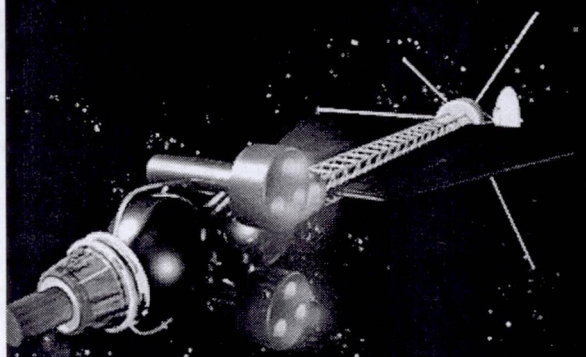
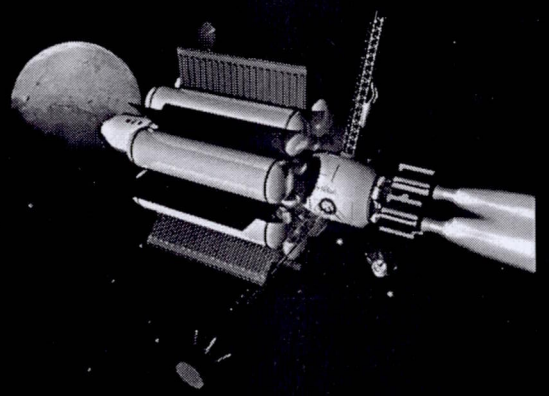
Contains publically available methods info only! No sensitive info. Bill Pannell

Using a Genetic Algorithm to Design a Nuclear Electric Spacecraft





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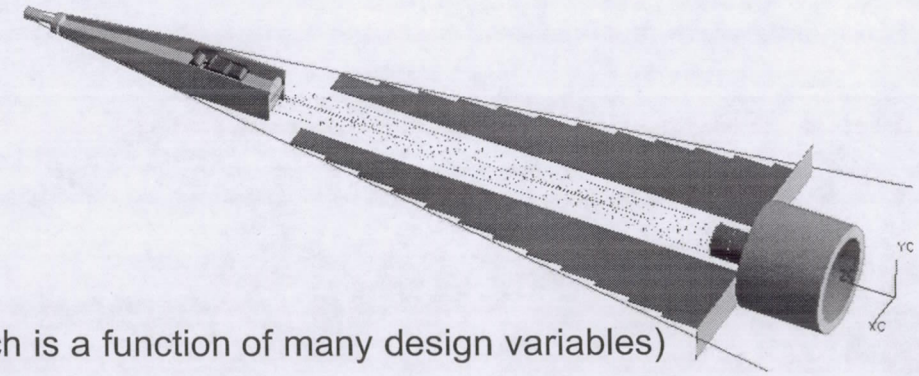
Problem Statement



Given:

- Goal

  Minimize vehicle mass (which is a function of many design variables)

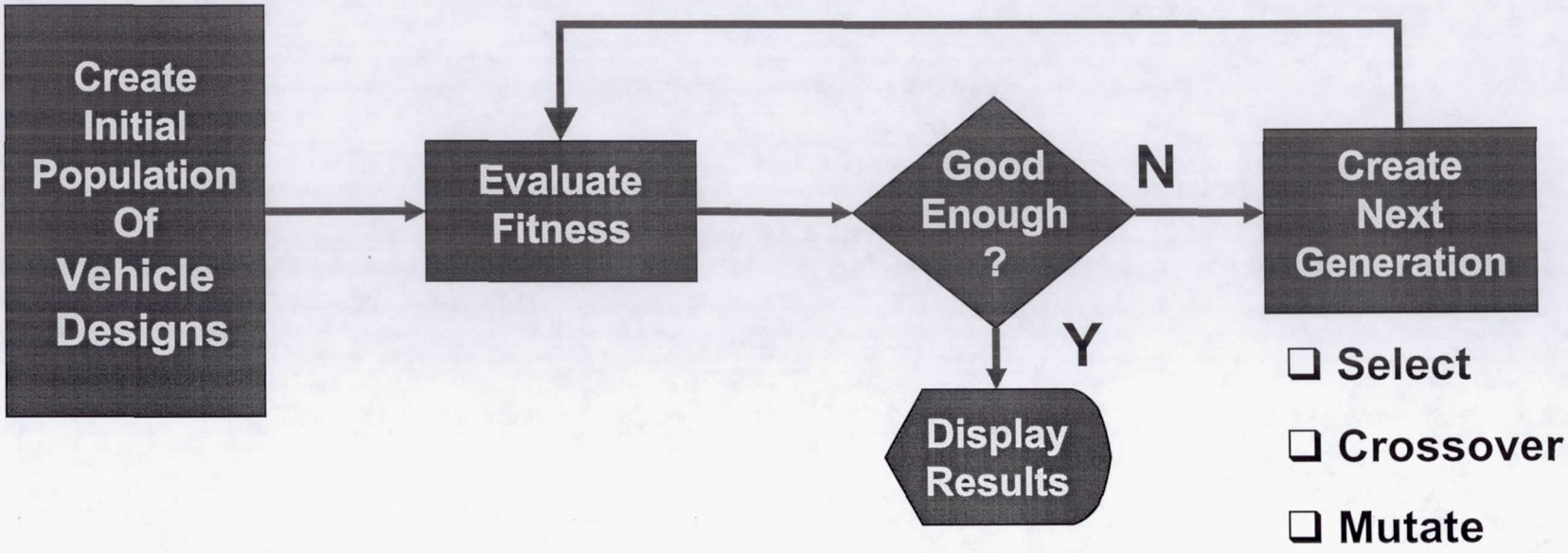
- Subject to these constraints
  - Trip time between 1 and 4 years
  - SRPSpwr out between 1 and 10MW
  - Ve between 30 and 150 km/sec

