Mechanical design and design processes for the Telescope Optical Assembly of the Optical Communications Demonstrator

Bryan von Lossberg

Jet Propulsion Laboratory, California Institute of Technology,
4800 Oak Grove Dr., M/S 171-300, Pasadena, CA 91109

ABSTRACT

A mechanical design has been developed for the Telescope Optical Assembly (TOA) of the Optical Communications Demonstrator (OCD). The TOA is the portion of the OCD instrument that integrates all the optical elements of the system with the exception of the Laser Transmitter Assembly (LXA) which is fiber coupled to the TOA. The TOA structure is composed primarily of aluminum components with some use of steel and invar. The assembly is contained within a 16 cm x 20 cm x 33 cm envelope and has an estimated mass of 5.5 kg. The mechanical design was developed using Computervision's CADDS 5 computer aided design software. Code V optical design data was used as a primary input and was efficiently and accurately transferred from the optical designer to the mechanical designer through the use of IGES files. In addition to enabling rapid transfer of the initial optical design as well as subsequent optical design refinements, the IGES transfer process was also used to expedite preliminary thermal and dynamic analyses.

1. INTRODUCTION

Near the completion of the initial optical design for the TOA portion of the OCD, work was initiated developing a mechanical design for a laboratory-environment qualified brassboard assembly. [1]

The mechanical design was to accomplish the following:

1. Integrate all TOA optical elements (see Figure 1) and interface with the laser subsystem (LXA)[2] and pointing and tracking hardware (gimbal).
2. Maintain the desired optical performance in a 25° C ±10° C operating environment.
3. House and support the CCD and associated electronics and provide a means for necessary adjustments of the CCD chip rotational orientation.
4. Keep the total mass of the TOA portion of the instrument to 10 kg or less,
5. Keep the TOA within a 20 cm x 20 cm x 30 cm volume,

The design section at JPL currently employs Computervision's CADDS 5 and CADDS 4X software running over a UNIX operating system on SUN Microsystems SPARC 2 and SPARC 10 terminals. Mechanical design began on a SPARC 2 running CADDS 4X and later continued on a SPARC 10 running

CADDS 5 software. Wire frame and solids geometry were utilized to represent the mechanical design. The CAD process used Code V information as a primary input and can output detailed drawings or databases for direct transfer to the machine shop where they can be used for computer numerical controlled (CNC) machining. in the same manner that the Code V information was electronically imported into the CAD system, CAD databases were exported by means of 80 column text files known as IGES files for preliminary analysis with COSMOS/M software.

2. DESIGN

External isometric views of the TOA are presented in Figure 2, and a cross-section of the assembly is presented in Figure 3.

The design calls for the primary mirror to be bonded to an aluminum central hub mount with RTV. This aluminum mount is then structurally connected to a flange in the main aluminum housing through three sets of blade flexures and spherical washer sets spaced about the optical axis 120° apart. The secondary mirror is bonded with RTV in an aluminum mount which is in turn fastened to an aluminum spider. The spider is supported by three flexure assemblies at the end of the main housing.

The spacing between the primary and secondary mirror is controlled in part by three invar rods which connect the flange inside the main housing with the secondary spider. The materials and pertinent lengths of the individual components contributing to the intervertex spacing of 135 mm have been chosen and sized appropriately to athermalize the design over the 25° C ±10° C operating environment. If future material substitutions are made, the design can be easily refined to preserve athermalization.

The main housing is structurally connected through three corrosion resistant steel flexures and shims to the aft housing. Inside the aft housing an aluminum chamber contains the beam splitter and collimating doublet. **A** cell supporting the retro mirror also attaches to this chamber.

A structural barrel connects the aft housing to the plate supporting the CCD and CCD electronics housing. An aluminum barrel containing the imaging triplet optical elements and filter fits inside the structural barrel. The optical elements are restrained and spaced inside the barrel using spacers and threaded retaining rings. The CCD and CCD electronics housing is fastened to a support plate which is in turn fastened to the structural barrel and registers to this barrel by means of a tightly tolerance boss fitting inside a tightly tolerance hole atop the structural barrel. A differential screw and spring mechanism fixed to the support plate is anticipated to enable fine adjustments to the angular orientation of the CCD chip within the housing. This adjustment was desired to enable proper alignment between the CCD chip's orientation and rotation of the two-axis fast steering mirror.

The fast steering mirror housing connects to the aft housing atop a nominal shim plate. It is designed to support the fast steering mirror assembly and provide a surface for attachment of the relay doublet and zoom element barrel.

The aluminum barrel containing the relay doublet and zoom element mounts to one face of the fast steering mirror housing and extends inside this housing. Again, the optical elements inside the barrel are spaced and restrained using spacers and retaining rings. Access is provided through the side of the barrel to the subcell containing the zoom element to enable fine tuning of this element after the connection to the LXA has been made. This barrel also provides a surface for the laser attachment flange to mount on.

