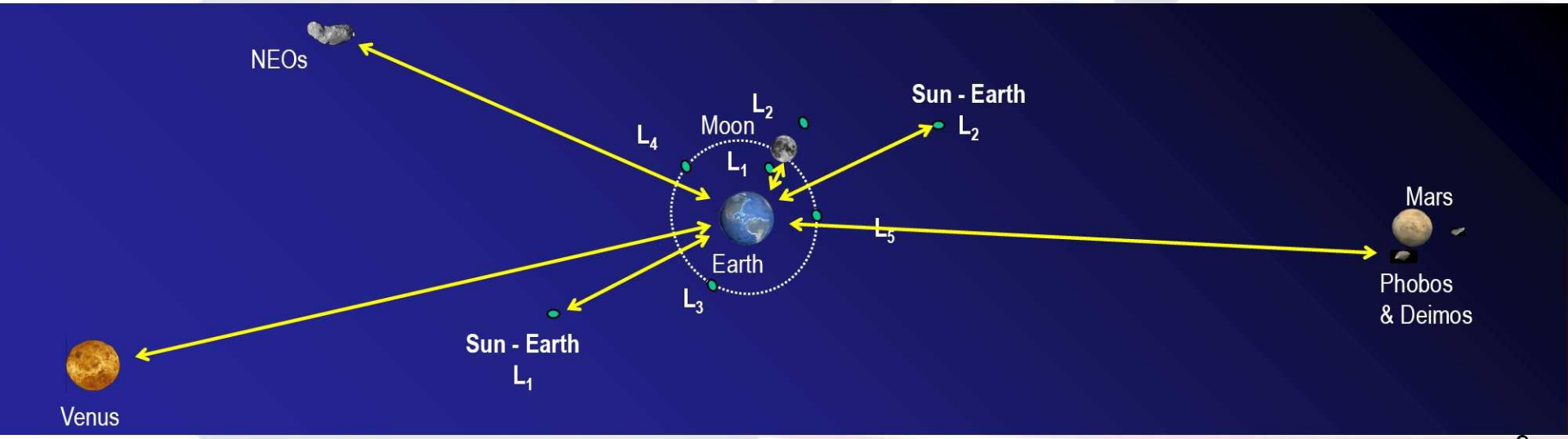
Synergy with Other Missions

A Flexible Path of Human and Robotic Exploration:

- Crewed exploration missions to many places in the inner solar system
- Orbit planets with deep gravity wells, but do not land on the surface
- Rendezvous with small planetary bodies such as NEOs and Mars moon Phobos
- Tele-robotically explore and sample planetary surfaces

Key Ground Rules and Assumptions:

- 1 Crewed flight per mission, 1-2 Cargo launches
- Orion Capsule for crew
- Visibly new destinations every few years



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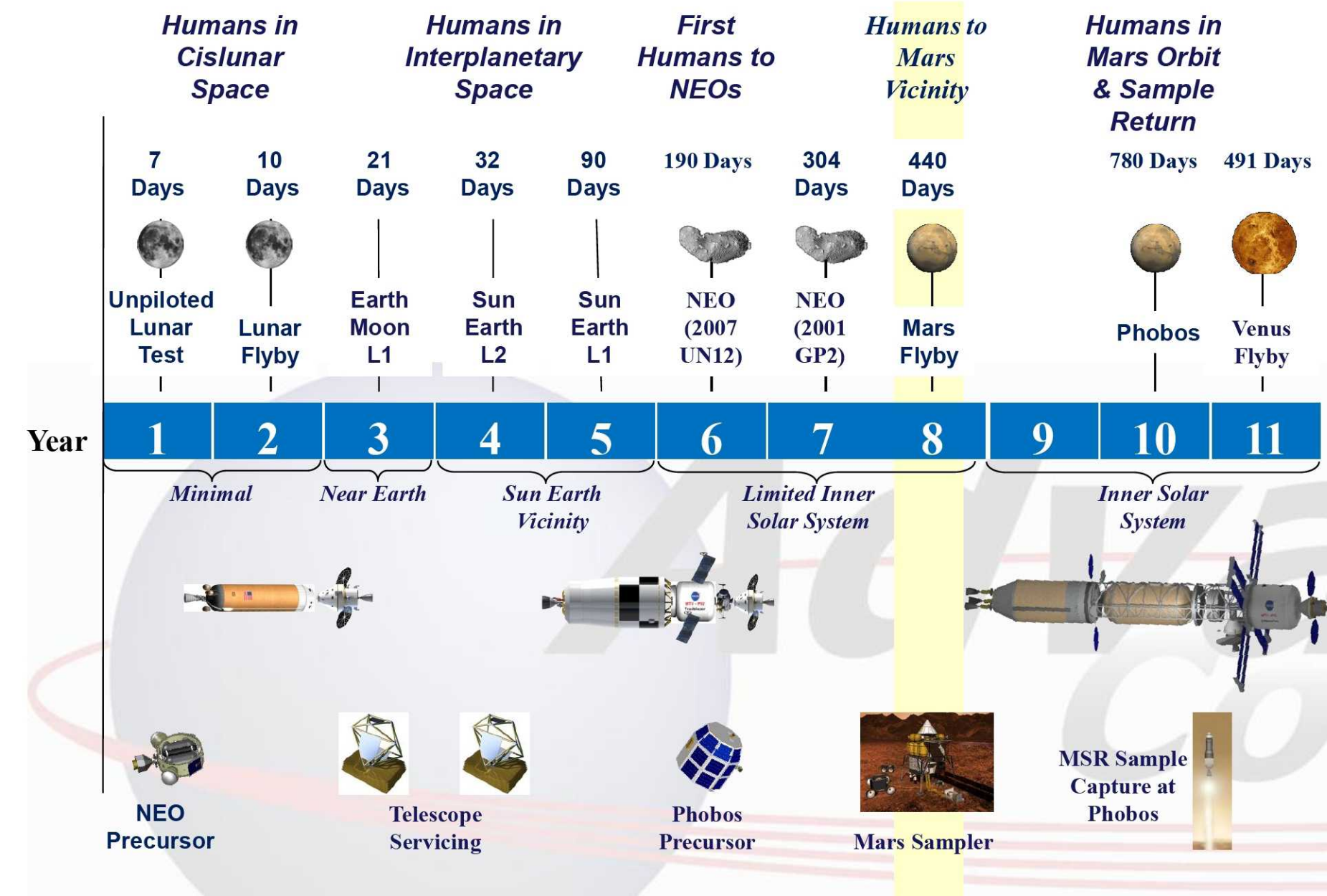

