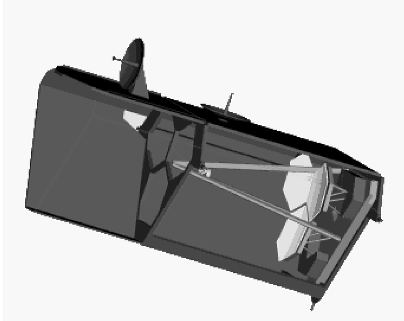
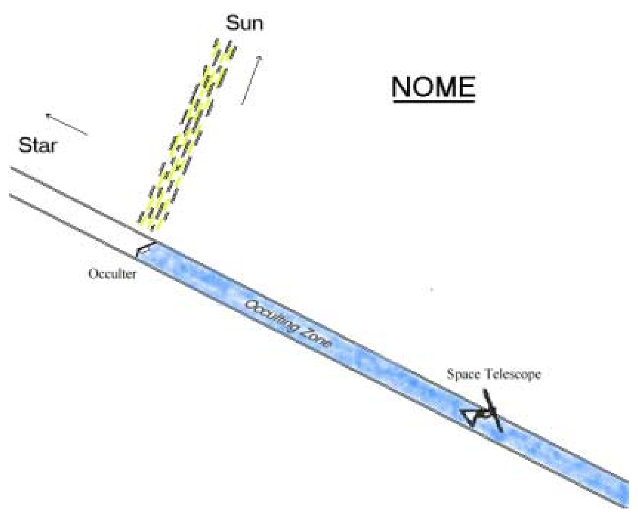
# Modifying L2 Missions into Occulters for NGST



Above is an engineering diagram of the cancelled Nexus spacecraft showing telescope elements. Nexus is used, in this poster, as a model for how to augment a spacecraft with occulting capabilities.

In this study, the Nexus design was used as a testbed to which an occulter payload was added. The Nexus Occultation Mission Extension (NOME) features a group of light-weight 'screenlets' which deploy into an opaque 'Paleolithic' occulting screen (external coronagraph) for use with NGST. Shown at right are NOME (the occulter), NGST (the telescope), and the relative directions to the Sun and a target star. NOME is also provided with onboard propulsion, enabling it to be repositioned for observing multiple targets. No substantial changes to NGST hardware are required for such a mission.





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Publication of the work supporting the results in this 198th AAS poster is forthcoming, and will be found at the UMBRAS website: http://www.stsci.edu/~jordan/umbras/. Contact the authors for additional information: *jordan@stsci.edu, kochte@stsci.edu, schultz@stsci.edu, hart@pha.jhu.edu*


