Preliminary jitter stability results for the large UV/optical/infrared (LUVOIR) surveyor concept using a non-contact vibration isolation and precision pointing system

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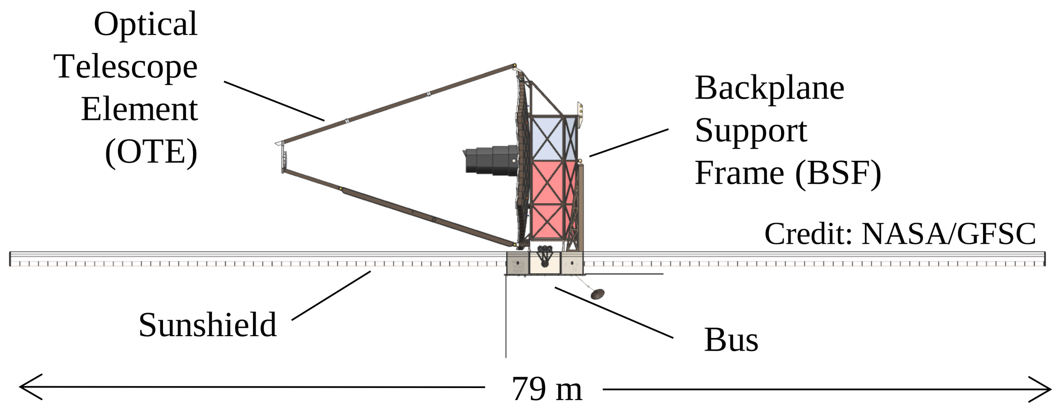
MISSION CONCEPT

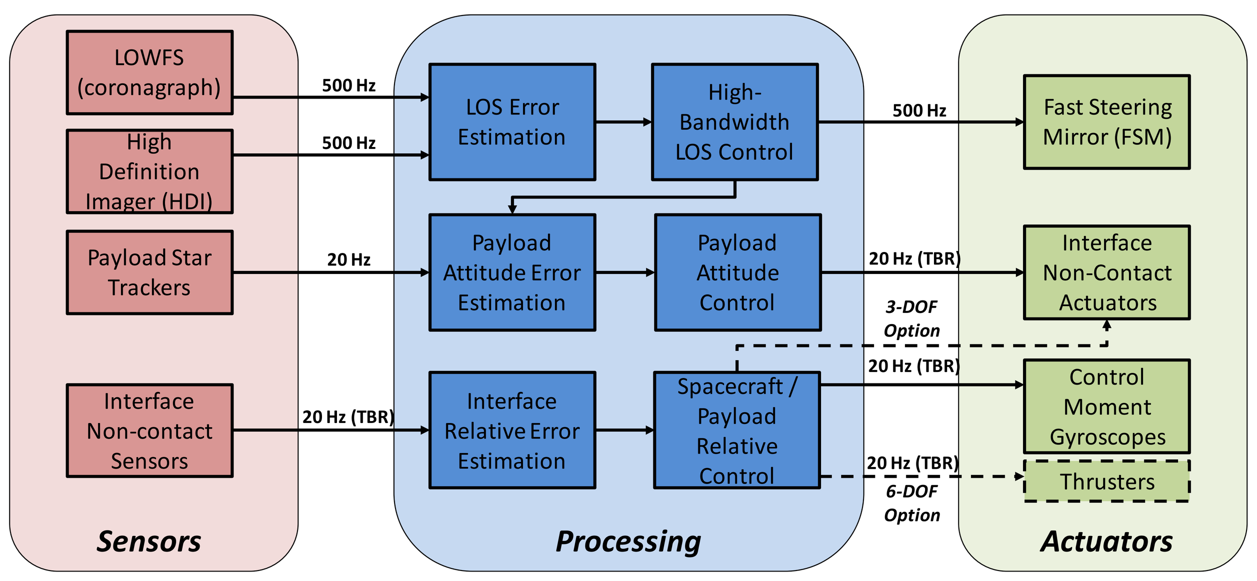
The Large / UltraViolet / Optical / InfraRed (LUVOIR) Surveyor is a concept mission for a large multi-wavelength serviceable observatory with ambitious design and science goals to enable advances across a broad range of astrophysics[1]. The payload, which includes the telescope instruments and Backplane Support Frame (BSF), is separated from the spacecraft, which includes the spacecraft bus, sun shield, and tower up to the 2-DOF gimbal, by a non-contact interface called the Vibration Isolation and Precision Pointing System (VIPPS).