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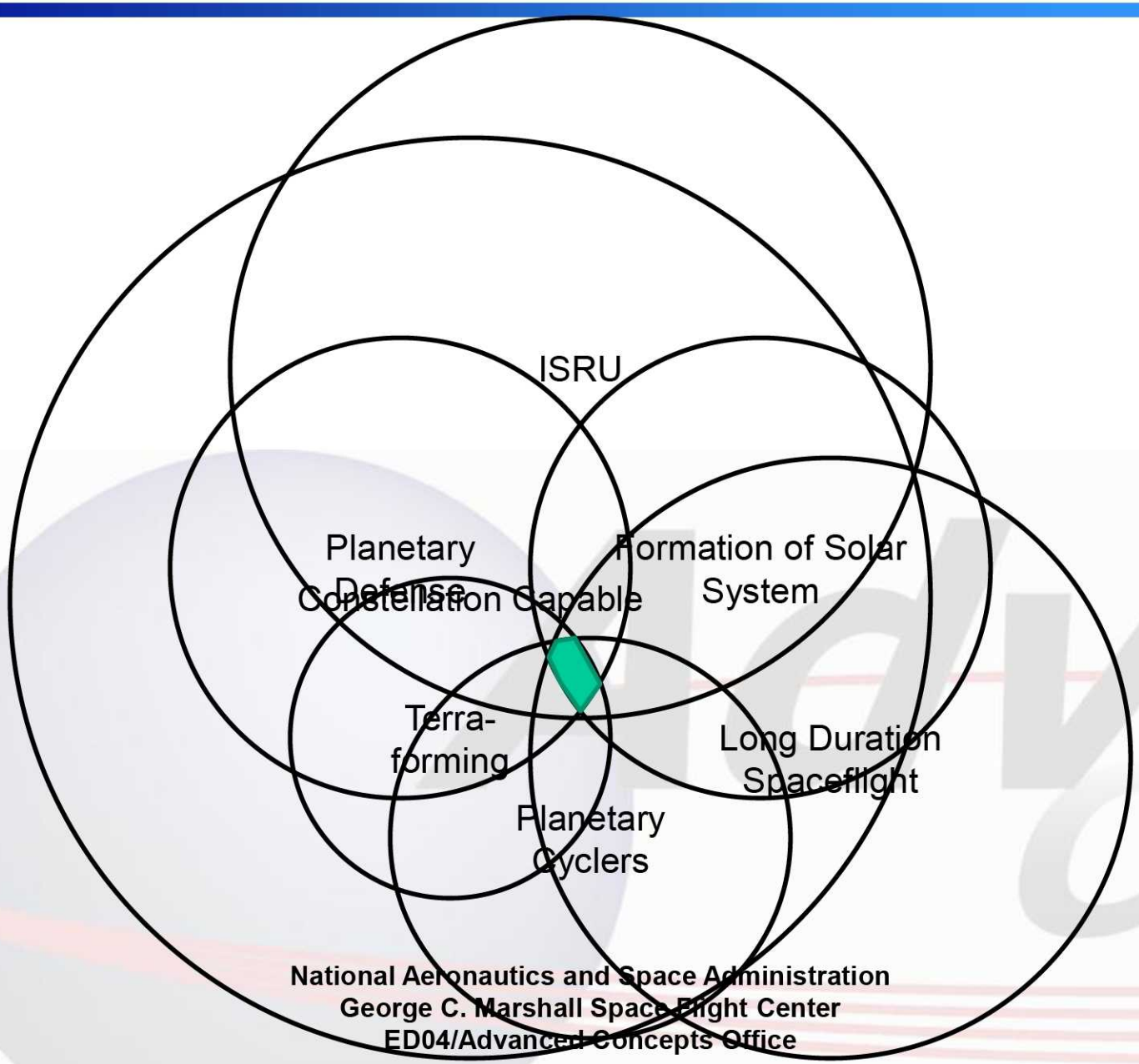