Two interface locations are also indicated on the exterior of the main housing where sufficient material remains to facilitate an interface with either a gimbal assembly or, in the event a gimbaled flat is used in front of the telescope, a fixed mount.

In its current state the TOA mechanical configuration occupies a 16 cm x 20 cm x 33 cm volume (10,560 cubic cm). This satisfies the design goal of a 20 cm x 20 cm x 30 cm (12,000 cubic cm) volume.

The wire frame geometry initially utilized in the CAD process to represent the mechanical design was also used to construct solids at a point in the mechanical layout when it was possible to obtain a fairly accurate estimate of the system's mass. At that time the mass of the TOA was estimated to be 5.5 kg, well within the 10 kg or less design goal. Envelope and mass information is presented in Figure 4. Solids can again be employed when the mechanical design has been finalized to obtain an updated mass estimate as well as to identify where the center of gravity of the system is situated. This information would influence the design of any interface between the TOA and either a gimbaled or fixed mount.

3. DISCUSSION

Various tools and processes were used to design the mechanical hardware which constitutes the TOA portion of the OCD. Essentially every hardware design process is an iterative one where concepts evolve, mature, and are refined. A current wire frame depiction of the TOA is presented in Figure 5. Invariably, refinements or outright changes in one aspect of a design, for example the optical layout, significantly affect design in other areas, such as the hardware restraining the optical elements. To minimize the time such an iterative process consumes and ensure accurate knowledge of the most recent design status, several tools and processes were utilized. Aside from the capabilities of the CAD software, the most useful process utilized in the TOA design was the electronic transfer of data between Code V and Computervision's CADDS 5 software.

Code Visa powerful and popular optical design tool. The first hardware concepts for the TOA formed around the optical layout generated in Code V. "The optical design is divided into three channels: a transmit, boresight, and receive channel.[3] The Code V layout was converted into several IGES files, each file representing one field position for each of the three channels, and transferred via the laboratory network to a terminal in the design section. At the CAD terminal the files were accessed and read by the design section's CAD software using an IGES file converter. Once processed, the Code V data could be viewed and manipulated within the CAD software. Code V generated optical elements and ray traces and their position in the mechanical design appear in Figures 6, 7 and 8. One advantage of such a paperless data transfer is that it eliminates the introduction of potential errors resulting from miscommunication or misinterpretation of verbal or paper-based communications. In such a transfer verbal and paper-based communications augment the electronic data transfer rather than serve as the primary means for transferring design data.

Transfers via IGES files were not entirely clean, however; and significant care was taken to ensure accurate information transfers. It was discovered that in the IGES conversion of the Code V data the entire optical system was mirrored about a plane containing the optical axes of the system. In addition, wire frame elements do not always transfer cleanly through the IGES transfer process. Nevertheless, the IGES transfers of data between Code V and CADDS 5 proved to be a powerful design process.

The IGES transfer capability also aided the preliminary thermal and dynamic analysis of the system. In the same manner that Code V data was transferred to the CAD system via IGES files, the CADDS 5 database containing the initial mechanical configuration was electronically transferred to the software used to perform the preliminary analyses. This was achieved by constructing several IGES files containing various groupings of the designed hardware and electronically transferring those files to a terminal where a new but essentially copied mechanical model was constructed and analyzed for thermal and dynamic frequency responses using COSMOS/ M. Results from the preliminary analyses were used to further refine the mechanical design.

4. ACKNOWLEDGMENT

The work described in this paper was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

