NGST Integrated Science Instrument Module (ISIM)

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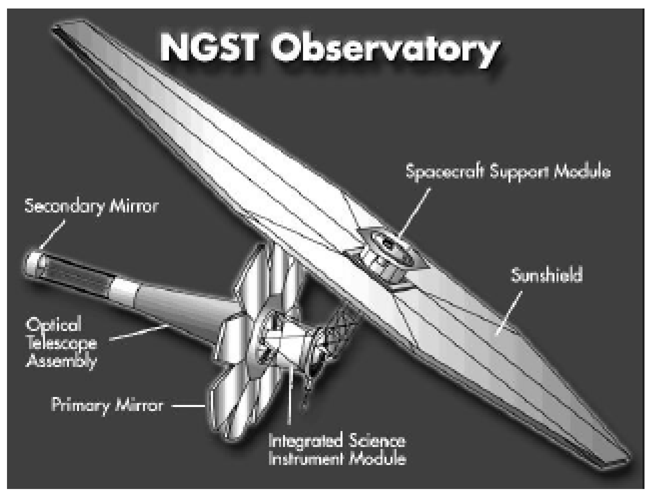
ABSTRACT

A brief overview of the Next Generation Space Telescope science instrument module is given, development plans for engineering design, enabling technologies, and science instruments are discussed. Up-coming schedule milestones of community interest are also presented.

Keywords: NGST, ISIM, Infrared Instrumentation, Spectrometer

1. INTRODUCTION

The NGST observatory is composed of three major subsystems: the Optical Telescope Assembly (OTA), the Spacecraft Support Module (SSM) and the Integrated Science Instrument Module (ISIM). The ISIM is a distributed system consisting of a cryogenic instrument module located at the focus of the OTA, a computer system located in the SSM that is used for science instrument control and data processing, and other thermal, electronic, and structural instrument support systems located both in the SSM and the cold instrument module.



A central challenge area for the NGST instrument module is to achieve a substantial reduction in-development costs relative to previous missions such as the Hubble Space Telescope (HST). The strategy that has been adopted to meet this challenge has three primary elements: [1] develop all enabling science instrument (SI) technologies to flight readiness prior to ISIM Critical Design Review (CDR), [2] enforce strong systems engineering to enable a tightly integrated instrument module system design, [3] follow a design-to-cost development approach.

In order to meet goal [1], baseline SI methodologies were selected during early phase A[1]. Detailed engineering designs were developed for these SIs and the complete ISIM system. This design activity was then used to identify technology challenge areas in order to focus technology development spending and enable accurate schedule and cost planning. Goal [2] favors design solutions that minimize non-recurring engineering cost through system integration. Here, integration refers to a design approach in which common SI functions such as: command and data handling, detector and mechanism control, and thermal control are performed by systems that are shared among the SIs. Voltaire said that better is the enemy of good. Goal [3] eases this tension by anchoring trade studies to integrated system performance metrics such as the observing time required to perform the NGST Design Reference Mission[3] -- a set of strawman observing programs that embody the baseline NGST science mission.

Consistent with goal [2], the ISIM will be developed by an Integrated Product Team (IPT) led by NASA Goddard Space Flight Center (GSFC) and composed of the ISIM system stake-holders: the Space

Telescope Science Institute, the European Space Agency, the Canadian Space Agency, the NGST prime contractor, and the SI principal investigators. Science instruments for the ISIM will be procured from the US, European, and Canadian science and engineering communities. This IPT will provide top level systems engineering for SI development within the US, Europe and Canada. Flight qualified SIs will be delivered to GSFC for integration into the ISIM. GSFC will then deliver the ISIM to the prime contractor for observatory level integration.

2. ISIM DEVELOPMENT DURING NGST PHASE 1

The NGST development plan is divided into two phases[2]. During phase 1, separate prime contractor candidates are developing competing observatory architectures. At the onset of phase 2 (late FY01), a single observatory design and prime contractor will be chosen.