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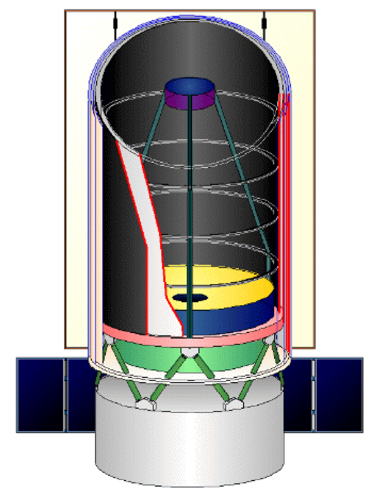
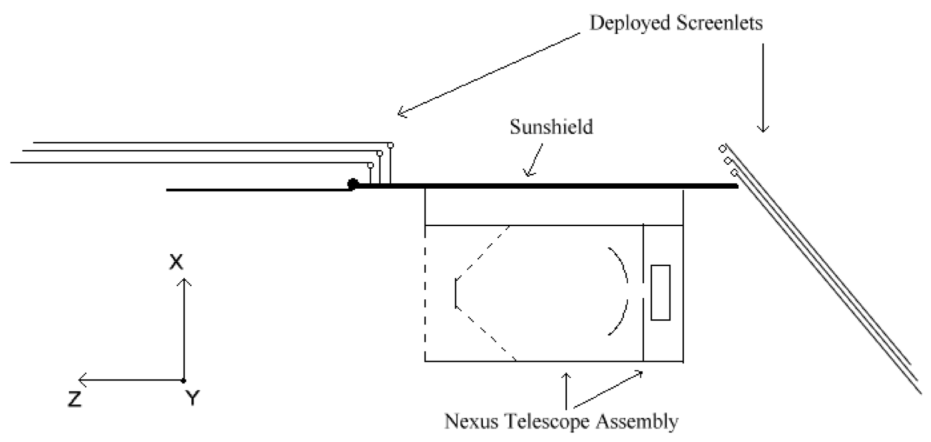
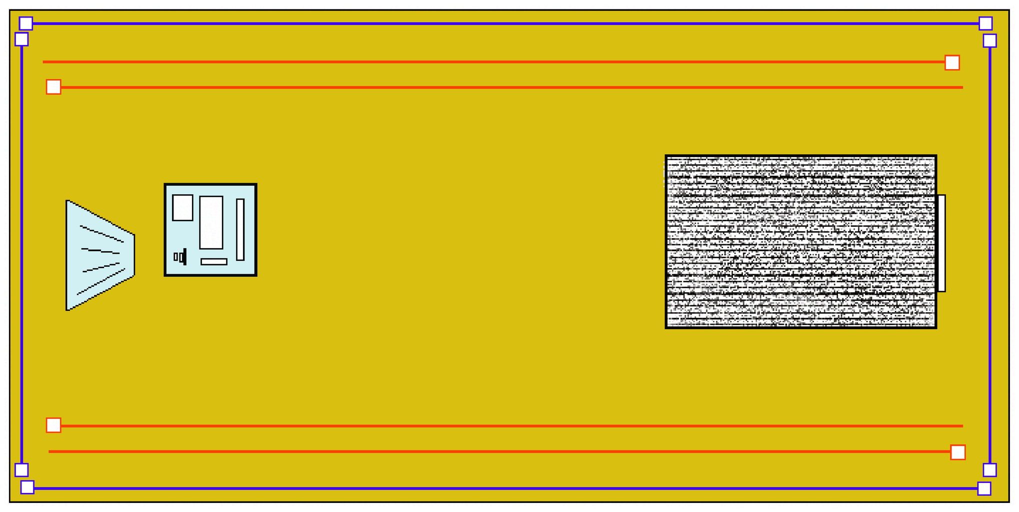


Above is an engineering artist rendition of the proposed ISAS (Japanese) HII-L2 4-metre infrared space telescope. The HII-L2 could be modified into an occulter for use with NGST in a manner similar to how we outline doing so for Nexus. HII-L2 could serve as an occulter for NGST after its prime mission is complete.

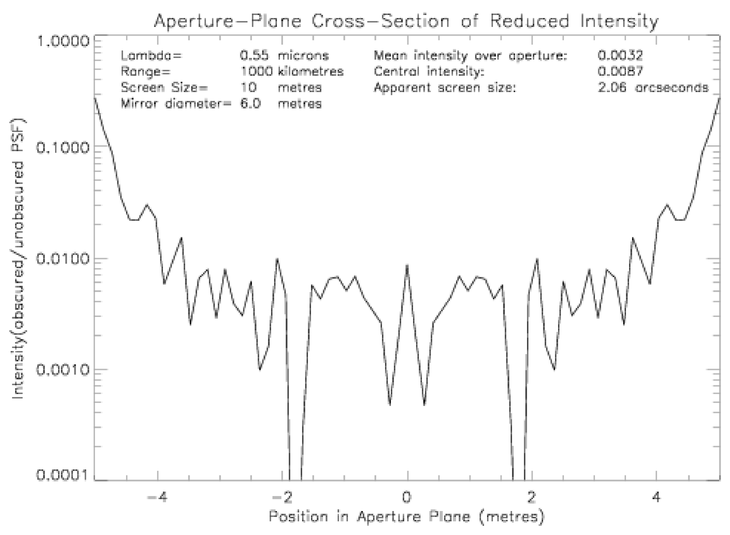

**Abstract:** The Next Generation Space Telescope (NGST) has a goal to study the formation of stars and planets. The current slate of NGST instruments does not provide coronagraphic imaging capability. One possible approach to enable NGST to image circumstellar disks and extrasolar planets is to use a self-propelled occulter. Such an approach requires a second spacecraft and modest additional cost. Results of a design study for a minimal occulter using an existing or proposed L2 mission are presented here. As a test case, we explore the possibility of using the Nexus spacecraft as a fully controlled occulter craft upon completion of its prime mission.

