SECONDARY MIRROR SUPPORT (LST)

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Ever since the year 1609, when Galileo first used a telescope to study the sky, structural mirror supports have played an important role in optics. With the advent of large space telescopes, the requirement for precise pointing and alignment became more pronounced than ever.

Although mirror supports have been developed for ground-based systems, they are heavy and inefficient when used for space applications. With the help of Figure 1, let me outline the problem. Consider the Cassegrain telescope with its long secondary mirror support. For a telescope focal ratio of 12 and 3-meter diameter primary mirror, the length of the secondary mirror support is determined by the mirrors intervertex distance, about 7.3 meters (24 ft). Actually, the secondary mirror support is a metering truss: it maintains a precise position between the secondary mirror and the primary mirror. To

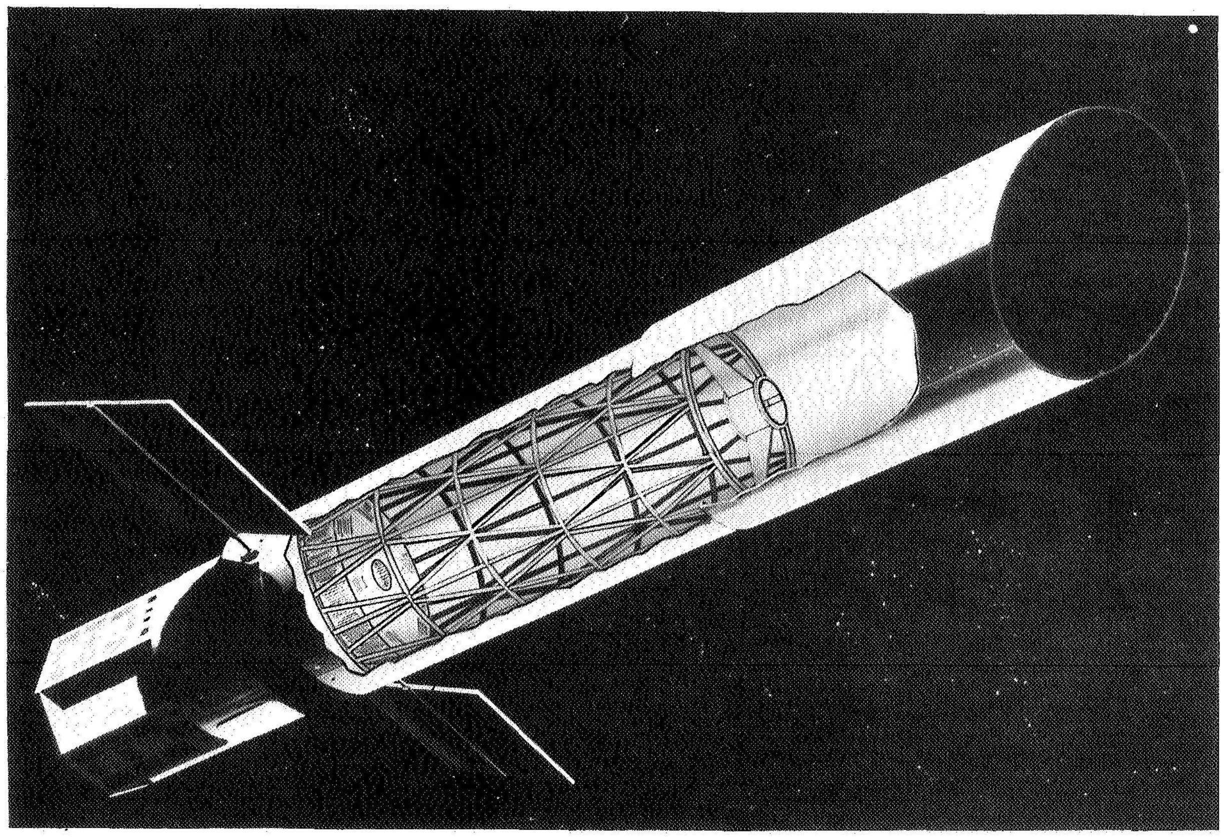


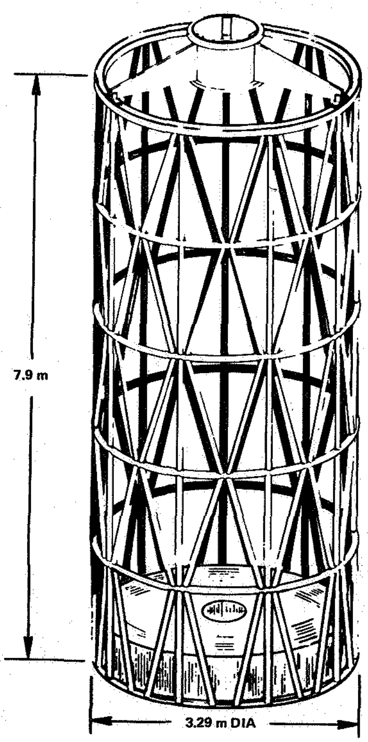
Figure 1. Large space telescope composite showing location of secondary mirror support.

achieve and to retain full optical performance, the secondary mirror support design had to meet the following requirements:

- Develop a dimensionally stable structure 7.9 meters (26 ft) tall with a natural frequency of not less than 13 Hz
- Be thermally compatible with the total telescope assembly, and able to carry the weight of mirror and support mechanism through the launch phase without damage

The most difficult requirements to meet was high dimensional stability. Unfortunately, most stable materials are either extremely brittle, expensive, and difficult to manufacture; are too heavy for flight worthiness; or simply are not available in quantities. Fortunately, a materials study made by Battelle Memorial Institute under contract to Goddard revealed that titanium alloy 6A1-4V has the highest microyield strength/density ratio of all the candidate materials. Microyield strength is defined as the stress level necessary to cause a residual strain of one-millionth of a meter per meter. For titanium 6A1-5V, this occurs at about 480×10^6 N/m^2 (70,000 lb/in^2).