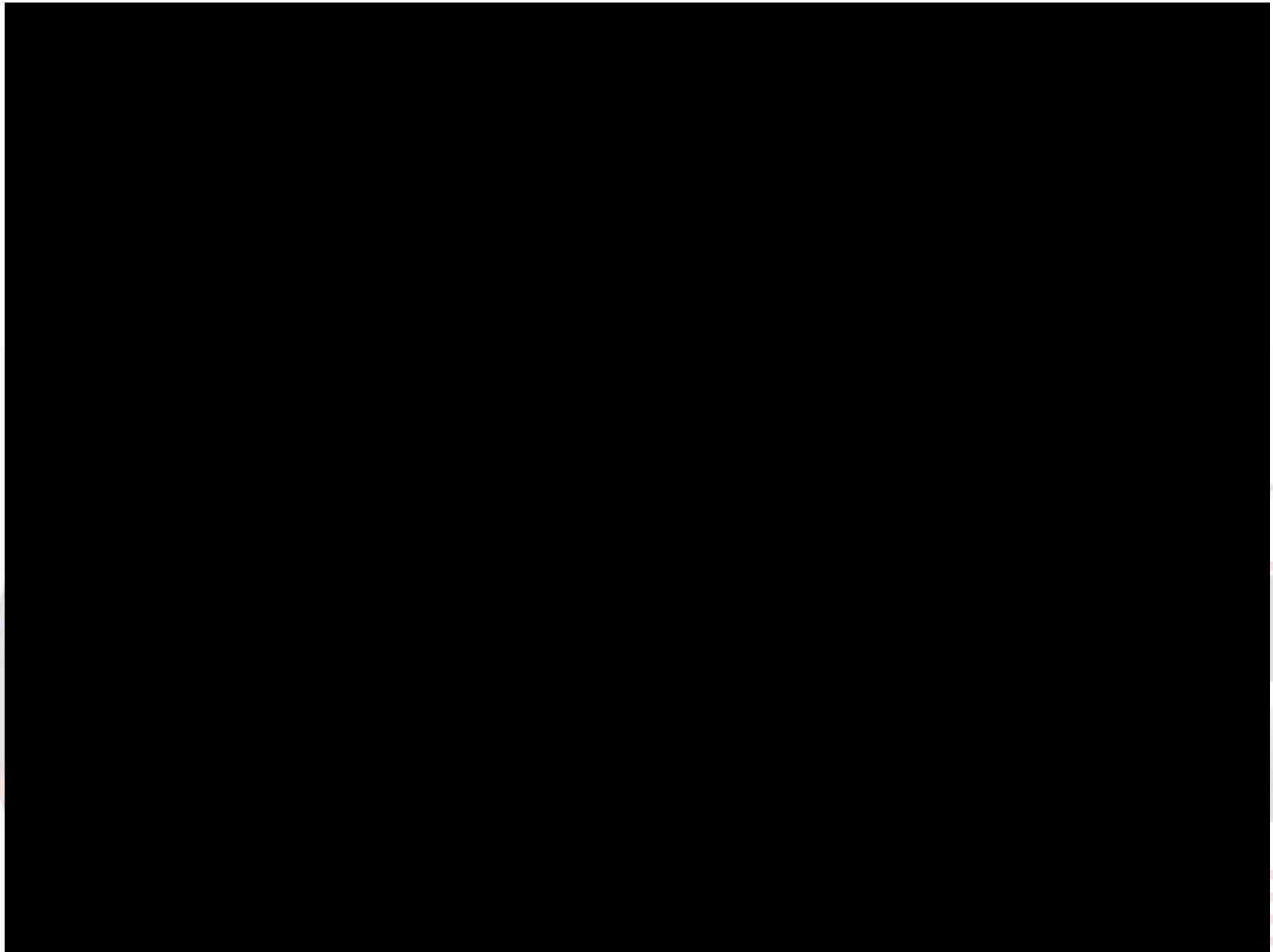
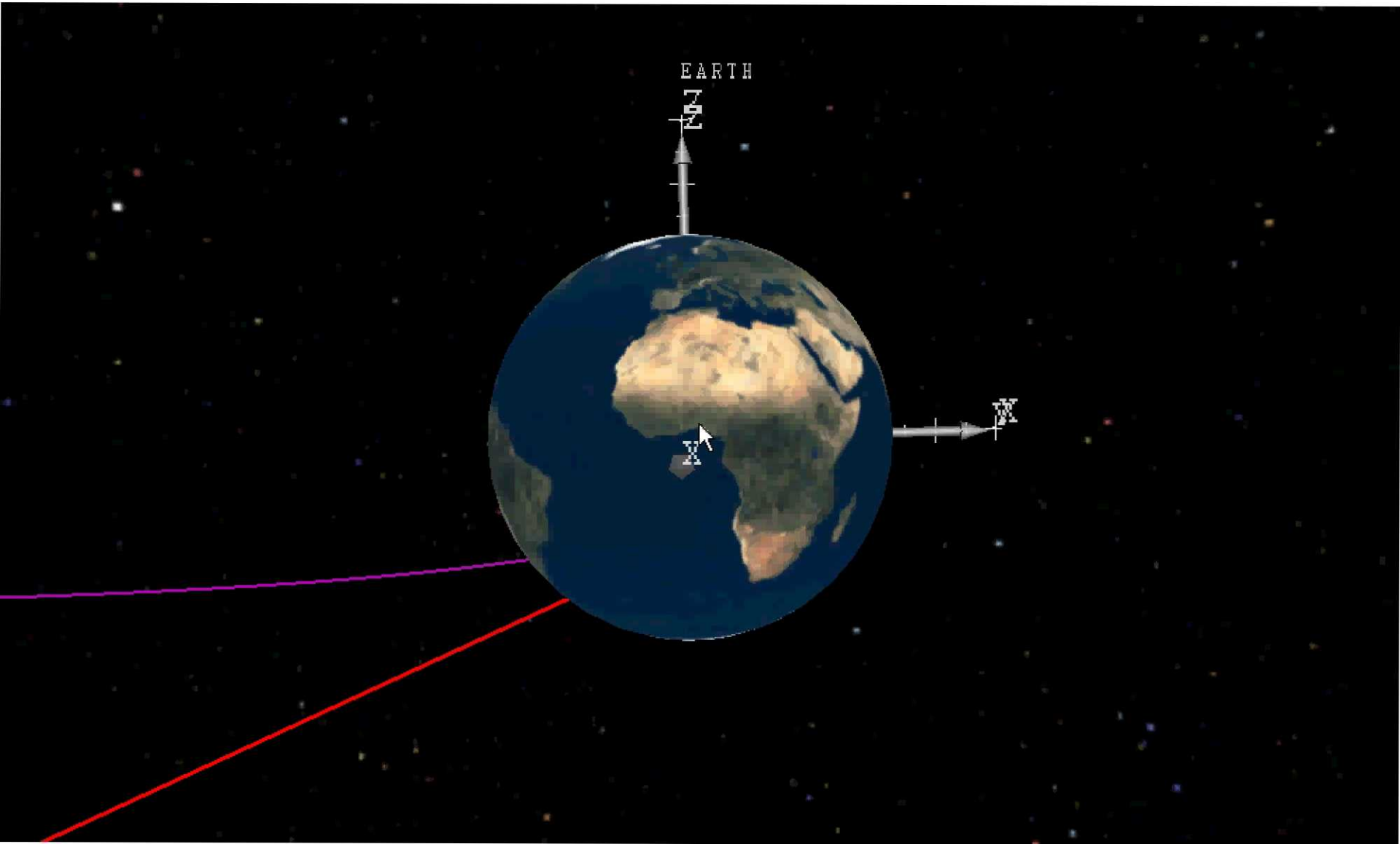