- And a set of initial parameters
  - Power to electric thruster
  - Other power needed
  - Electric thruster type

Determine:

- If the vehicle can be build using the assumed initial mass
- Number of thrusters required
- If vehicle can perform the mission in the desired trip time

How GA's Work



Basic approach: Generate a group of candidate designs, see how "fit" the designs are, and carry best designs forward to the next generation. Some designs eliminated, some randomly modified and carried forward.

Genetic Algorithm Software Package

- Over 70 software packages were evaluated
- DAKOTA (free download from Sandia National Labs) was chosen
  - Price was right
  - Runs on Linux and other Unix (coded in C)
  - Good documentation and support
  - Has many other optimization techniques included
  - Loosely coupled to other codes through ASCII file data passing and Perl scripting allows maximum use of existing codes

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How Dakota works with your code(s)

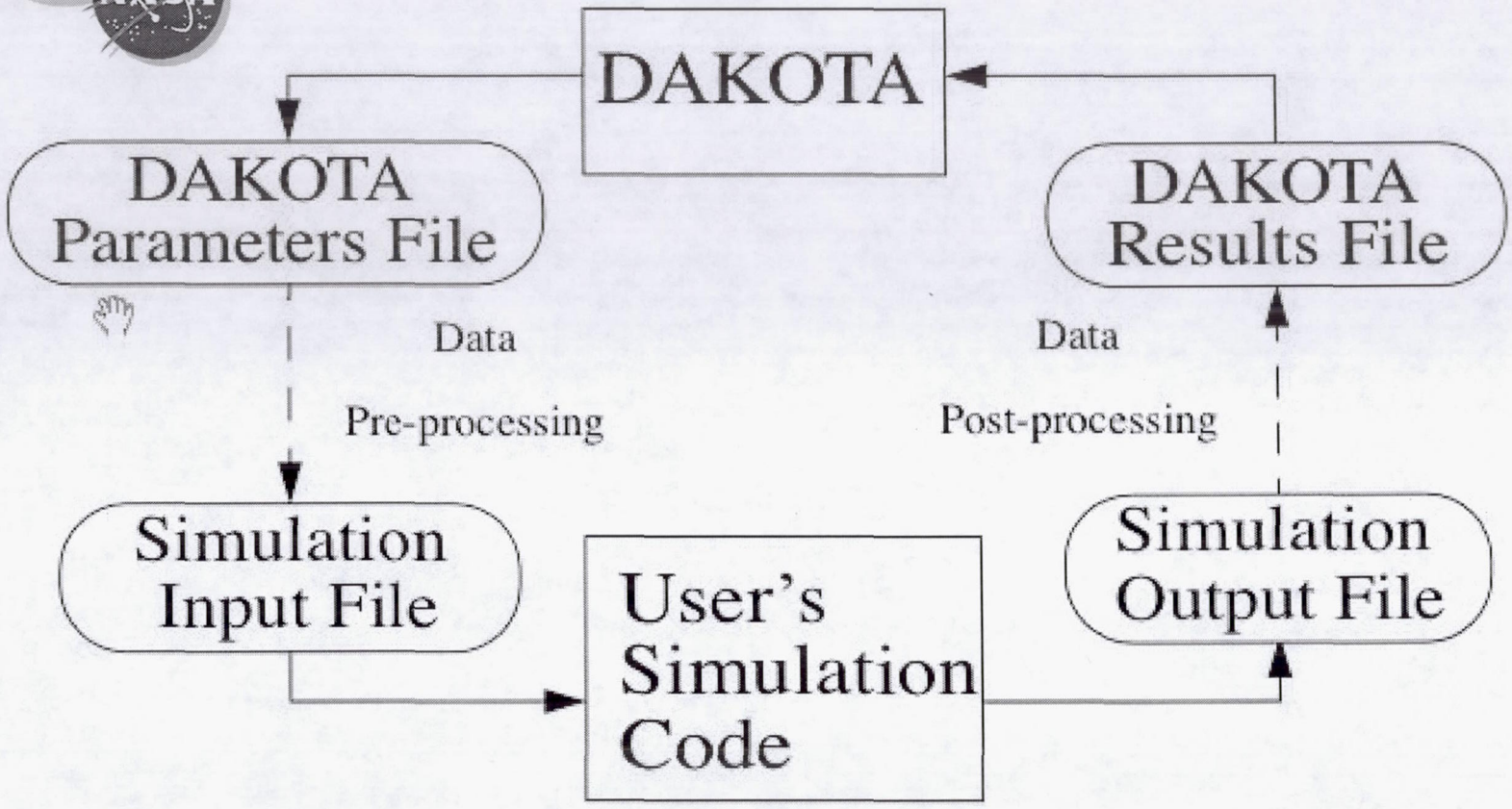
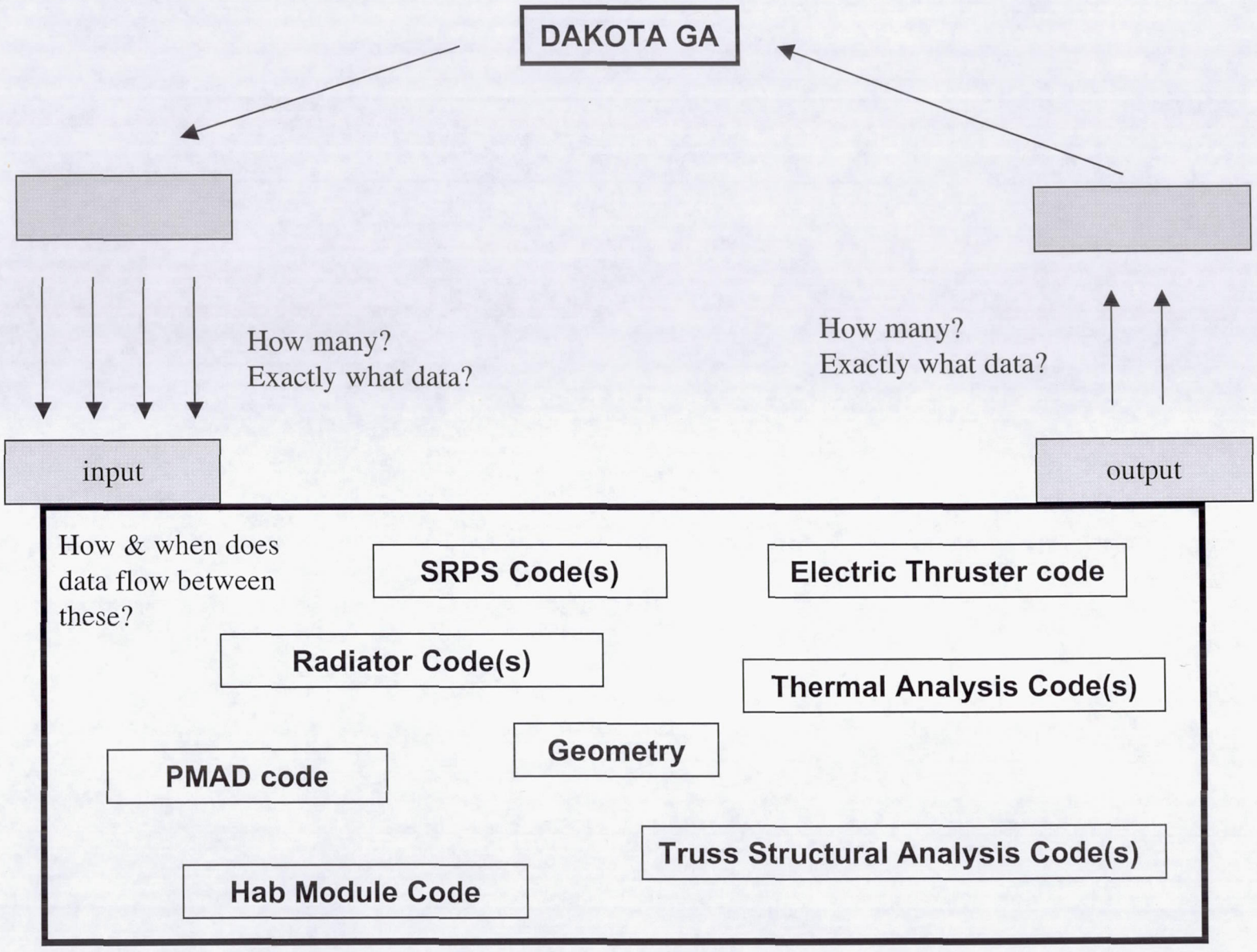
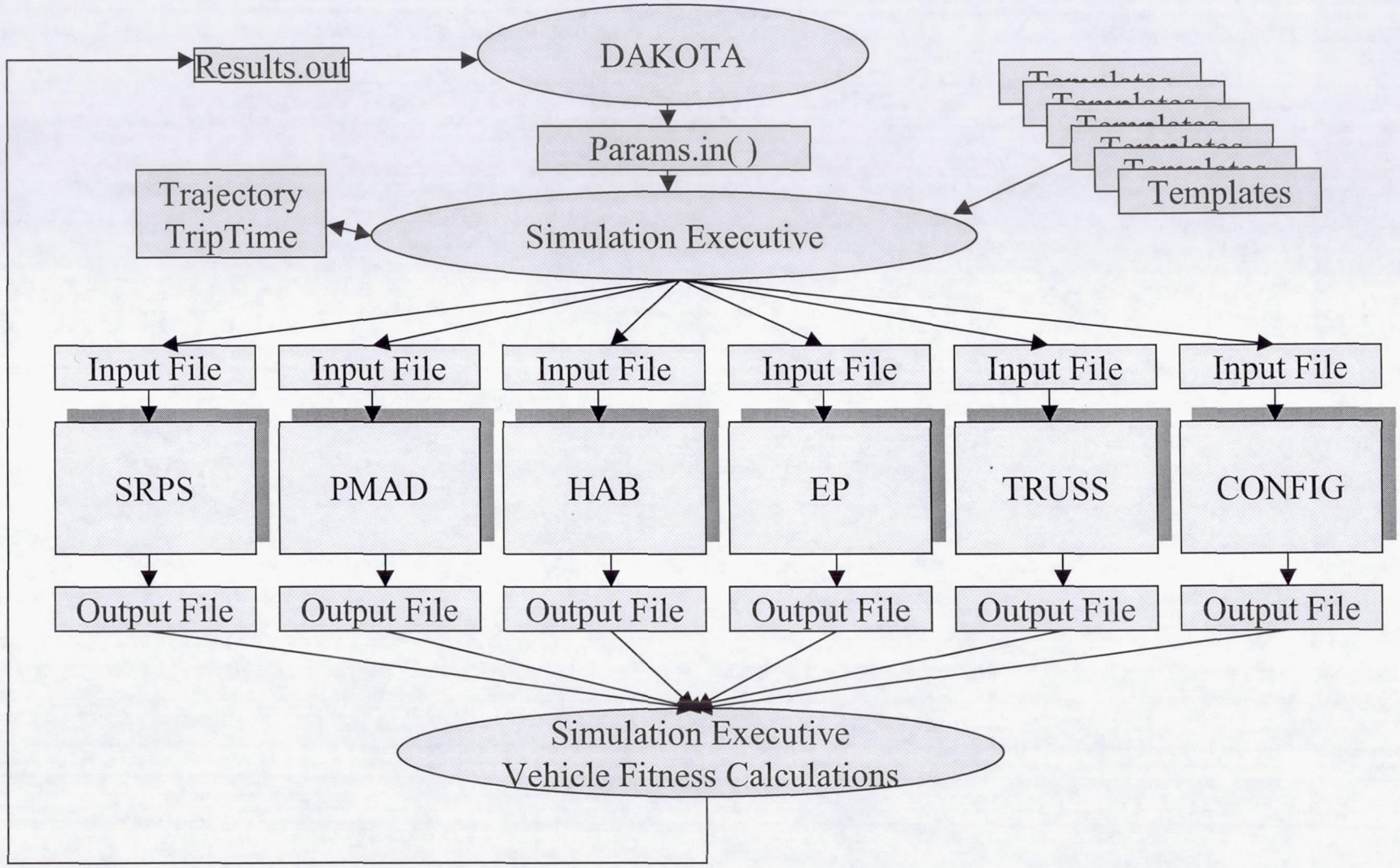