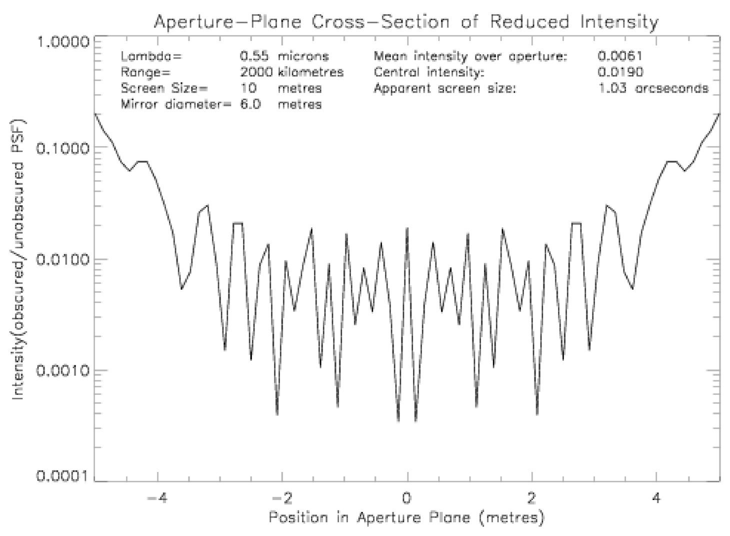



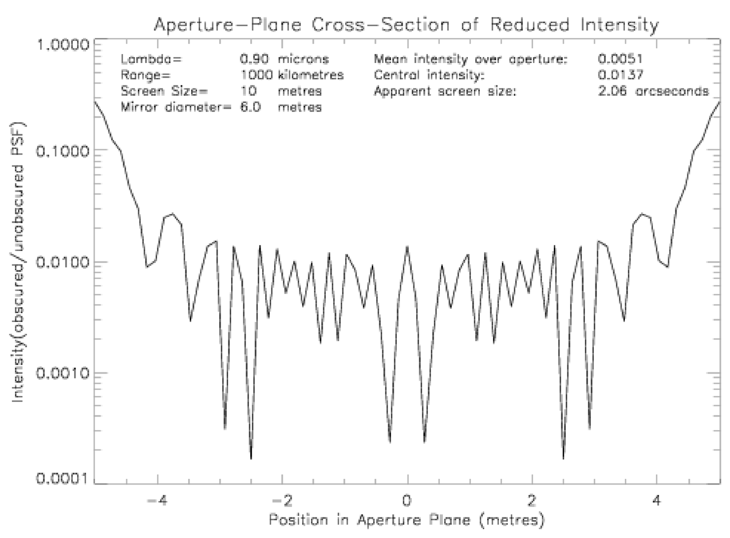

Above is a 'side' view of the Nexus/NOME spacecraft with the screenlets deployed in the + and - Z directions (the +/- Y screenlets would deploy directly into and out of this poster, causing no end of consternation to our neighbor behind us). The body-fixed Y-screenlets, the solar array, and the RIT-10 ion engine are not shown for clarity.



Above are shown the occulting payload elements mounted on the sunward-side of the Nexus sunshield (in gold). On the left-center are the RIT-10 ion thruster and plume shield (silvery-blue). To the right-center is the solar array panel. The 8 screenlets are shown in their stowed configurations, indicated by the red and blue lines/boxes.




The performance of the occulter with NGST is a critical consideration in the mission design. In order to extract unique science using the occulter, we must ensure that its performance exceeds that of existing stellar coronagraphs. The NOME design would allow examination of a region as close as 0.5" to a star, suppressing the total light from the star by at least 5 astronomical magnitudes (100x).

At left are 3 cross-sections showing the relative intensity of star light in the aperture plane centered on the star-occulter optical axis. Note that the intensity fluctuates across the aperture and is a product of the diffraction pattern produced by the occulting screen. Upper and center figures are V-band simulations for occulter distances of 1000 and 2000 kilometres from the telescope. The lower figure is I-band at 1000 kilometres range.

With the original 8-metre NGST mirror, little drift and positioning tolerance (~ 10 cm) of the occulter across the telescope-star line-of-sight is allowed. For proposed smaller diameter mirrors, requirements on initial positioning of the occulter (~60 cm for a 7-metre mirror, and ~1.1 metres for a 6-metre mirror) are not as stringent and are more easily met.

