Accommodation Study for an Ultra Large Space Telescope in the Magnum Launch Vehicle

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Abstract

Most mission concepts currently under study for visible/IR astronomical observatories in space have been performed assuming available payload volumes no larger than the shuttle's. A real potential still exists that a larger payload launcher, called Magnum, may be available in the not-too-distant future. Design rules for packaging segmented optics (which led to the formulation of the NASA-developed concept for the Next Generation Space Telescope) are re-applied to the Magnum case to discover what potential exists for delivering very large single apertures and multiple aperture interferometric missions to libration point destinations in a single launch.

Introduction

During the past several years, MSFC has been in the process of developing the concept for a very large launch vehicle, called Magnum, designed to support the extremely large payload requirements for a Mars manned mission as well as other potential demands for exceptionally large satellite programs. In the meantime, another study was conducted last year to assess the Shuttle's capabilities to launch the NGST as an alternative to the baseline "yardstick" approach using an expendable launch vehicle. One of the options addressed in this study was the possibility of making the NGST as big as the Shuttle could accommodate. The conclusion of this effort was that the Shuttle could launch a 15m NGST, and with the addition of EVA, even a 20m version. Encouraged by this result, the present study was initiated to determine just how large an aperture telescope could be packaged and placed into an L2 orbit using the Magnum launch vehicle.

Magnum Capabilities

In its role as the NASA lead center for space transportation, MSFC has been conducting in-house studies of various launch vehicles to meet the future needs for space exploration missions. In the heavy lift category, the Magnum launch vehicle, which is presently in a phase A study effort, will take advantage of advances in technology derived from the Reusable Launch Vehicle (RLV) and Evolved Expendable Launch Vehicle (EELV) Programs to develop a cost effective launch system for the 2005+ time frame.

The proposed Magnum, illustrated in Figure 1, is an inline core vehicle with two attached Shuttleshrouds, such as the "Hammerhead", will also be available for the Space Based Laser (SBL) and other larger payloads.

Figure 1 Magnum Launch Vehicle

Magnum with LFBB Data Sheet

Vehicle Concept Characteristics

GLOW	**4.82 Mlb**
Shroud Weight	**25.0 Klb**
Booster Type	**LOX / RP**
# Boosters	**2**
Booster Propellant Weight (usable) each	**1.12 Mlb**
Booster Separation Weight each	**260 Klb**
Booster Engine Data:	
# Engines per Booster	**4 (RD-180)**
Booster Engine Thrust	**860 Klbf @ SL; 933 Klbf @ Vac.**
Booster Engine Isp	**311 s @ SL; 338 s @ Vac**

Figure 2 Magnum Characteristics

Lofting a payload into an L2 halo orbit with the Magnum vehicle requires the use of an upper stage. A size estimate for an upper stage that would achieve the largest payload capability to L2 is shown in Figure 3. Roughly 22 feet in diameter and 39 feet long, this LOX/LH2 stage would weigh approximately 25.9 Klb and carry 103.6 Klbs of propellant. With an estimated payload adapter weight of 25.0 Klb, a total payload weight of 69.2 Klb could be injected into an L2 orbit.