Figure 1.1 **The loosely-coupled or "black-box" interface between DAKOTA and a user-supplied simulation code.**

Our Nuclear Electric Spacecraft Problem Setup



NEVOT Computational Framework

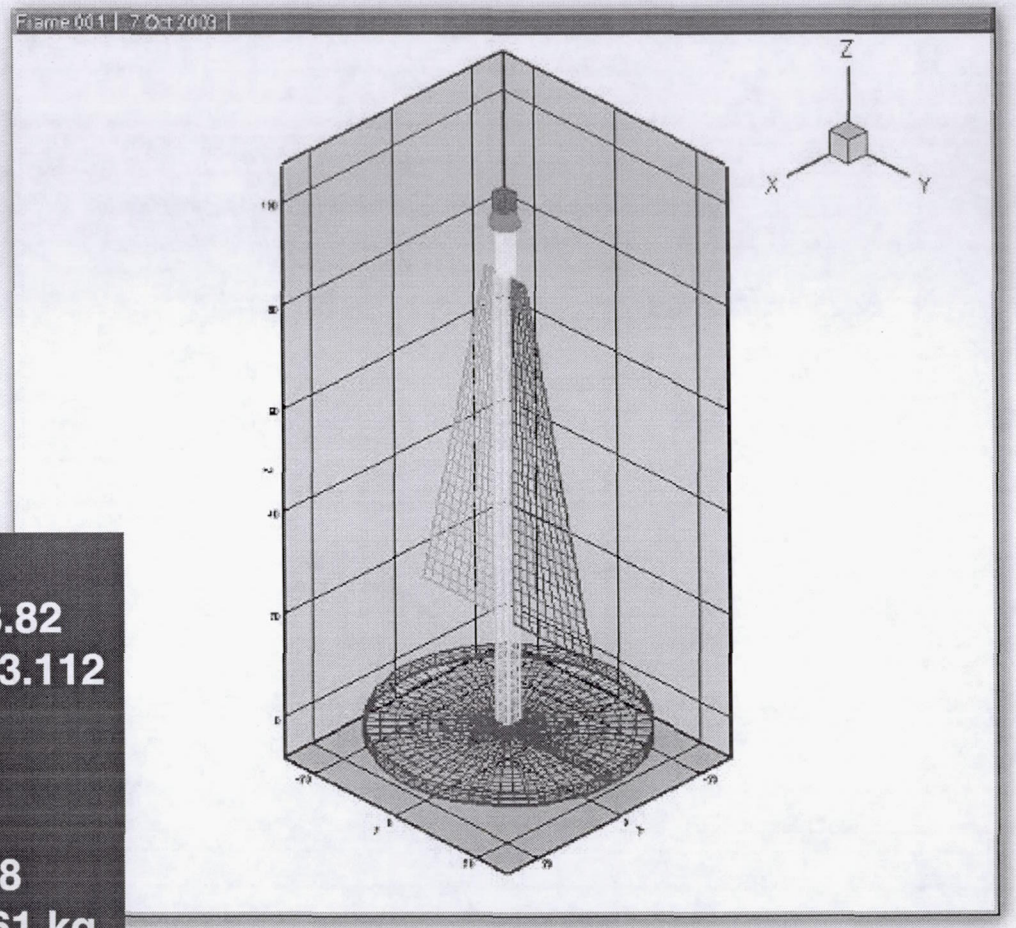


Initial Optimization Results

Vehicle Mass = 505821.86 kg
- SRPS Mass = 245560 kg
- Radiator Mass = 11600 kg
- PMAD Mass = 6004.9 kg
- Truss Mass = 8390 kg
- Total Hab Mass = 111921 kg
- Overboard Mass = 16 kg
- Hab only Mass = 74021 kg
- Thruster Mass = 29682 kg
- Tank Mass = 13599 kg