Synergy with Other Missions

- Concept of Crewed NEO mission



Synergy with Other Missions



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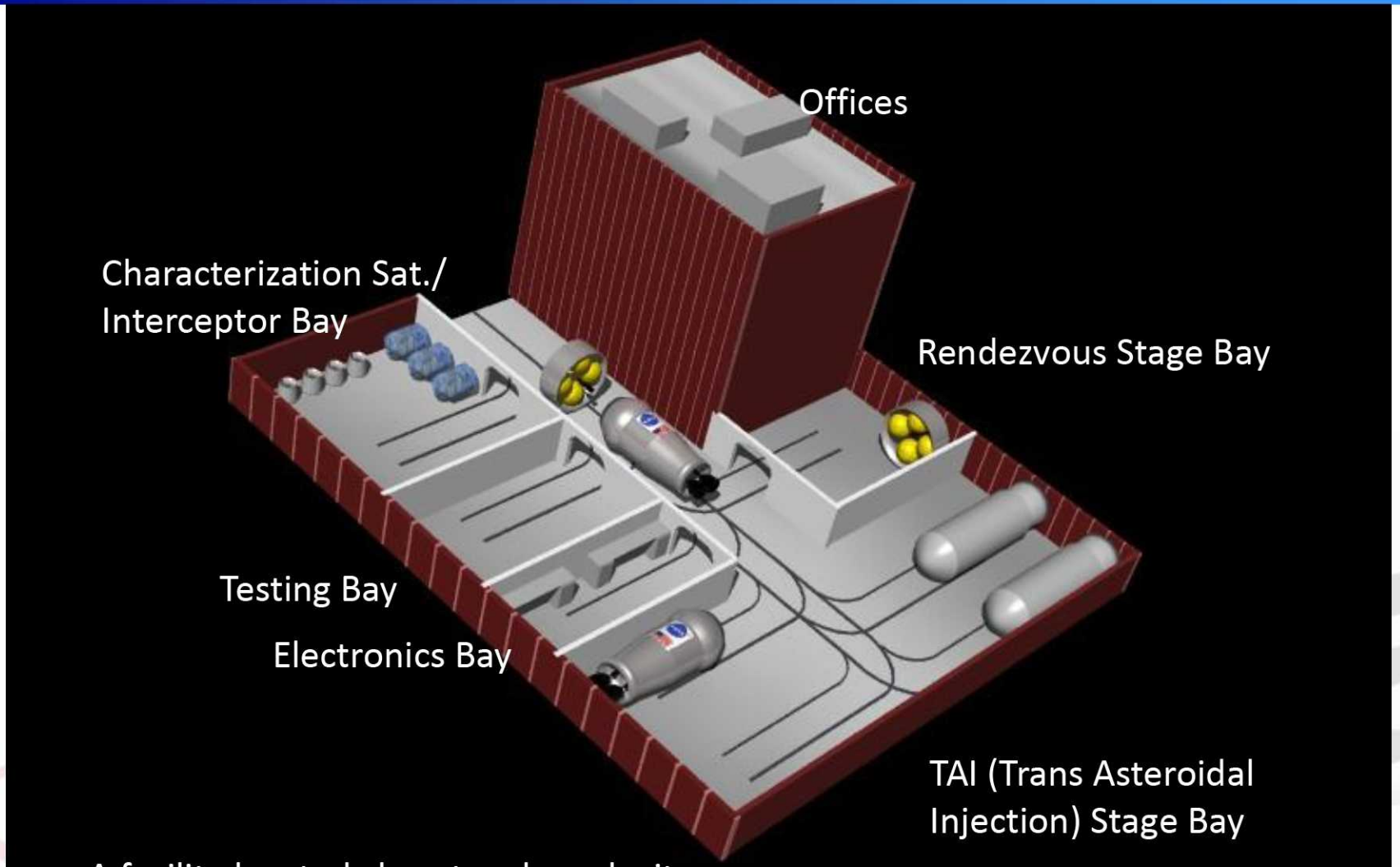