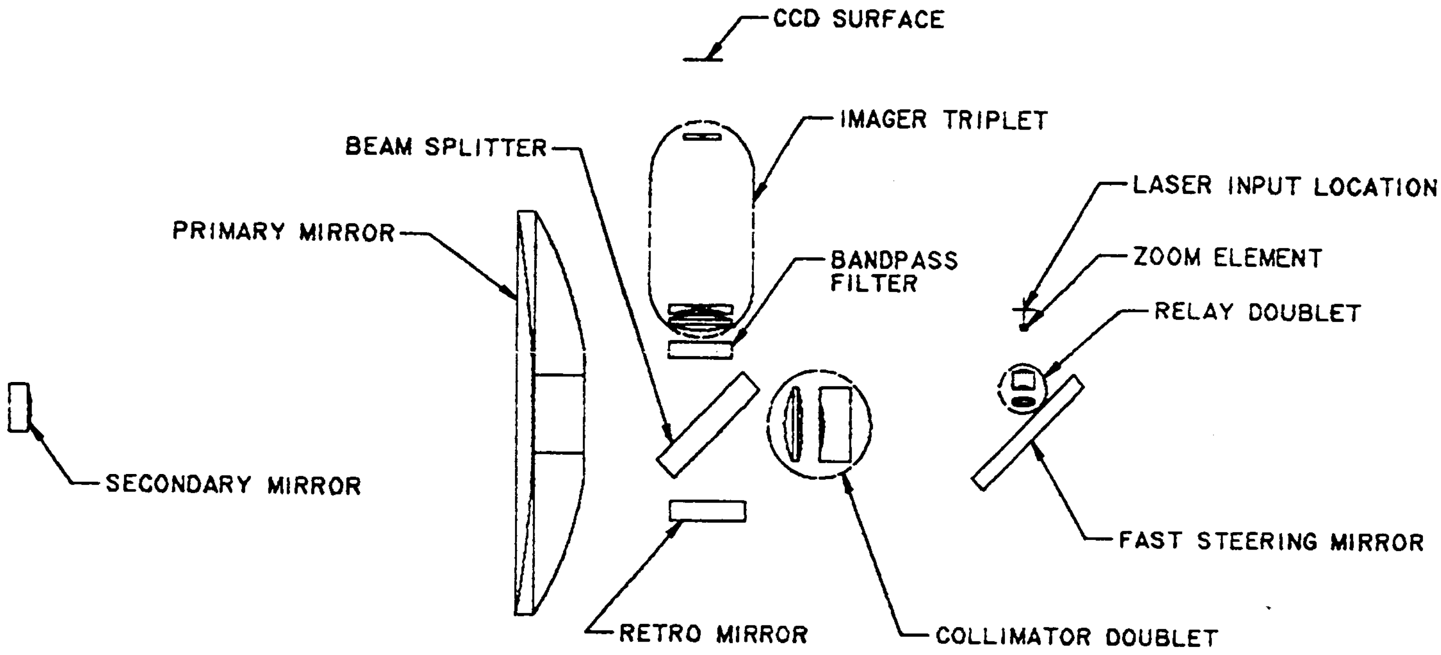
5. REFERENCES

1. J. Lesh, "1'regress and Plans for the Optical Communications Program at JPL," Proceedings of SPIE OE/Lase 94, Paper #21 23-02, Los Angeles, CA, January 1994.

2. H. Hemmati and D. Copeland, "Laser Transmitter Assembly for Optical Communications