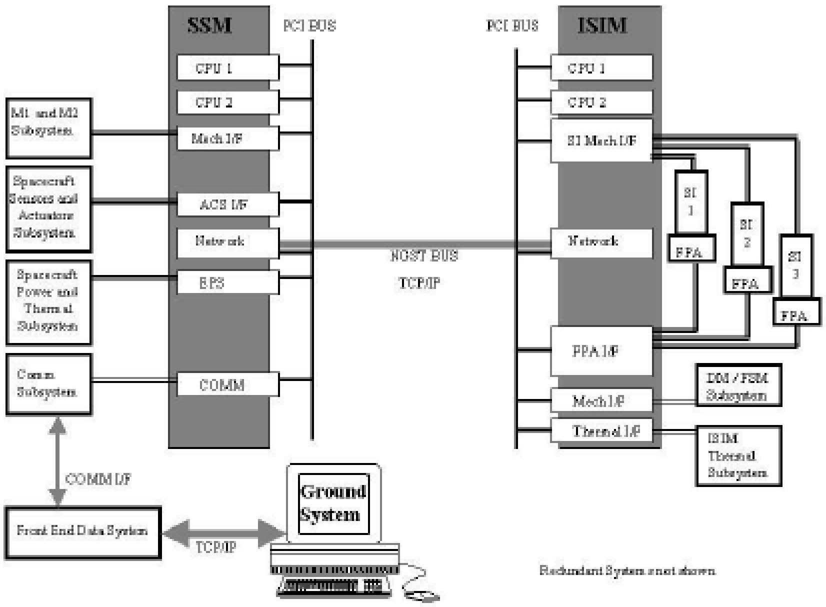
During phase 1, the ISIM IPT is working to meet four objectives: [1] produce conceptual ISIM designs that are optimized for integration with two competing observatory architectures, [2] fund and manage development of instrument technologies that enable performance, reduce risk, and enhance cost efficiency, [3] develop ISIM and science instrument cost and schedule estimates, and [4] develop ISIM and SI performance and interface requirements.

In the performance of [1], each ISIM design supports the same set of strawman science instruments that are designed to satisfy the baseline NGST instrument requirements[4]:

- 0.6-5 μm camera, 16 sq arc-min FOV, Nyquist sampled at 2 μm
- 1-5 μm multi-object spectrometer (MOS), 9 sq arc-min FOV, >100 simultaneous source spectra, $\lambda/\Delta\lambda = 100$ & 1000
- 5-28 μm camera/spectrometer, 4 sq arc-min FOV, Nyquist sampled at 10 μm, single slit spectroscopy at $\lambda/\Delta\lambda = 1500$

The design of these strawman SIs and the ISIM for each observatory architecture is being developed with sufficient engineering detail to: enable both grass-roots and Integration and Test (I&T) plan-based costing and enable determination of ISIM and SI interface requirements and technical budget targets (mass, power, etc.) in support of observatory architecture suitability assessment and development of flight instrument solicitations. This design activity also includes the command and data handling system for the SIs.

The SSM will contain two separate computer systems for operation of the spacecraft/OTA and its ISIM payload. In order to minimize development and operations costs, it is planned that both systems will utilize RAD 750 processors developed by the JPL X2000 program[5] and a common software environment.



It is planned that each SI will share this computer system for control of all instrument functions. It is expected that the SI developers will provide instrument control software objects that will reside on this system as well as PCI hardware interface cards for control of unique mechanisms.

3. Instrument Technology Development

Several instrument technology development projects were started during the Yardstick ISIM study program. These projects focused on risk and challenge assessment of the Yardstick science instruments[6], and provided a basis for cost and schedule estimates. The focus areas included detectors[7], MOS aperture control[8], and tunable near-infrared filters[9].