A facility located close to a launch site contains the stages and prefabricated characterization probes and interceptors

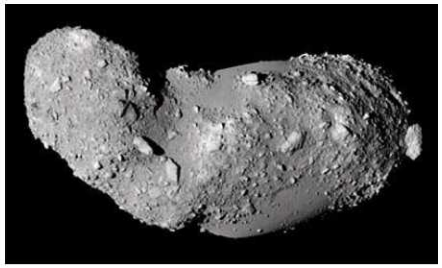
Proposed Design Process

- Goals
  - Create broad group of contributors from various disciplines
  - Informal collaboration between all contributors
  - Allow contributors to concentrate on their areas of expertise
  - Propose new concepts, methodologies to group
  - Share knowledge to maximum extent law allows

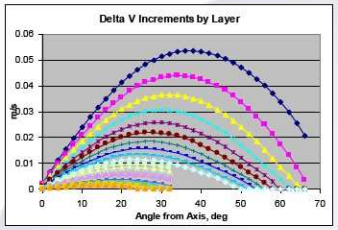
Mission Design Process

Mission Design Process

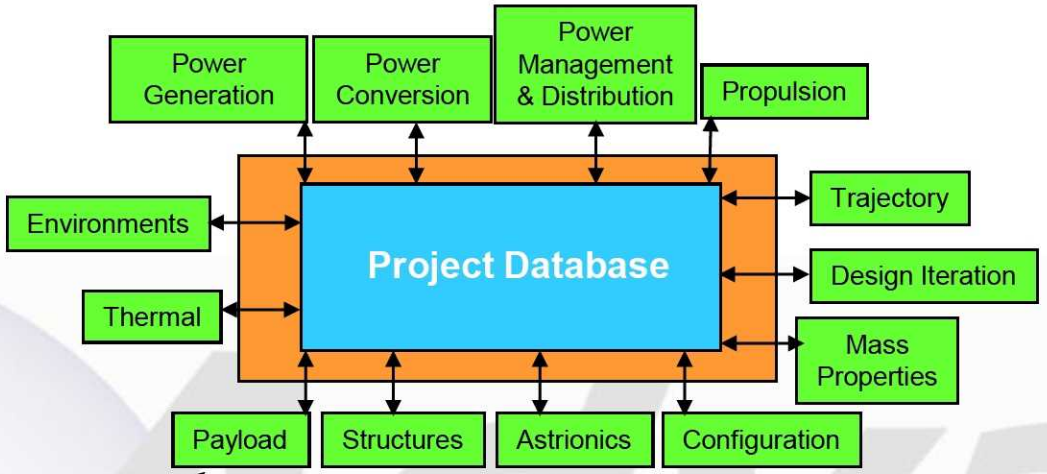
Asteroid Model



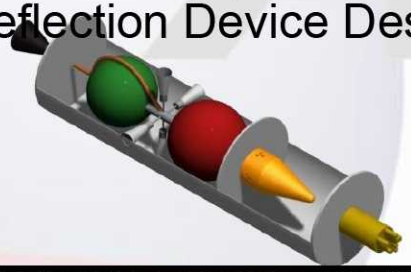
Deflection Simulation



Vehicle Design

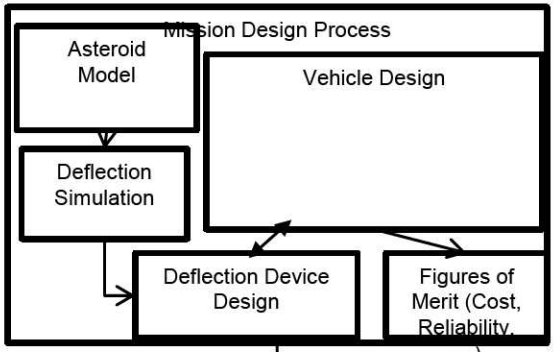


Deflection Device Design



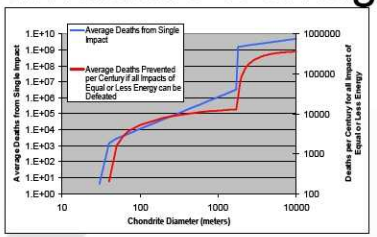
Figures of Merit (Cost, Reliability, …)

Architecture Design Process



New Infrastructure Design

Cumulative Damage



Architecture Definition (Available and Required Infrastructure, Potential Synergy)