Demonstrator," Proceedings of SPIE OE/Lase 94, Paper #2123-24, Los Angeles, CA, January 1994.

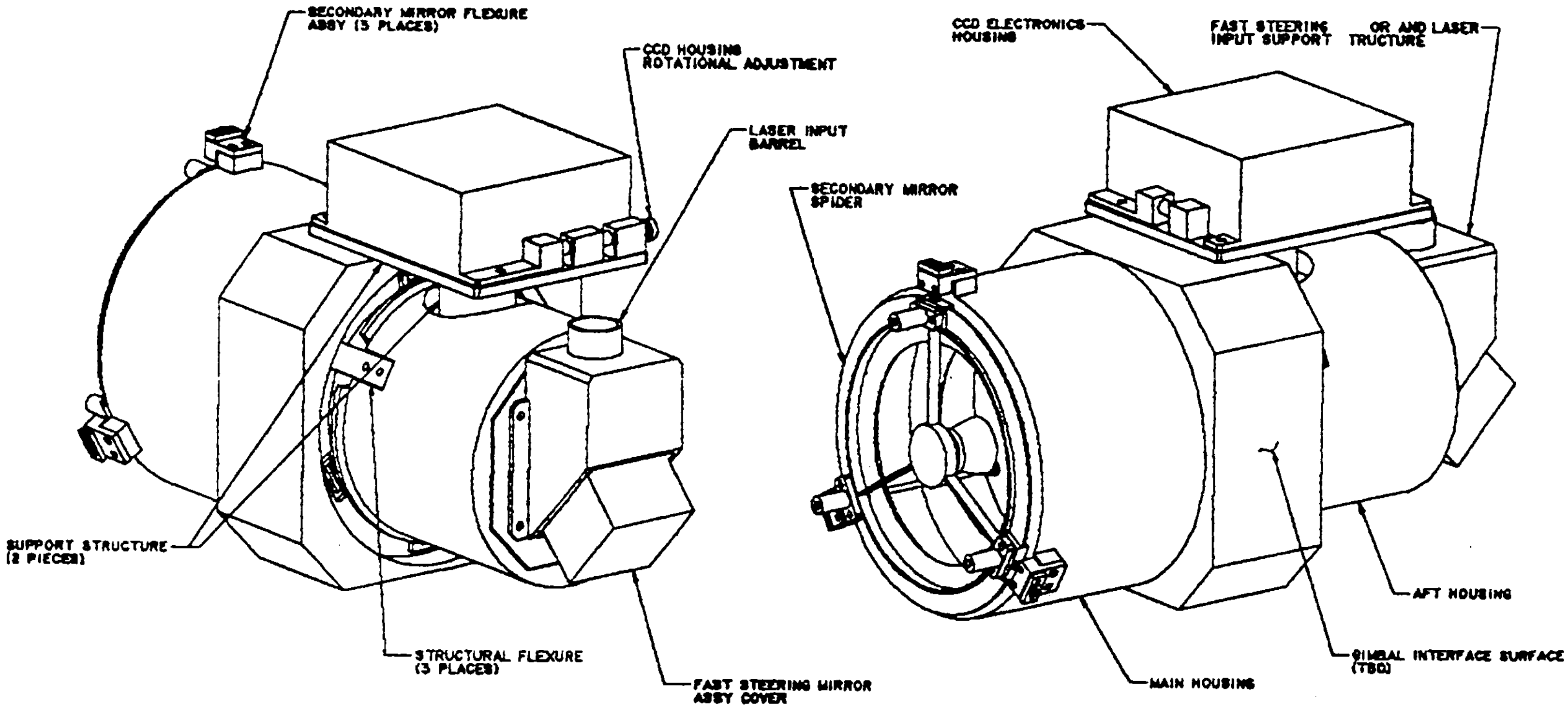
3. N. Page, "Design of the Optical Communications Demonstrator Instrument Optical System," Proceedings of SPIE OE/Lase 94, Paper #2123-46, Los Angeles, CA, January 1994.