With this new information on hand and after numerous trials comparing performance, dimensional stability, telescope configuration, materials, manufacutring processes, and above all, cost, the engineering model secondary mirror support looked like this (see Figure 2). By configuration, it is a cylindrical space truss having a natural frequency of



MATERIAL

TITANIUM ALLOY 6AL-4V

PROPERTIES

ELASTIC MODULUS	11.44×10^{10} N/m^2
ULTIMATE STRENGTH	9.51×10^8 N/m^2
DENSITY	4.43×10^3 kg/m^3
COEFFICIENT OF EXPANSION	8.82×10^{-6} cm/cm/K
MICROYIELD STRENGTH	480×10^6 N/m^2

STRUCTURE

ALL WELDED

6.3 cm DIA AND 7.6 cm DIA TUBING

0.32 cm WALL THICKNESS

WEIGHT	1100 kg
NATURAL FREQUENCY	14 Hz
DIMENSIONAL TOLERANCE	
FLATNESS (TOP AND BOTTOM)	0.025 cm
ROUNDNESS (RINGS)	0.32 cm
PARALLELISM	0.15 cm
PERPENDICULARITY TO C_L	0.32 cm
OVERALL LENGTH	±0.64 cm

MANUFACTURING

TUBING: AUTOMATIC PLASMA ARC WELDING

JOINTS: MANUAL TUNGSTEN INERT GAS WELDING

Figure 2. Secondary mirror support configuration and engineering data.

14 Hz, as determined by computer analysis and later experimentally verified through a "twang" test. It is an open structure permitting free exchange of thermal radiation across its diameter. It is capable of carrying a 230-kilogram (500 lb) secondary mirror through 15-g lateral launch acceleration without exceeding the microyield strength of the titanium alloy.

After we completed the design, manufacturing drawings, analyses, and specifications here at Goddard, Battelle Memorial Institute undertook the job of manufacturing the secondary mirror support. Figure 3 shows this structure as it appears now in Building 5, high bay area, at GSFC.

The completed structure is an all welded cylindrical truss formed from 6.3- and 7.6-centimeter (2½ and 3 in) diameter tubing made of 0.32 centimeter (1/8 in) thick titanium plate, and seam welded using automatic plasma arc welding. All other joints are hand welded using the tungsten inert gas method. Weight of this 7.9-meter (26 ft) tall and 3.4-meter (11 ft) diameter structure was kept down to 1100 kilograms (2210 lb), and the cost a mere $90,000. It is, to the best of my knowledge, the largest all-welded titanium alloy structure.