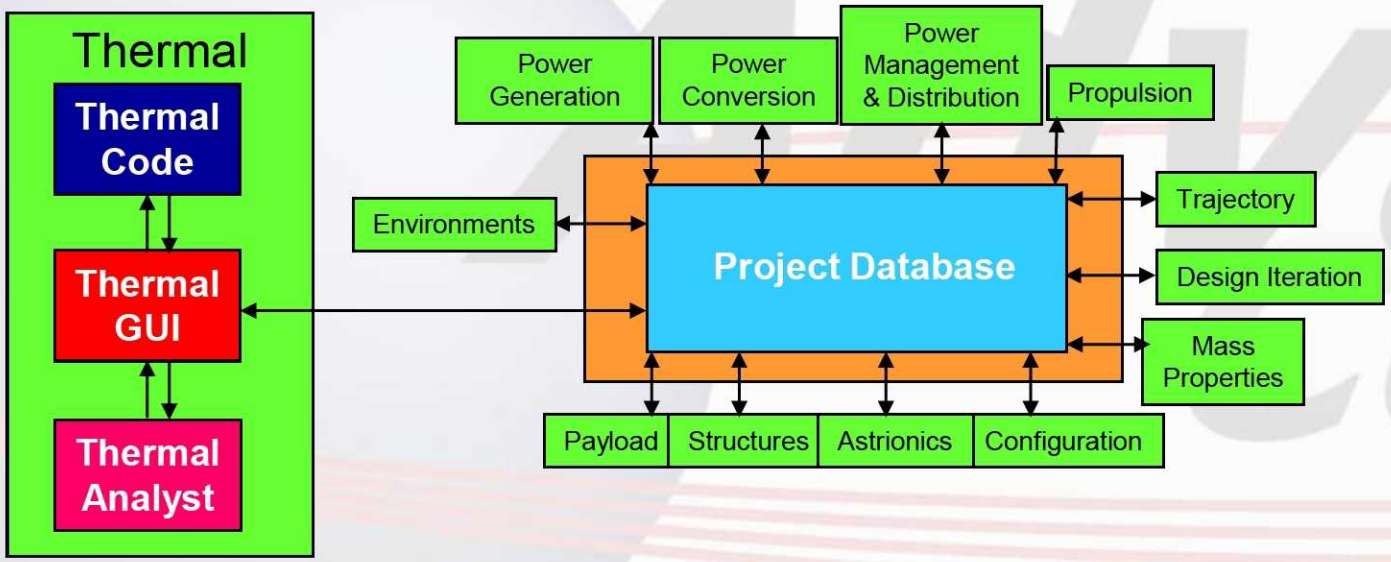
Effectiveness of Concept/Architecture

Team Integration

- Need a way to put it all together
  - of a number of engineers and scientists
  - That are distributed across the country
  - That maintains data integrity, security
  - And facilitates quick evaluation of a number of different concepts and missions
- Several options available
- MSFC has in-house solution recently released to public
  - http://sourceforge.net/projects/parseccee