JPL



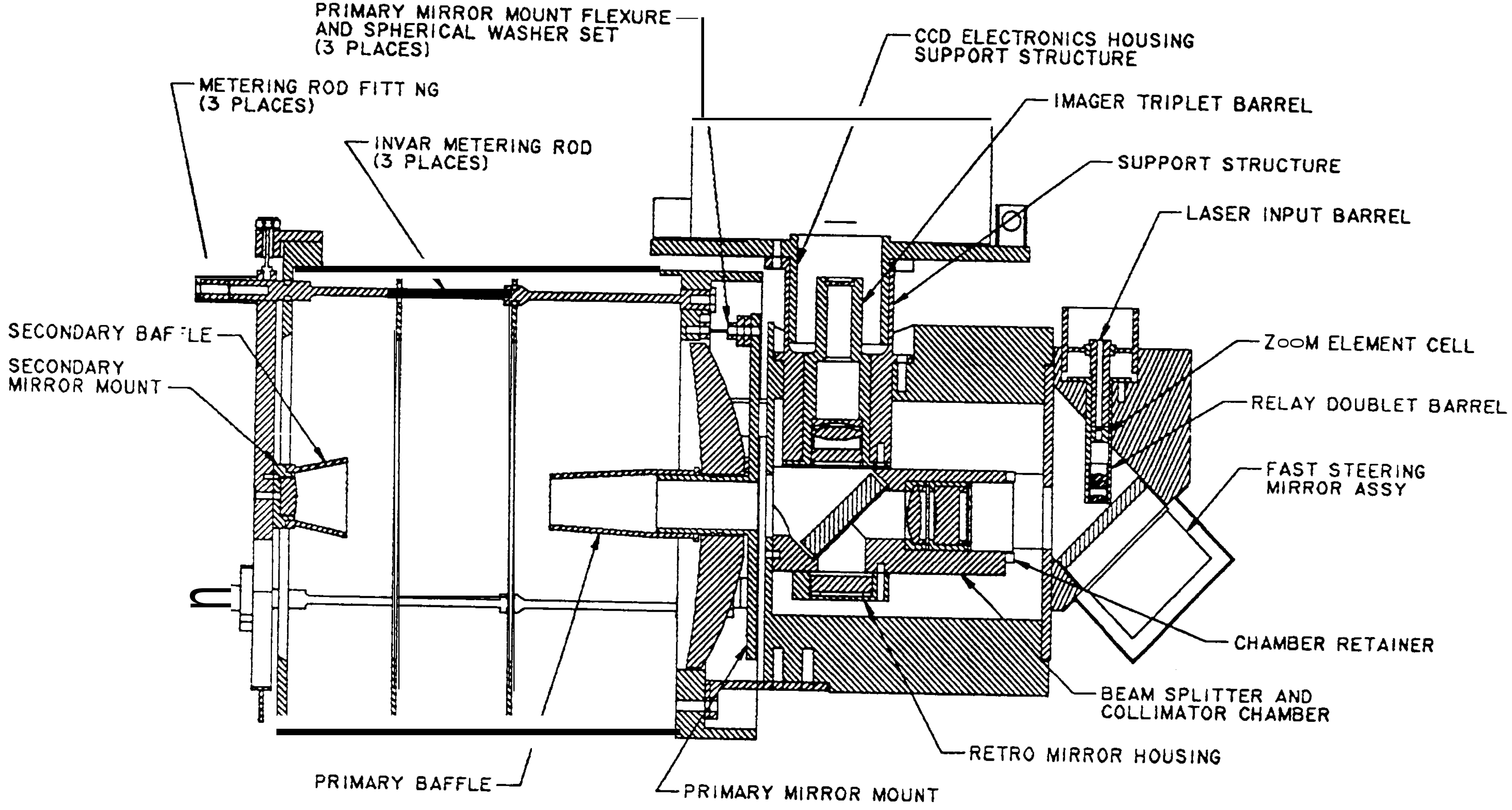
TOA OPTICAL ELEMENTS LAYOUT

Figure 1



TOA EXTERNAL ISOMETRIC VIEWS

Figure 2