VIPPS

The VIPPS being designed for LUOVIR is an isolation architecture that involves no mechanical contact between the telescope and host spacecraft structure. Lockheed Martin has developed and patented a Disturbance Free Payload (DFP) non-contact architecture from with the VIPPS is derived[2]. This design allows for requirements on the spacecraft structural dynamics and actuator disturbances (arising from reaction wheel or CMG induced vibration) can be similar to current controller designs that exists while still achieving the tight requirements on the observatory.

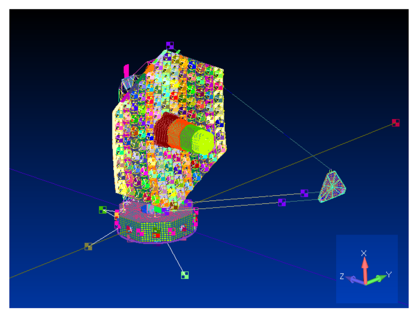
CONTROL ARCHITECTURE

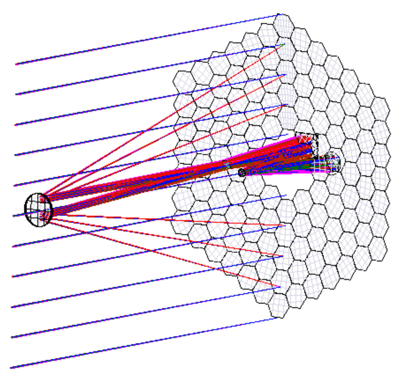


The multi-loop architecture takes advantage of the VIPPS non-contact interface to achieve the pointing accuracy and stability required by the mission.

INTEGRATED MODEL

Finite Element Model (FEM): A free dynamics analysis was run up to 200Hz for a total of 4373 modes. Motions were recovered for 125 optical nodes, 4 attitude control nodes, and 2 isolation system nodes.



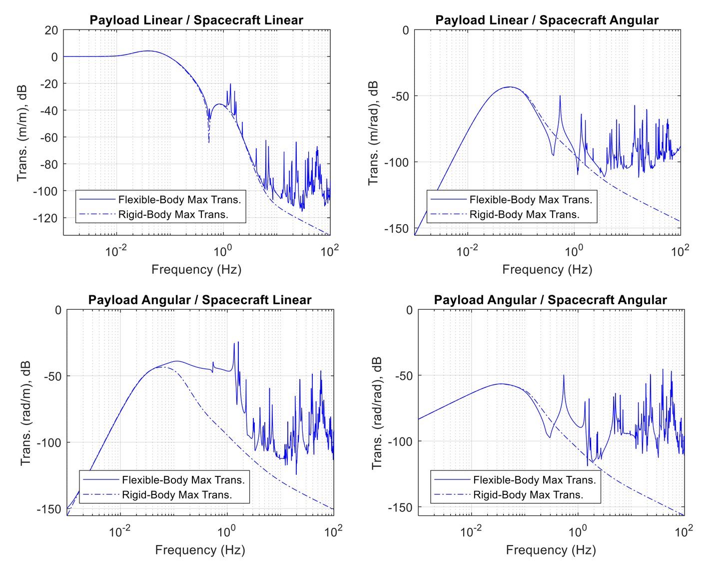


Linear Optical Model (LOM): Matrix of optical sensitivity data derived from the Optical model. For the 6DOF mirror motions or alignment modes, the change in wavefront and line of sight is recorded.