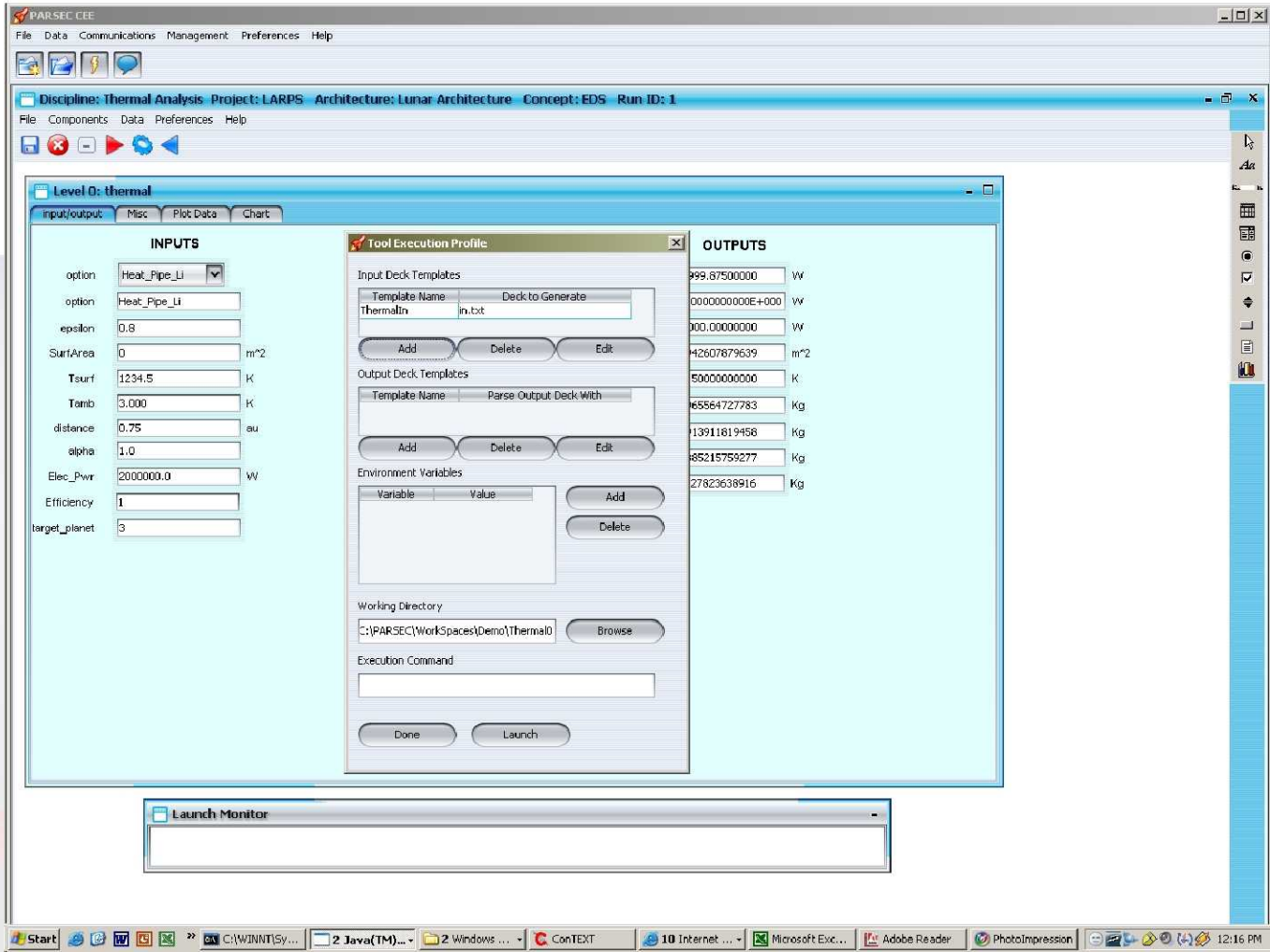
Team Integration

- Suppose a thermal analyst is preparing to participate in a team study to design a particular asteroid mitigation concept
  - The analyst interfaces with his design code via a Java GUI that the analyst specially configures for his design/analysis code
  - The thermal analyst will create this interface using a point-and-click system
  - The analyst will then communicate with other team members through a central database that handles data management



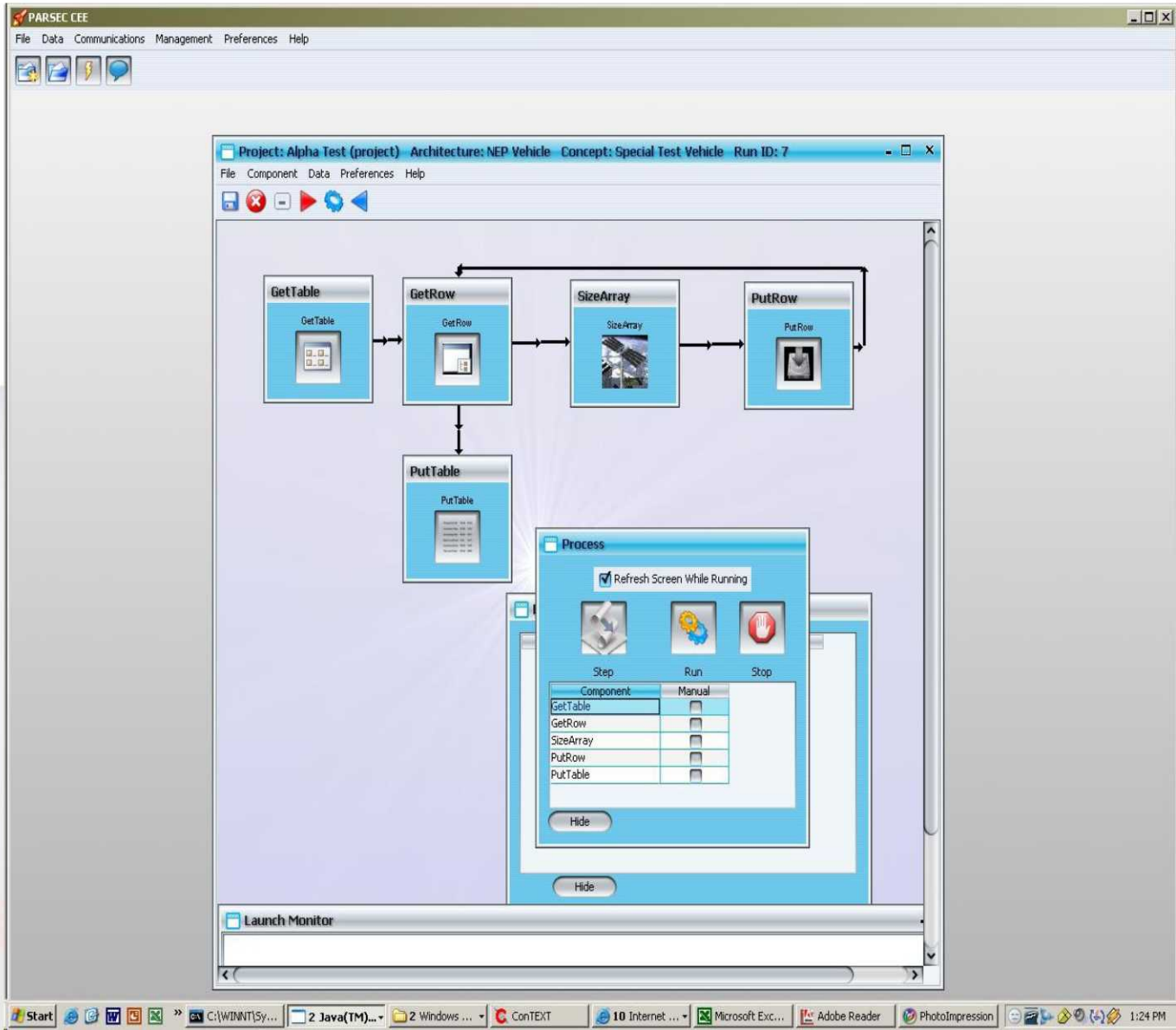
Team Integration

- Analyst states in workspace set up the input, output and executable files to be interfaced with
- PARSEC can interface with any design code that can generate an input and an output file
- PARSEC is also compatible with Excel files as well as Java plug ins
- User builds links to input and output files using point and click interface