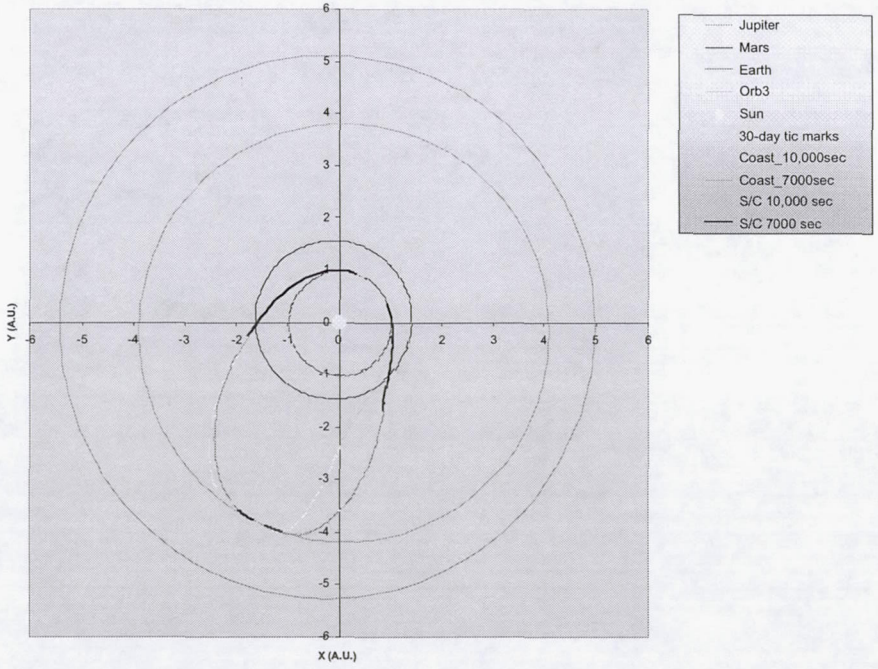
Vehicle Fitness = 1264692.44

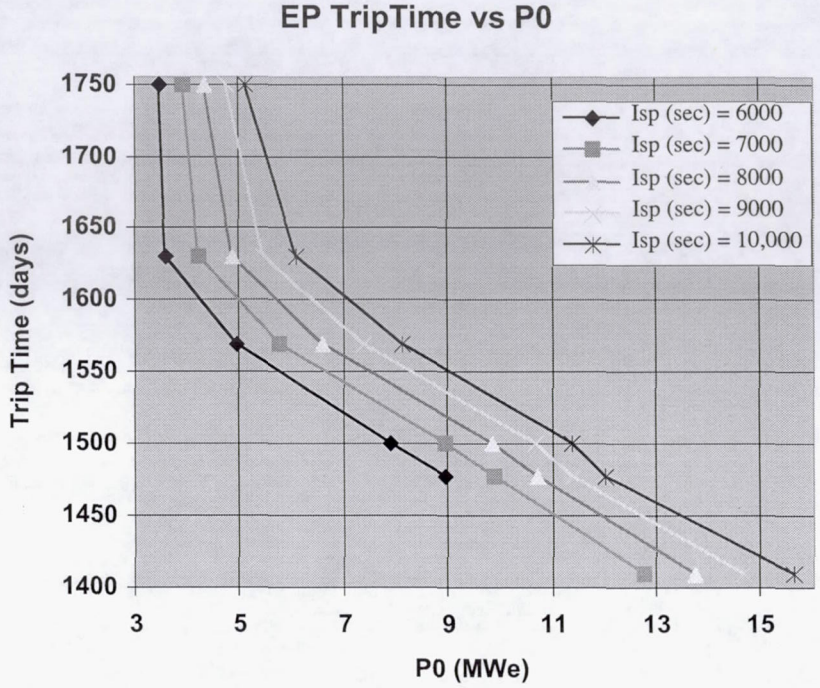
Truss Length: 167 m
Front Shield Diameter = 3.82
Total Shield Thickness = 3.112
Power (kW) = 3931
Force Applied = 88.956 N
Isp = 9000
Mass Flow Rate = .001008
Starting Fuel Mass = 90661 kg
Fuel Remaining = 18841.77 kg
Radiator Area = 3026



Review of Mission Analysis (Kos/TD03)

- *Reference mission to the asteroids allows exercise of optimization software*
- *Trip times of 4 years appear feasible for Isp 7000-10000 sec*





- *For a given vehicle design (power P0) generated by DAKOTA, trajectory curves provide actual trip time*