We have shown you that large structural mirror supports which meet the stiff requirements for launch and orbit operations in particular, dimensionally stable structures made of titanium alloy, can be manufactured with present-day technology and at reasonable cost. With continuing research and development in this area, designs of astronomical telescopes and related earth observatory satellites should benefit from this knowledge.

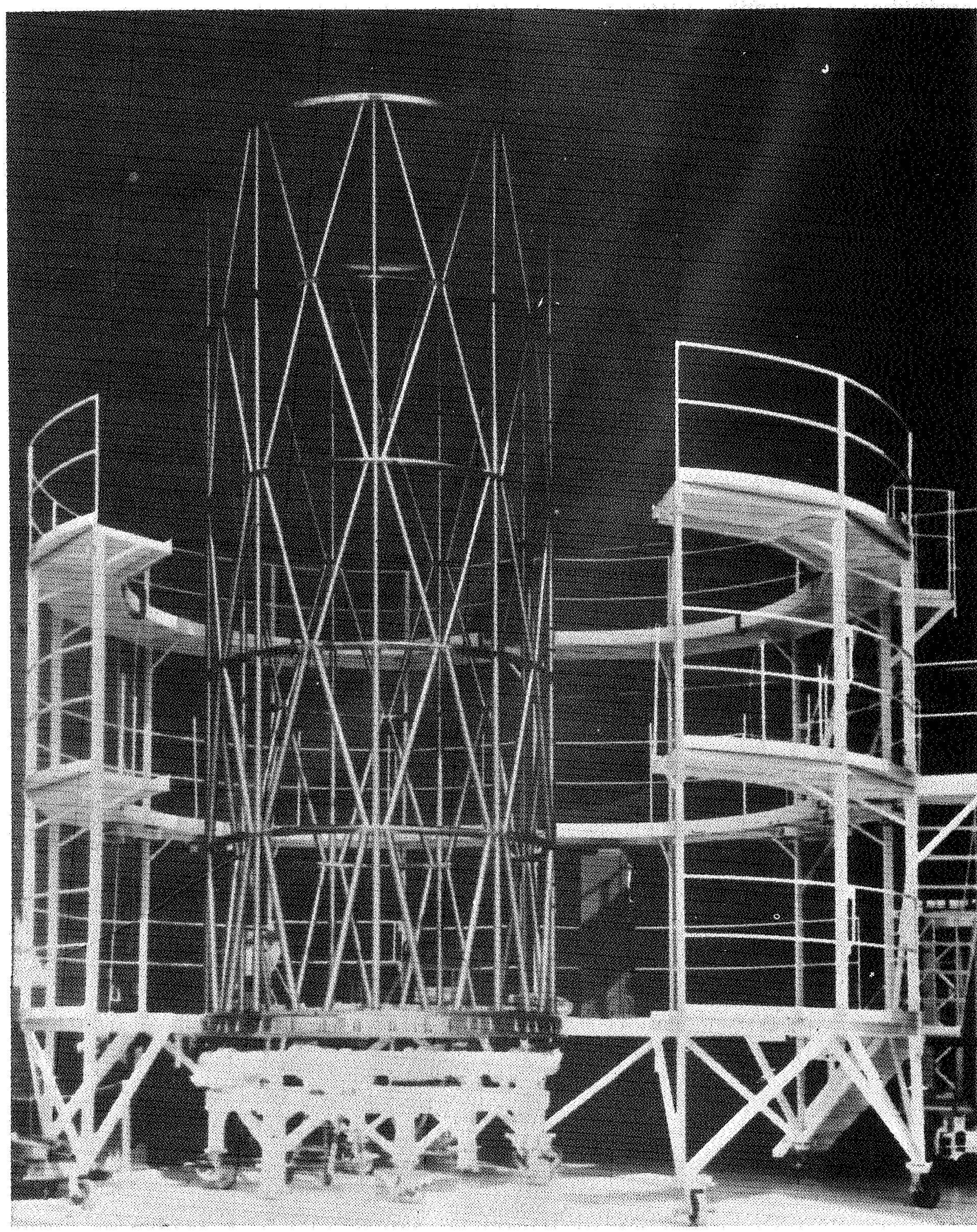


Figure 3. The secondary mirror support surrounded by work platform.