**Occulter Performance at 1000 km Range**

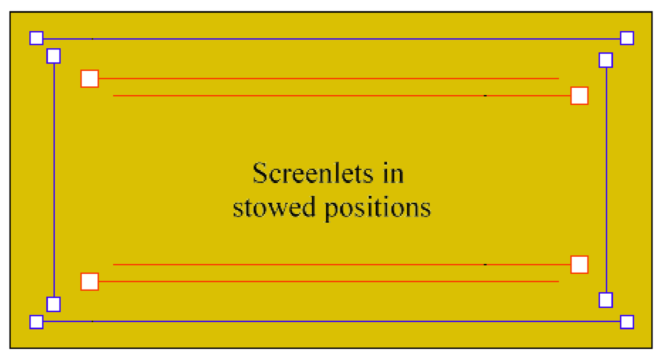
| | 6 metre | 7 metre | 8 metre |
|---|---|---|---|
| V-band | 0.32% | 0.37% | 0.46% |
| R-band | 0.42% | 0.50% | 0.64% |
| I-band | 0.51% | 0.60% | 0.75% |

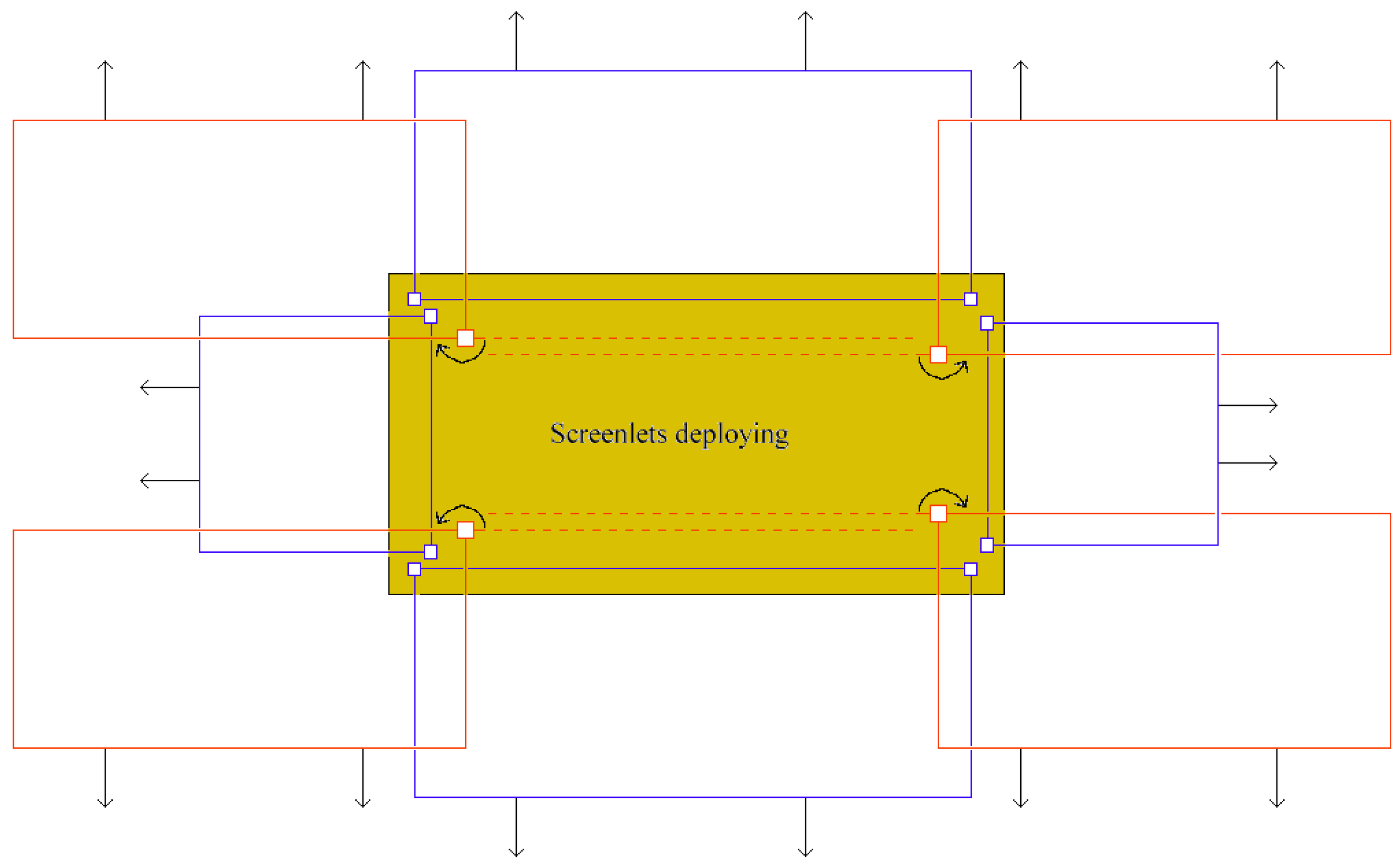
**Occulter Performance at 2000 km Range**

| | 6 metre | 7 metre | 8 metre |
|---|---|---|---|
| V-band | 0.61% | 0.73% | 0.92% |
| R-band | 0.83% | 0.94% | 1.27% |
| I-band | 1.02% | 1.18% | 1.49% |