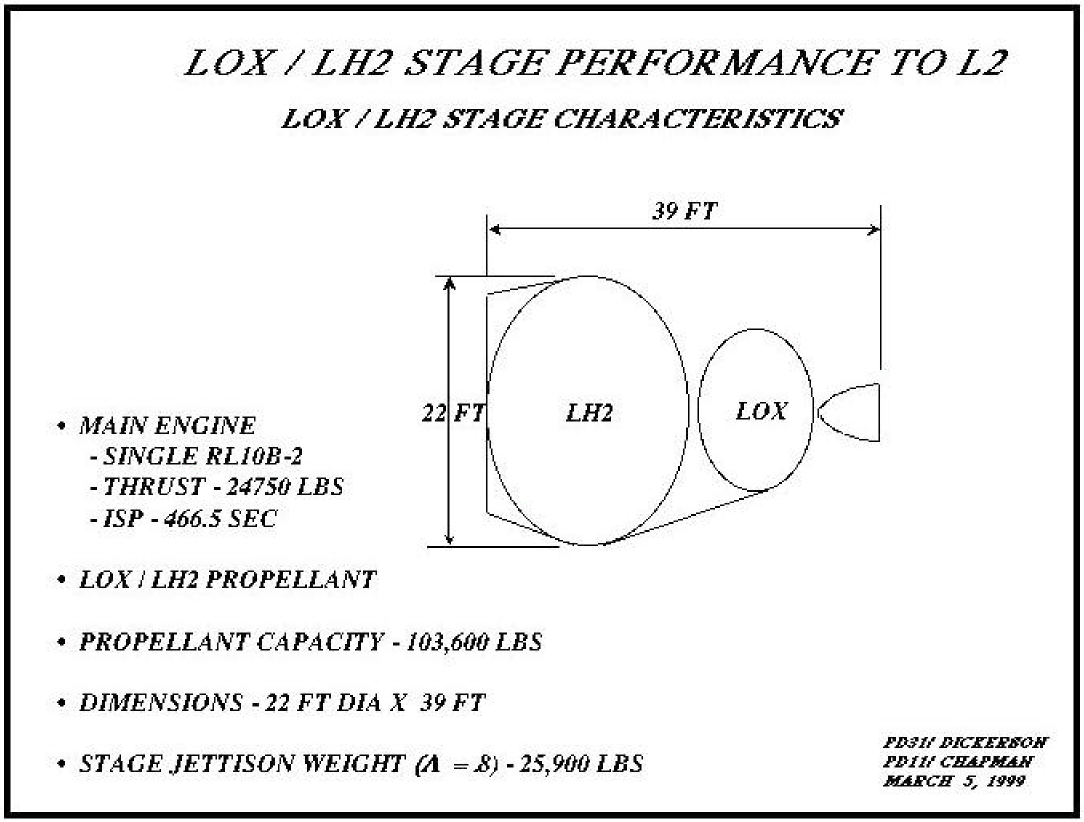

Figure 3 Upper Stage Characteristics

Telescope Design Parameters

Working backwards from the Magnum payload injection performance and the payload shroud dimensions, the goal of this study was to design an ultra large telescope that would fit into the

Magnum Space Telescope

PRIMARY MIRROR SYSTEM OPTICAL SPECIFICATIONS

Item	Standard Shroud	Hammerhead Shroud	Units
Primary Aperture	24.9	30.9	m
Primary Area	408	628	m^2
Areal Density	5	5	kg/m^2
Primary Mass	2040	3140	kg
F/#	1.25	1.25	
RoC	62.2	77.2	
Figure	Slightly Aspheric		m
Cluster Aperture	5.0	6.2	m(flat-to-flat)
Cluster Area	21.5	33	m^2
Cluster Mass	107	165	kg
Segment Aperture	1.0	1.24	m(flat-to-flat)
Segment Area	1.1	1.7	m^2
Segment Mass	5.65	8.7	kg
# Actuators	3/1083	3/1083	per segment/total

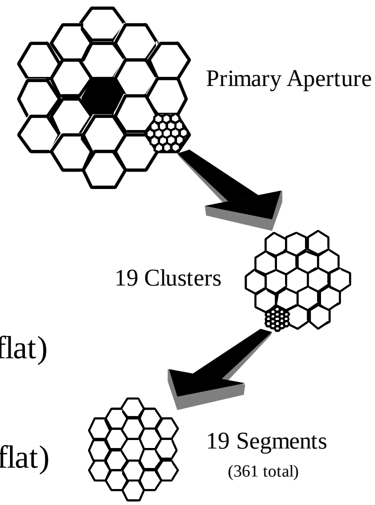

Table 1 Magnum Mirror System Specs

<u>Telescope Packaging Concept</u>

In keeping with the approach used in this study, the packaging concept was derived from the NGST concept. This method of folding and deploying precision segmented reflector systems was created by Martin Mikulas and his colleagues at the University of Colorado and the Jet Propulsion Laboratory. Specifically, this is the STARBURST method described in reference 5. Figure 4 illustrates the stowed configuration of the "Magnum Telescope" folded and packaged in the standard Magnum payload shroud. The spacecraft and sunshield systems are scaled estimates based on the NGST "yardstick" concept. Mass estimates for the telescope and each of the spacecraft subsystems is displayed in Table 2 below.