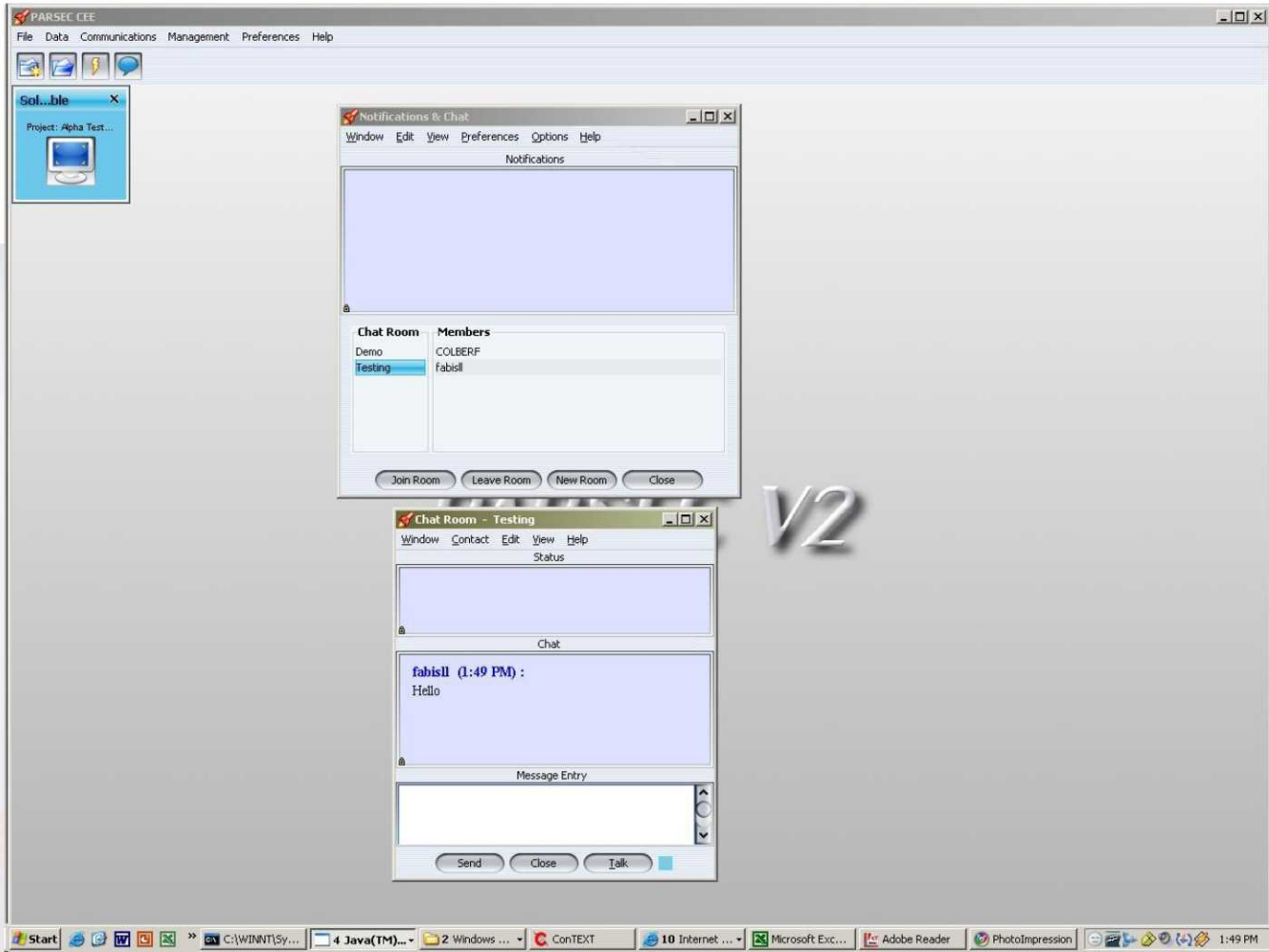
Team Integration

- The PARSEC CEE allows users to run multiple codes in batch mode
- The process workspace allows users to link multiple workspaces
- Logic nodes allow the user to control the path of the code
- Process workspace is also used to generate parametric plots on particular variables



PARSEC Design Process

- The PARSEC CEE includes text and voice chat for multi-engineer communication
- With this feature users can be located next door or in the next country and still work on the same project
- Notification window has system generated messages when particular data is published
- Project lead can send out project wide notifications
- Voice chat uses a toggle button to enable privacy when not chatting
- Chat feature allows users to create separate “rooms” for sidebar chats



Conclusion

- Its time
  - To bring planetary scientists, deflection system investigators and vehicle designers together on the characterization/mitigation problem
  - To develop a comprehensive trade space of options
  - To trade options under a common set of assumptions and see what comparisons on effectiveness can be made
  - To explore the synergy that can be had with proposed scientific and exploration architectures while interest in NEO's are at an all time high