3.1 Detectors

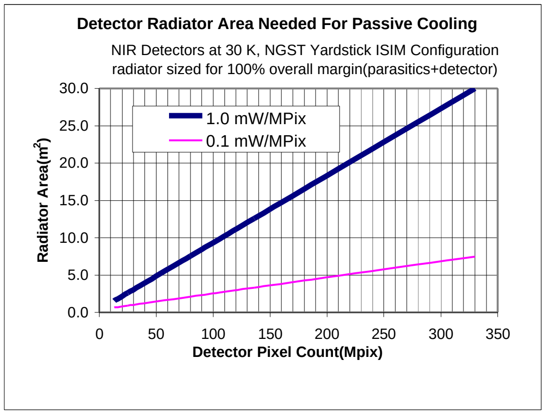
The Yardstick science instruments present a detector technology challenge with respect to the number of detectors that are required to enable the wide FOV observations described in the DRM and the noise level required to yield background limited sensitivity. The above near-infrared instruments together require five 16 Mpixel focal plane arrays (FPA), and the mid-infrared instrument requires a 1 Mpixel FPA (a 1000 and 16 fold increase over the SIRTF[10] near- and mid-infrared detector complement respectively).

In addition to manufacturing, packaging, test, and verification challenges associated with this FPA format scale up, a 5 fold reduction in near-infrared read noise and a 10 fold reduction in dark current relative to SIRTF detector performance is required to meet NGST goals.

	T (K)	QE	Read Noise (e-) multiple	Dark Current (e-/s)
SIRTF InSb	15	0.9	7	0.1
NIR goal	30	>0.9	<1.5	<0.01
SIRTF Si:As	6	0.6	10	<1
MIR goal	8	>0.8	<9	<0.1

Candidate detector technology options for the 0.6 – 5 μm wavelength range include InSb and HgCdTe. Si:As IBC detectors have been baselined for the 5 –28 μm region. It is planned that during FY03, NASA will issue a detector solicitation in support of all of the SIs -- after selection of the instruments themselves.

It is planned that cooling for the near-infrared instruments and detectors will be provided by thermal radiators. Approximately 8 m^2 of radiator area is necessary to provide 30 K cooling for the baseline near-infrared detector complement (84 Mpixels). The mid-infrared instrument requires additional cooling of the post-filter optics (18-20 K) and the detector (6-8 K). This additional cooling will be provided by a cryo-cooler or a solid hydrogen cryostat to be selected by the Advanced Cryo-Cooler System Demonstrator program during early FY02.