<u>Magnum Telescope Mass Estimate</u>

Table 2 Magnum Telescope Mass Estimate

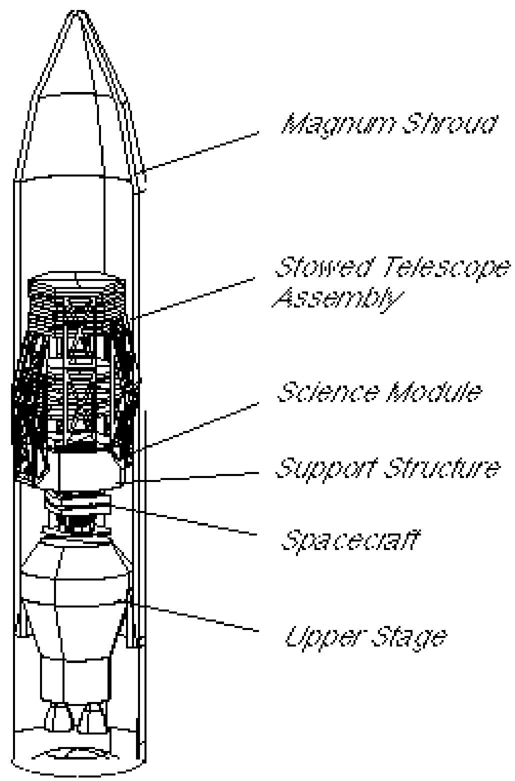

Figure 4 Stowed Configuration

Deployment Concept

As mentioned above, the deployment method follows the Mikulas STARBURST petal unfolding technique. This sequence for the Magnum Telescope is depicted in Figure 5 below. Deployment of the sunshield and spacecraft systems is similar to that of the NGST concept. The deployed configuration of the Magnum Telescope is illustrated in Figure 6.