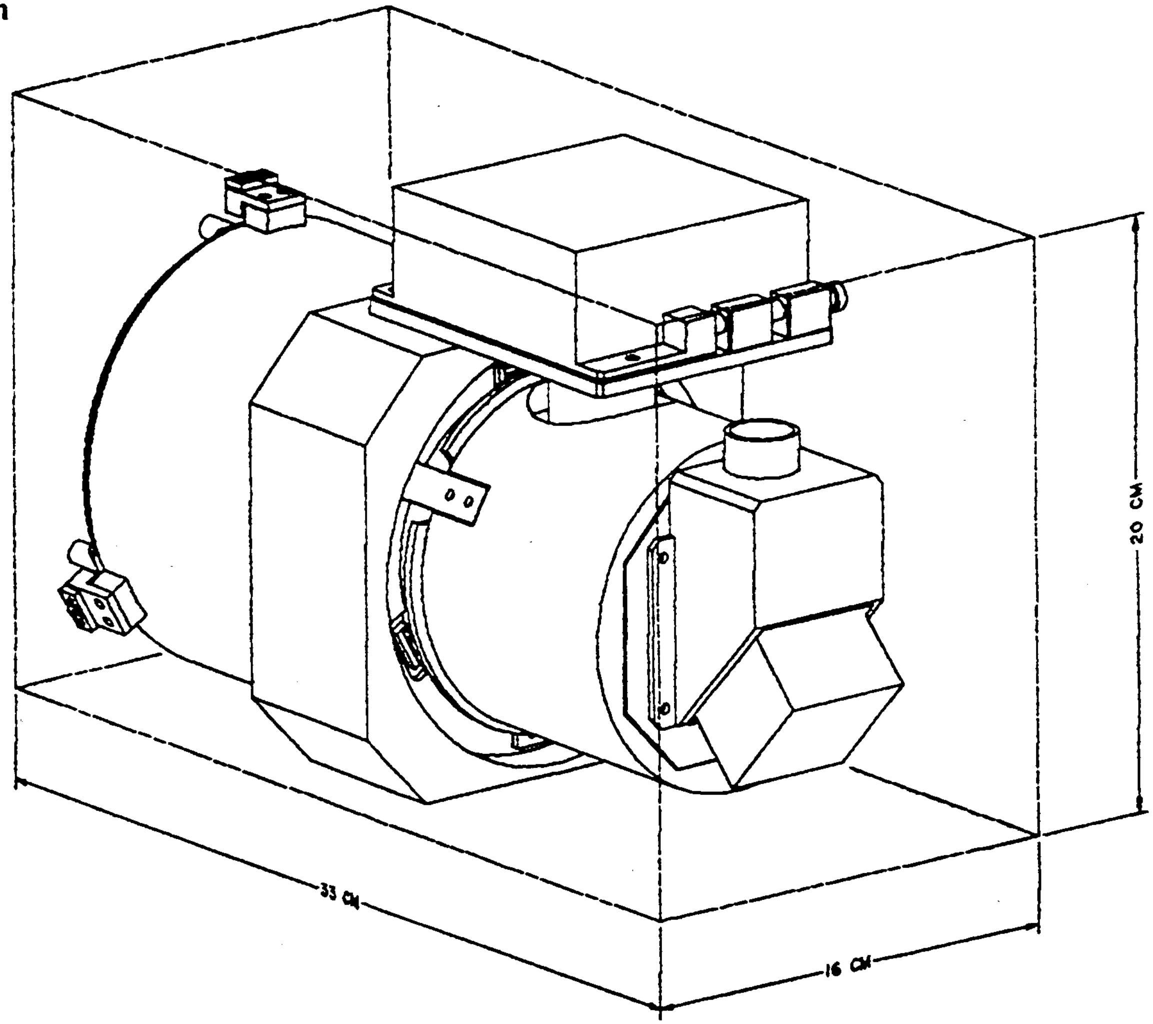
TOA CROSS-SECTION

Figure 3

JPL

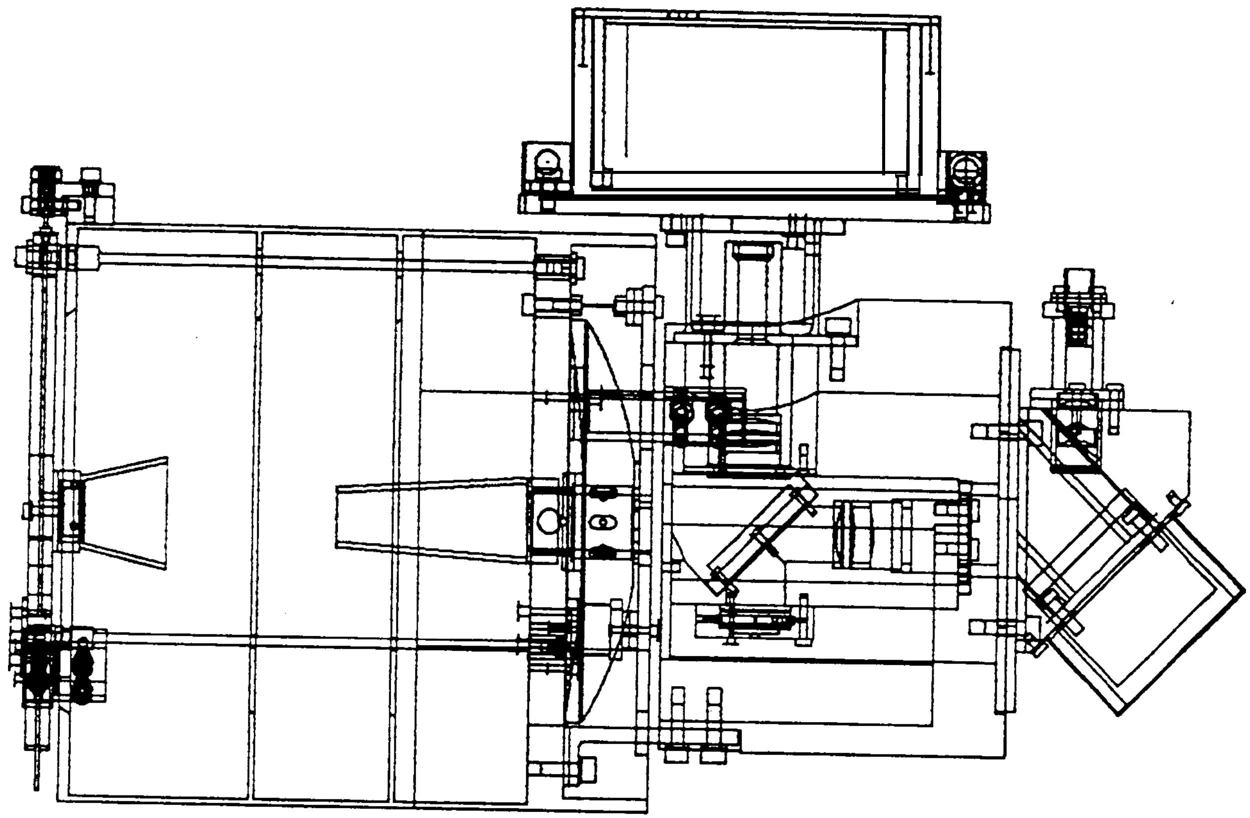
TOA ENVELOPE: 16 cm x 20 cm x 33 cm
(10,560 cubic cm)