The above two tables show the relative performance of the NOME occulter in 3 wavelengths (V-, R-, I-band) at 2 telescope-occulter ranges (1000 & 2000 km) for 3 different mirror sizes (6, 7, and 8 metres). The values in the tables are the relative intensities of the occulted starlight to that of the unocculted star averaged across the aperture.

The diagrams below and to the right illustrate the screenlets in both the stowed (left diagram) and the deploying (right diagram) configurations.

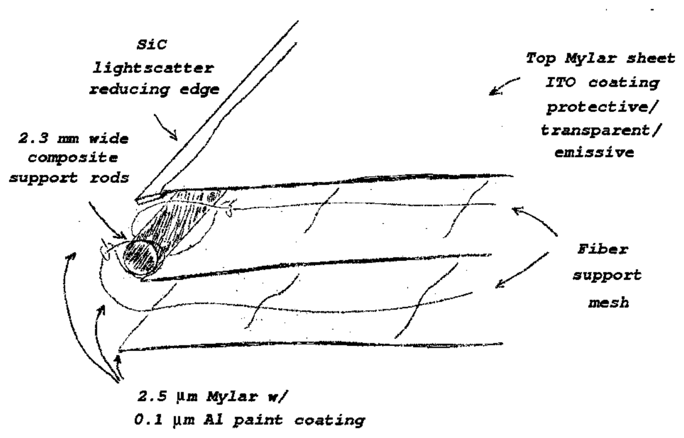



The screenlets indicated in red articulate by rotating out to the left or right. Those in blue are fixed on the sunshield, unrolling after the articulated spindles have rotated out. When fully deployed, the screenlets overlap as shown, forming an extended rectangular occulting screen of dimensions approximately 10 metres by 14 metres. Solar array and propulsion systems are not shown for clarity.

In order to adapt a spacecraft designed for other purposes into an occulter, *without interfering with the prime mission*, specific requirements must be met. The NOME study identified requirements and needed modifications which, combined, entail only a modest cost. For modifying nearly any L2 mission, these are:

- **Do not degrade/interfere with the host spacecraft's prime mission!**
- Screen
- Propulsion (& fuel)
- Translation capability (& fuel)
- Enhanced power production
- Inter-spacecraft communications (low-gain)
- Inter-spacecraft drift accommodations
- Meet minimum occultation science requirements




Each screenlet is composed of 3 layers of aluminized Mylar and is supported by thin composite rods. Loads on the deployed screenlets are taken up by a fiber support mesh between each Mylar layer. Scattered sunlight is suppressed along external screenlet edges by a thin, sharp edge.

**NOME Mass Budget Summary**

| Subsystem | Mass (kg) |
|---|---|
| Screen[a] | 12 |
| Propulsion[b] | 31 |
| Power | 20 |
| Attitude & Translation Control System[c] | 8 |
| Nexus component redundancy/upgrades | 20 |
| Margin (20%) | 19 |
| **Total[d]** | **110** |

a. Includes all screen components, such as screenlets, spindles, motors, mounts, and mesh support.
b. Includes the de-rated RIT-10 Ion Engine, Power Control Unit (PCU), compressed gaseous Xenon propellant & tank, and wiring.
c. Includes extra nozzles, tankage, and hydrazine (station-keeping propellant)
d. This represents less than 13% of the approximate 900 kg Nexus spacecraft mass.

To the left is an artist rendition of the proposed ESA FIRST far infrared space telescope. The occulter payload scheme we outline in this poster could be readily adapted for FIRST to carry to the L2 point.

**Mission Design (NOME):**

- 1-year mission
- 15 targets, 2 visits per target
- 1000-2000 km range (telescope-occulter)
- 10m x 14m occulting screen (effective 10m x 10m)
- 5+ magnitudes starlight suppression
- 1.0" - 2.0" apparent mask (occulter) size
- Up to 1000 seconds integration times

To the right is an artist's conception of the ESA Planck spacecraft. It could also be modified to be an occulter for NGST. A somewhat different screen design would need to be implemented to accommodate the circular sunshield.