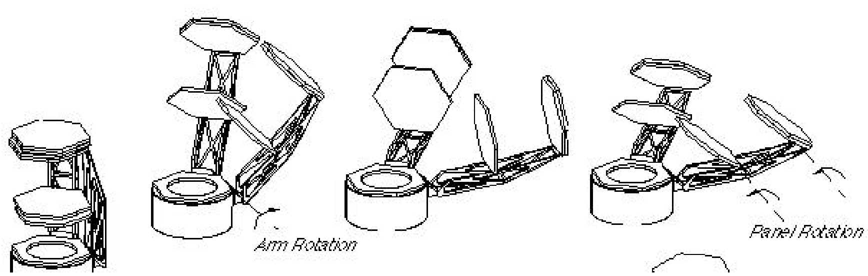

Figure 5 Deployment Scheme

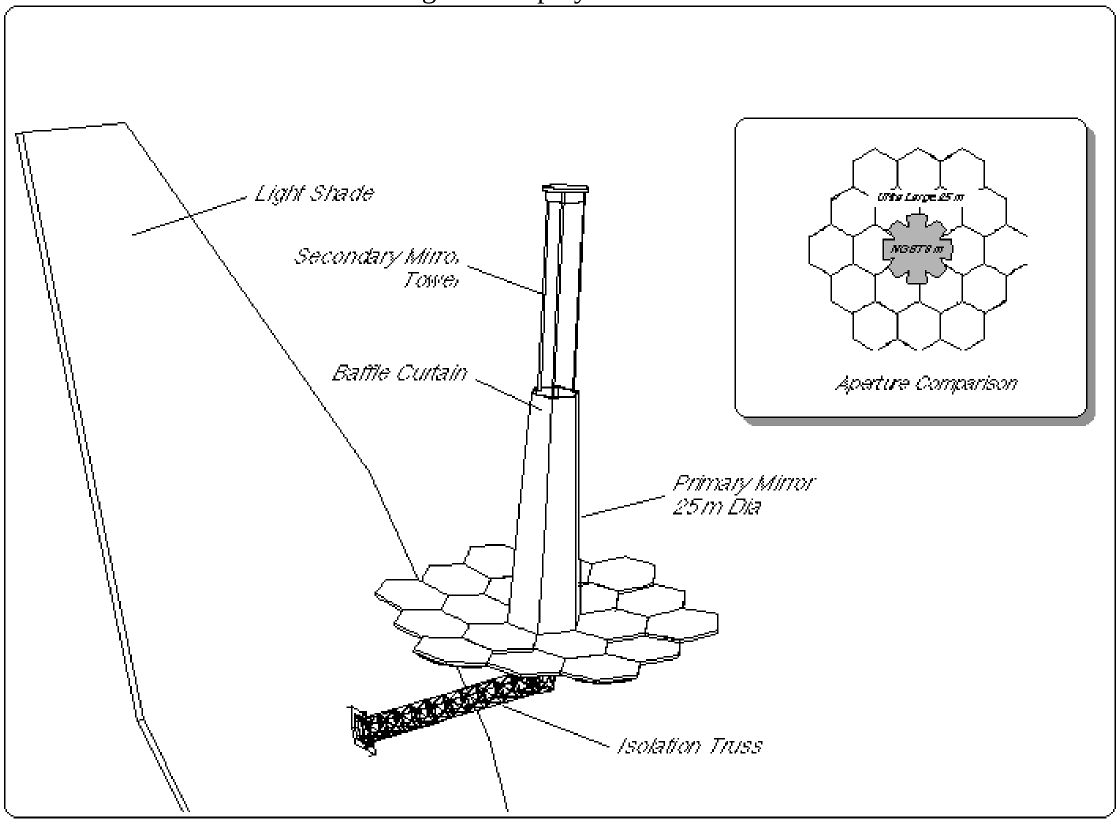

Figure 6 Deployed Configuration

Conclusions and Summary

It is obvious from the stowed configuration depicted in Figure 4 and the launch vehicle performance calculations that the Magnum vehicle is neither volume or performance limited for launching the Magnum Telescope to an L2 orbit. In fact, the margins are so large that this mission as configured would not make sense. To take full advantage of the enormous performance and volume afforded by the Magnum Launch Vehicle, a number of additional mission options would be viable. For example, with a smaller upper stage two Magnum Telescopes could be launched together and operate in an interferometric mode with combined beams. Other possibilities are 1) use the extra performance margin to insert the Magnum Telescope into an orbit outside of the ecliptic plane, and 2) launch another large payload desiring an L2 orbit, such as a very large X-ray

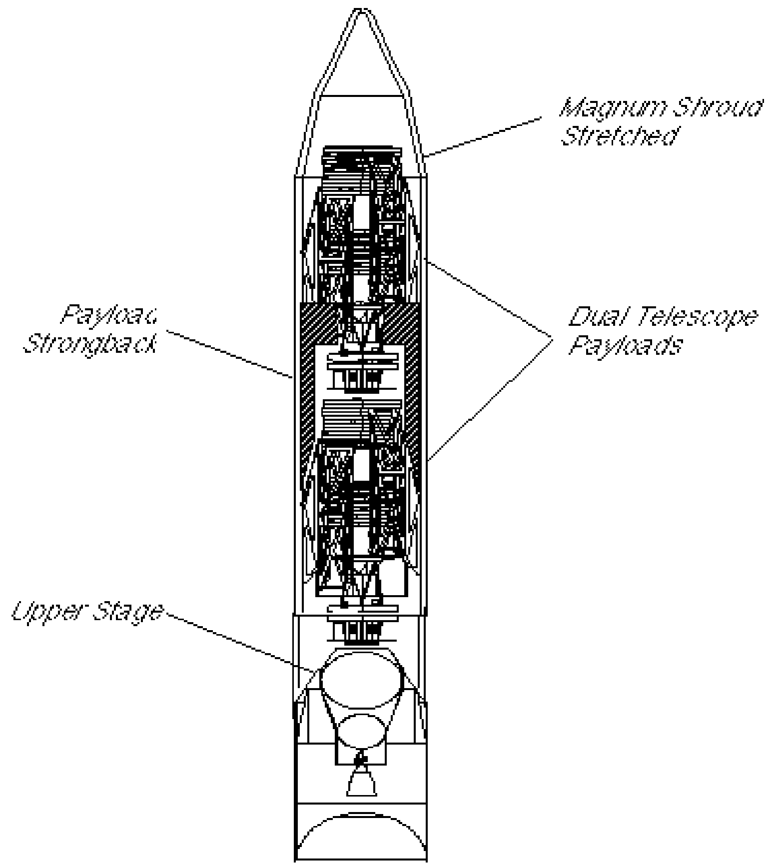

Figure 7 Magnum with Dual Payloads

References

1. "Shuttle Utilization Assessment" , Montgomery et al, MSFC Program Development study, July 30, 1998.
2. Magnum Launch Vehicle, MSFC ongoing study
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4. "Case for Segmentation of the Primary Mirror of Large Aperture Space Telescopes," E. E. Montgomery IV, Marshall Space Flight Center, Proceedings of Space Telescopes and Instruments V, SPIE vol. 3356-52, pg. 788, 25-26 March, 1998.
5. "Deployable Concepts for Precision Segmented Reflectors", Mikulas et al, NASA/JPL D-