ESTIMATED MASS: 5.5 kg



TOA ENVELOPE AND MASS ESTIMATE

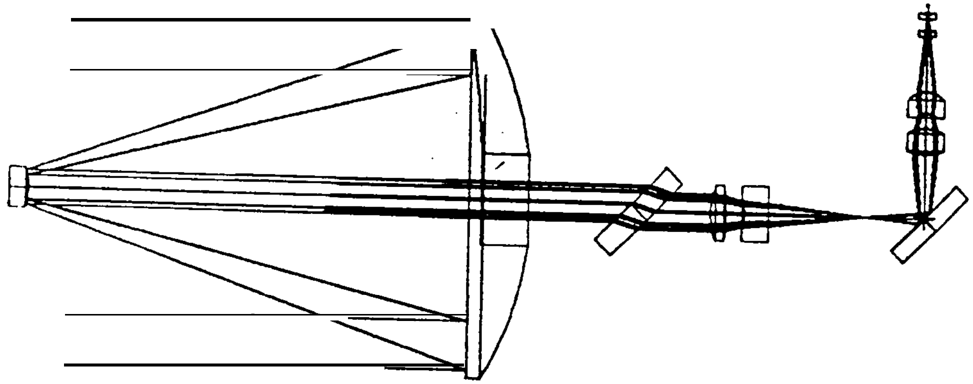
Figure 4



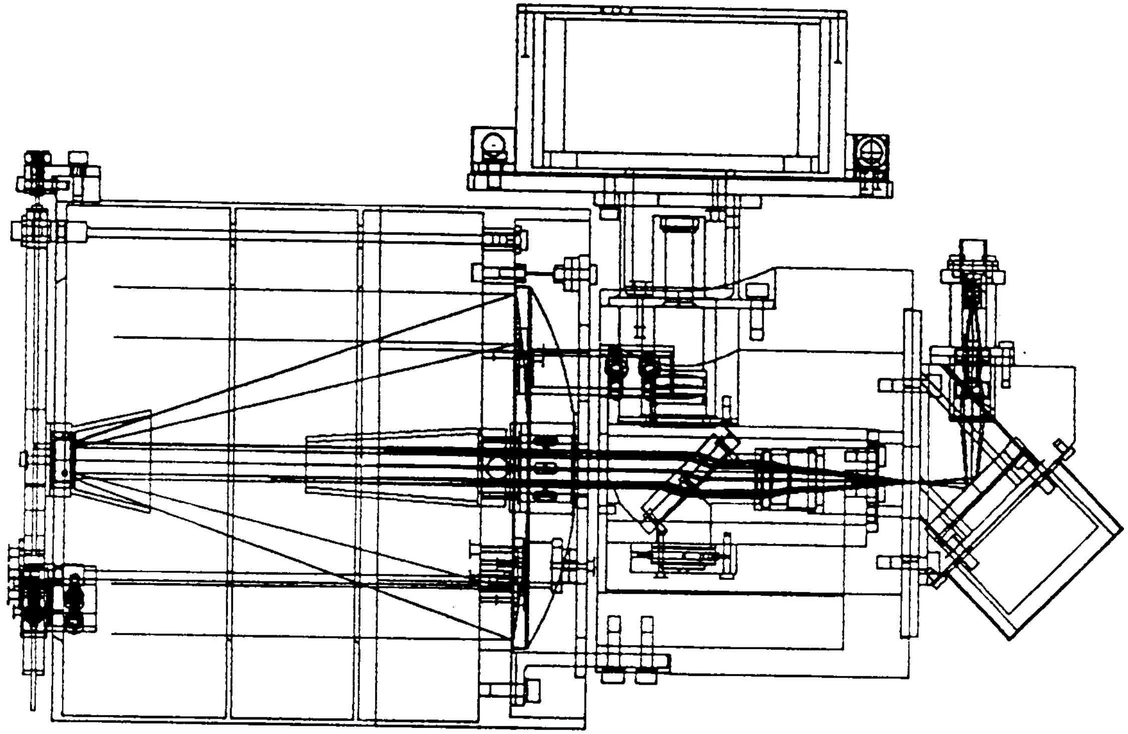
CURRENT TOA LAYOUT

Figure 5

JPL

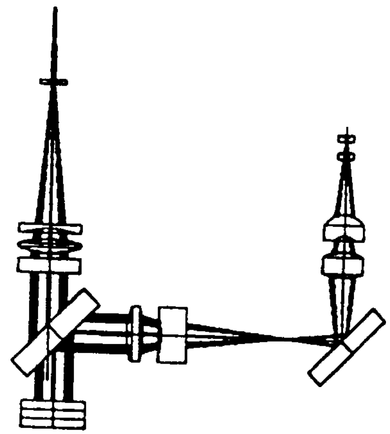


CODE V GENERATED OPTICS AND RAY TRACES

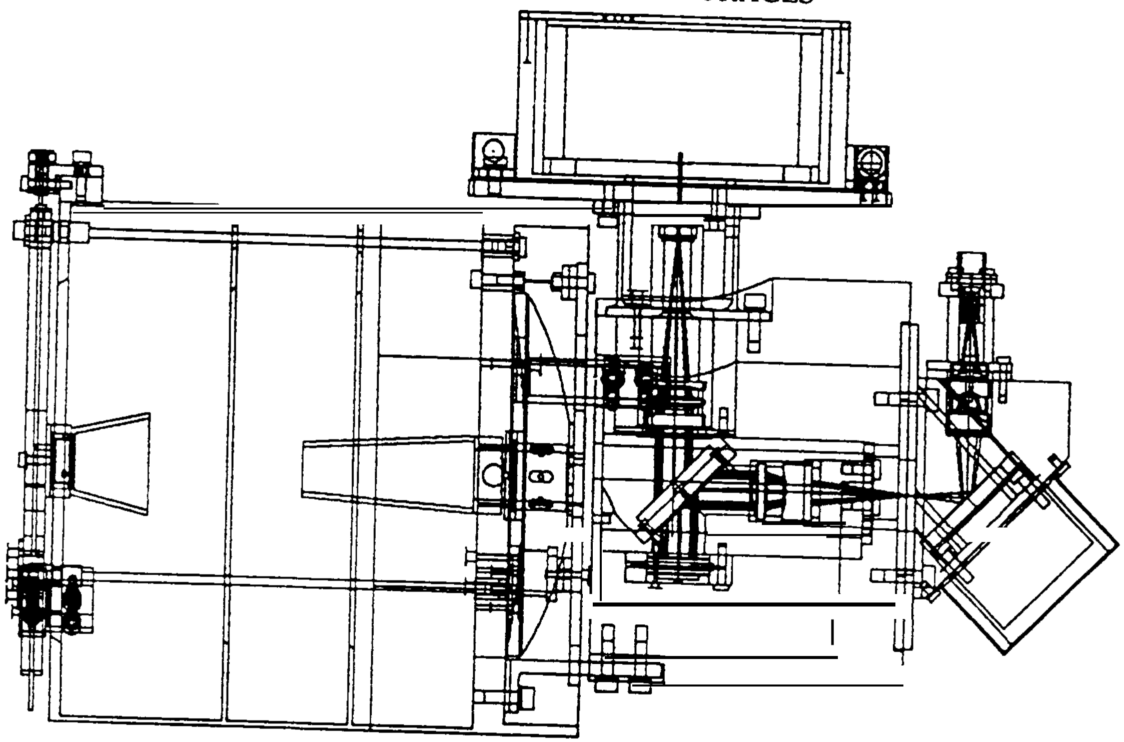