3.2 MEMS MOS Aperture Control

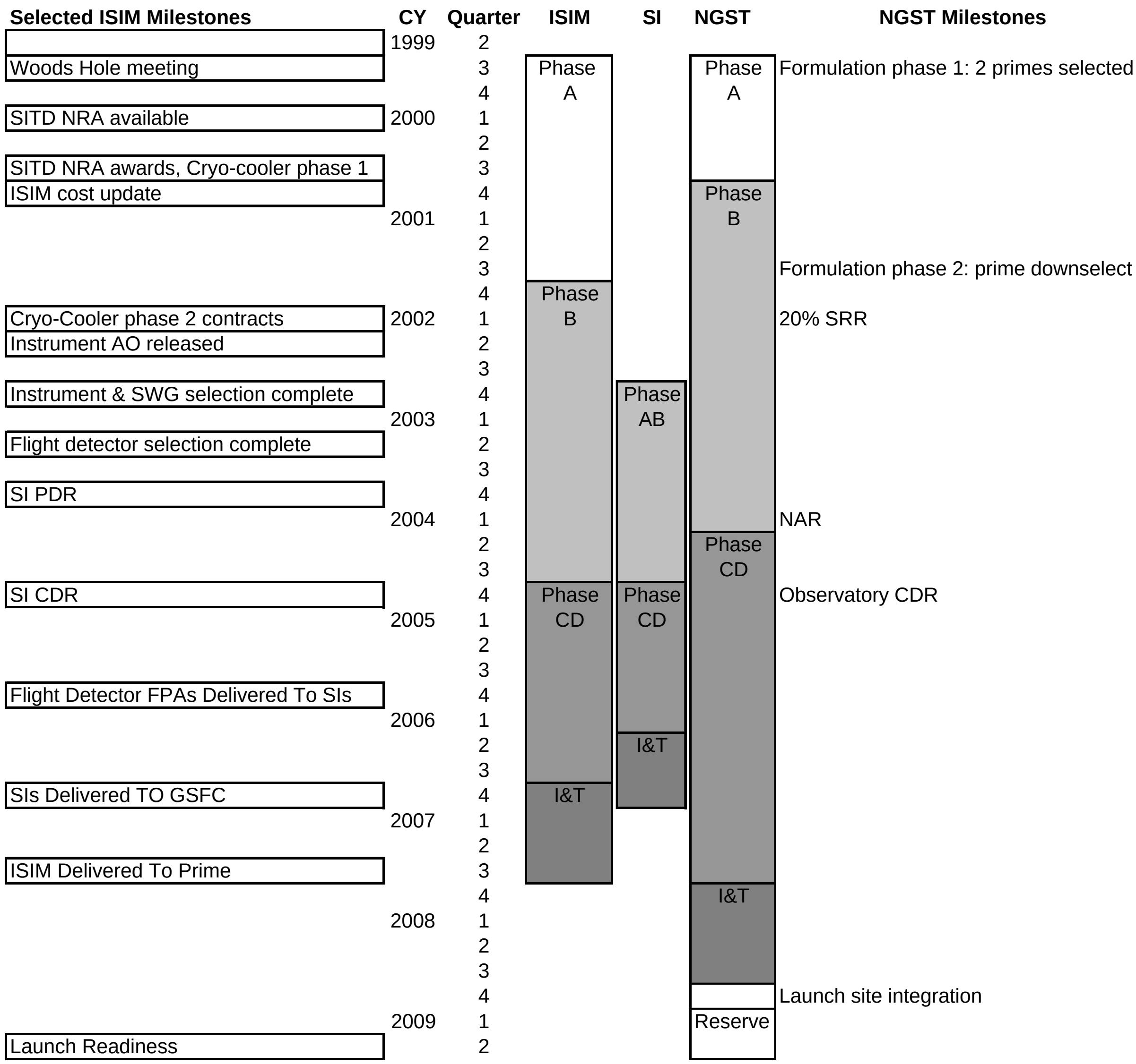
The baseline near-infrared MOS spectrometer presents a technology challenge in that traditional ground-based techniques for sparse target wide-field multi-object slit configuration such as punch plates and robotically deployed fibers are poorly suited to implementation in a cryogenic space flight environment. Integral field techniques such as image slicers and lenslet arrays necessitate a prohibitively large detector complement in order to target compact sparsely distributed sources over the required FOV at the required spectral and spatial resolution. As a consequence, alternative methods involving Micro-Electro-Mechanical Systems (MEMS) technology were investigated.

In the MEMS approach, arrays of reflective or transmissive slits (micro-mirrors or micro-shutters) are produced in large format arrays to yield a user programmable aperture mask for integration with a conventional dispersive spectrometer. Three development efforts were conducted in parallel and each yielded functional prototype devices designed to meet NGST requirments[11, 12, 13, 14]. Further development will be conducted through the NGST Science Instrument Technology Development (SITD) program. It is planned that the SITD program will support development of enabling technologies for NGST flight instruments during FY01-03. Development beyond FY03 will be conducted through the flight instrument development projects.

4. The Road Ahead

Science instruments provided by the US community will be solicited via a NASA Announcement of Opportunity (AO) during early 2002 shortly after the NGST Science Requirements Review (SRR). Instruments provided by the European and Canadian communities will be solicited by ESA and CSA via an analogous process. It is anticipated that NASA, ESA, and CSA will enable international participation on these SI development teams. It is planned that the flight Science Working Group for the NGST will also be solicited during 2002 by an international competitive process.

Selection of the flight SI teams marks the beginning of a 24 month phase A/B SI development period. A SI preliminary design review (PDR) is scheduled at the mid-point of this formulation period. The SI level PDR is scheduled to occur shortly before the NGST non-advocate review (NAR). It is expected that all SI enabling technologies will be at Technology Readiness Level 6 at this point[15] (late FY03). A SI critical design review (CDR) is scheduled for late 2004 and marks the onset of a 24 month SI phase C/D implementation period. Fully qualified flight instruments will be delivered to GSFC during late 2006. A twelve month ISIM level I&T period will precede delivery of the ISIM to the prime contractor for observatory level I&T. NGST is expected to reach launch readiness during mid-2009.



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