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Three-Meter Balloon-Borne Telescope

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The Three-Meter Balloon-Borne Telescope is planned as a general purpose facility for making far-infrared and submillimeter astronomical observations from the stratosphere. It will operate throughout the spectral range 30 microns to 1 millimeter which is largely obscurred from the ground.

The design is an f/13.5 Cassegrain telescope with an f/1.33 3-meter primary mirror supported with a 3-axis gimbal and stabilization system. The overall structure is 8.0 m high by 5.5 m in width by 4.0 m in depth and weighs 2000 kg. This low weight is achieved through the use of an ultra lightweight primary mirror of composite construction. Pointing and stabilization are achieved with television monitoring of the star field, flex-pivot bearing supports, gyroscopes, and magnetically levitated reaction wheels.

Two instruments will be carried on each flight; generally a photometric camera and a spectrometer. A 64-element bolometer array photometric camera operating from 30 to 300 μm is planned as part of the facility. Additional instruments will be derived from KAO and other development programs.

The scientific capability of this facility is based on two crucial features: the balloon altitude of 100,000 feet, where less than 1% of the Earth's atmosphere remains, including its water vapor, and the three meter aperture. The latter provides high angular diffraction-limited resolution approaching eight arcseconds at 100 μm wavelength, and a large collecting area, making possible sensitive high resolving power spectroscopy. The small residual atmosphere permits measurement of astronomical atomic and molecular spectral lines, which are obscured by similar atmospheric lines at lower altitudes, and provides a low sky emissivity resulting in greater detector sensitivity. The high angular resolution makes it possible to resolve and study in detail such objects as collapsing protostellar condensations in our own galaxy, clusters of protostars in the Magellanic Clouds, giant molecular clouds in nearby galaxies, and spiral arms in distant galaxies. Sensitive spectral line measurements of molecules, atoms, and ions can be used to probe the physical, chemical, and dynamical conditions in a wide variety of objects.

A NASA-supported design study has been carried out by the Smithsonian Astrophysical Observatory, University of Arizona, and Yerkes Observatory. This has resulted in an optimized optical, structural, and dynamic design which meets the overall scientific performance goals and is compatible with National Scientific Balloon Facility launch weight and other requirements.

This project deals with many technical issues directly relevant to NASA space missions such as the Large Deployable Reflector (LDR), and provides a focus for advancing required technologies at a reasonable size, time schedule, and cost. Already, considerable progress has been made in the development and testing of very lightweight composite mirrors which maintain 30 micron diffraction-limited figure quality at low temperature. Other related technologies include two-stage optics concepts, alternative approaches to secondary mirror chopping, and the development and operation of far infrared remotely operable instrumentation.

It is envisioned that the three-meter telescope would fly approximately five times a year. Each flight would carry two instruments, enabling an active guest observer program both for providing new instruments and for making astronomical observations. The definition study projects a three-year period for final design and construction, with initial flight operations of three flights during the fourth year. Subsequently, it is planned for five flights per year, each with a duration of ten hours or longer. A summary of the telesope parameters is given in TABLE 1.

TABLE 1. Three-Meter Balloon Telescope Parameters

Telescope	3 Meter Aperture f/13.5 Cassegrain
Spectral Range	Visible to millimeter, diffraction limited to 30μm (2.5")
Field of View	IR: 5' unvignetted, Optical: 15'
Secondary Chopper	16 Hz at 5 arcminutes (max.)
Pointing Stability	1 arcsec rms maximum, 0.25 arcsec goal
Aspect Sensing TV	
Acquisition	5° Field 11th magnitude sensitivity
Star Tracker	1° Field 10th magnitude sensitivity
Focal Plane	15' Field
Slew Rate	10 arcminutes/sec
Raster Scan Rate	24 arcseconds/sec max.
Telescope Observing Range	
Azimuth	360°
Elevation	-10° to +65°
Cross Elevation	$\pm$ 3°
Power System	Gondola and Experiments 250 amp-hrs each, max 15 amps at 28V each
Weight	
Telescope and Instrument	1724 lb.
Gondola	2026 lb.
Typical Flight Observing Time	10 hours at 29-31 km altitude
Experiments	Two per flight @ 115kg, 140 watts (typically photometric camera plus spectrometer)
Initial Photometric Camera	8 x 8 array of ^{3}He-cooled silicon bolometers covering 30μm to 300μm in several bands $0.1 < \Delta\lambda/\lambda < 0.5$, pixel $1.22\lambda/D$ (switchable magnification)

Photometric Sensitivity	NEFD/pix (chopping),	point source in 4 pixels 10σ in 30 minutes (chopping)
50μm	.09 Jy/$\sqrt{\text{Hz}}$	.04 Jy
100μm	.15 Jy/$\sqrt{\text{Hz}}$	.07 Jy
200μm	.19 Jy/$\sqrt{\text{Hz}}$	.09 Jy

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