RAY TRACES IN TOA

Figure 6 TOA TRANSMIT CHANNEL



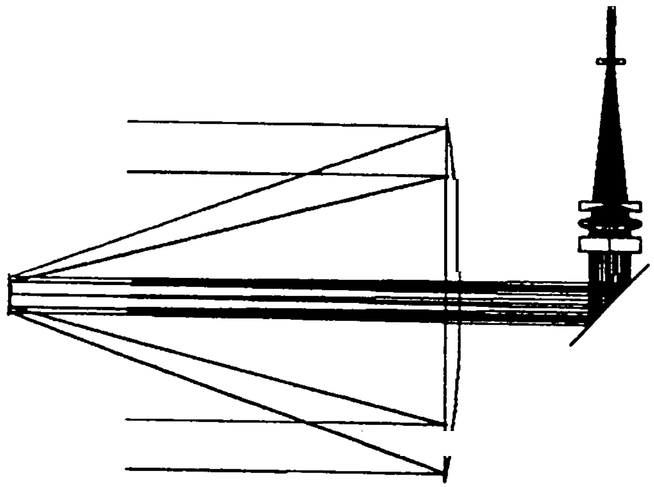
CODE V GENERATED OPTICS AND RAY TRACES



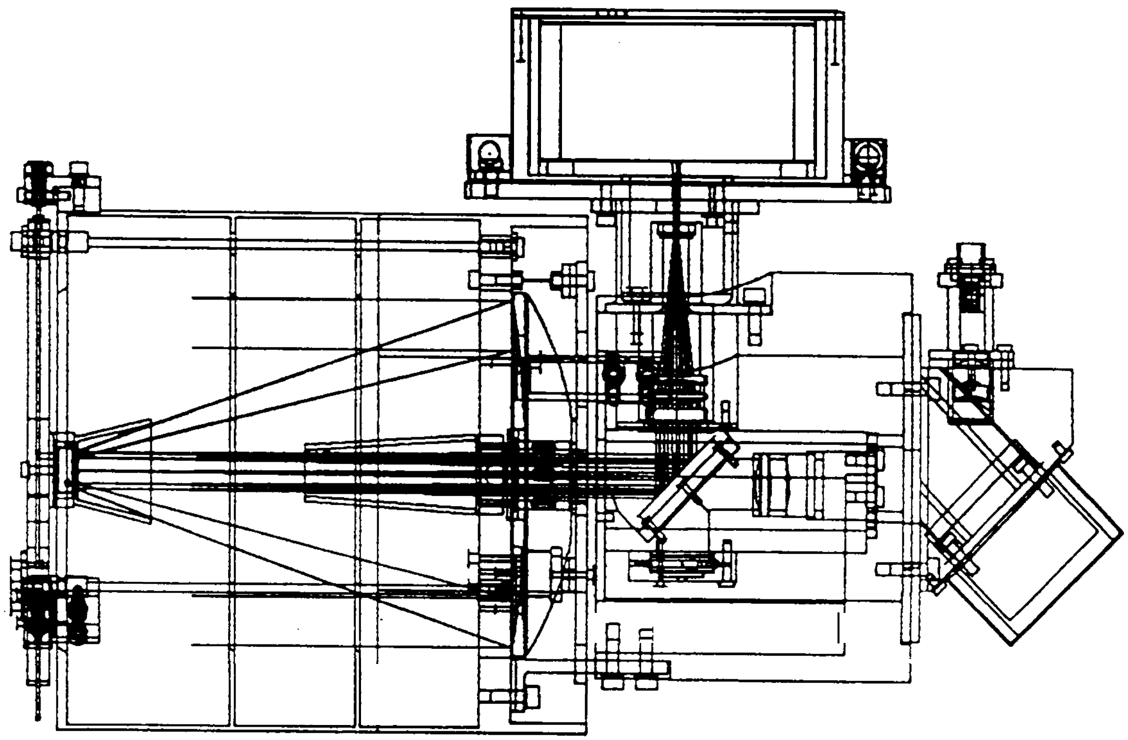
RAY TRACES IN TOA

Figure 7 TOA BORESIGHT CHANNEL

JPL



CODE V GENERATED OPTICS AND RAY TRACES



RAY TRACES IN TOA

TOA RECEIVE CHANNEL

Figure 8