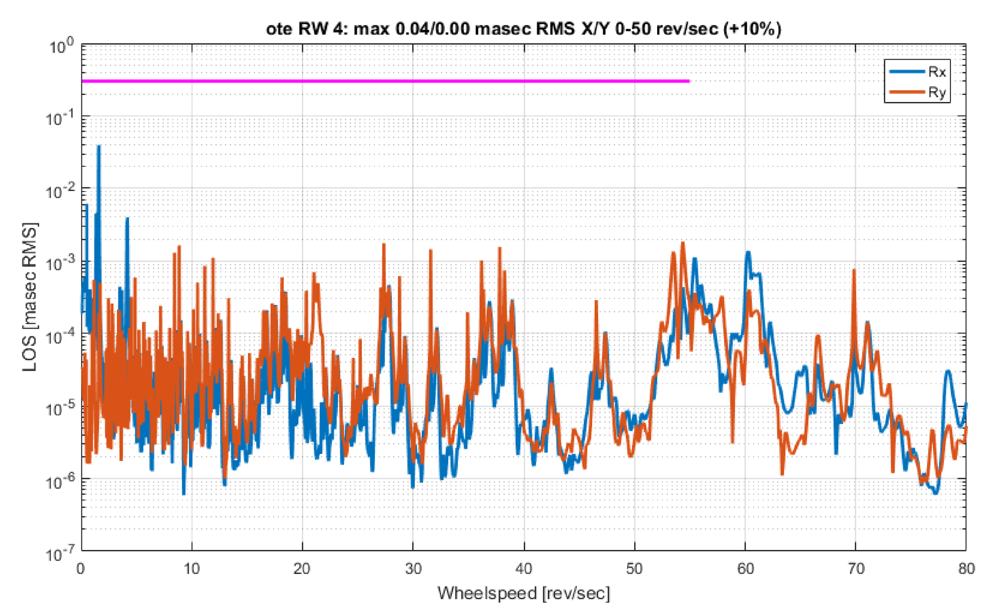
Reaction Wheel Disturbance Model: The attitude control devices used for this analysis were four Honeywell HR14-75 reaction wheels. The wheels have a torque capacity of 0.14 Nm and a maximum momentum storage of 75 Nms. LUVOIR attitude control is being explored with reaction wheels and control moment gyroscopes.

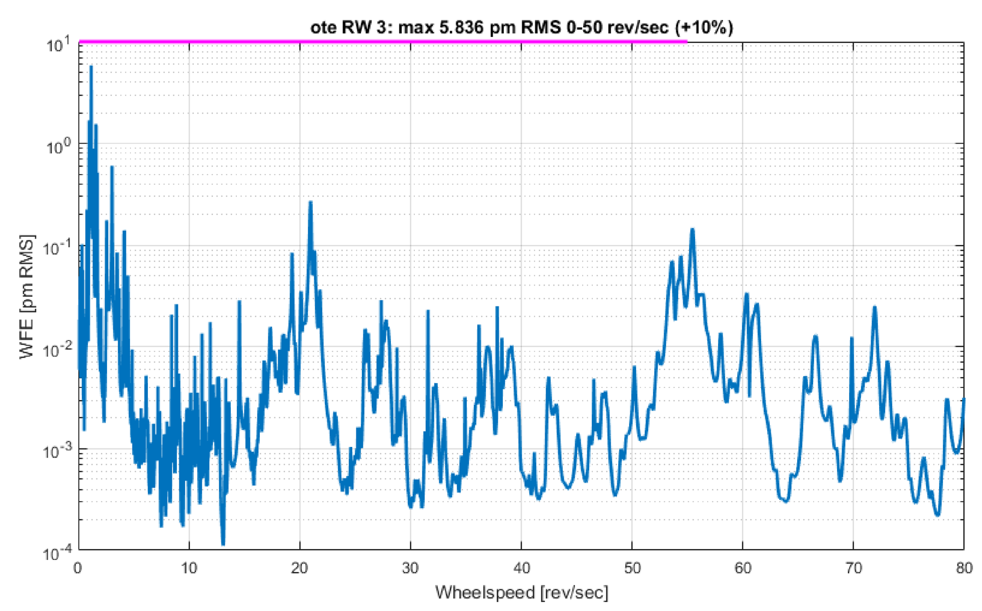
VIPPS Mechanical and Controls Model: The VIPPS model includes conservative interface cable stiffness and damping based on the James Webb Space Telescope (JWST). LUVOIR is expected to have fewer physical power and data cables that bridge the interface and with a higher interface temperature the cable model is expected to have a lower stiffness. VIPPS control parameters were chosen based on a LUVOIR agility study using non-contact vibration isolation[3].

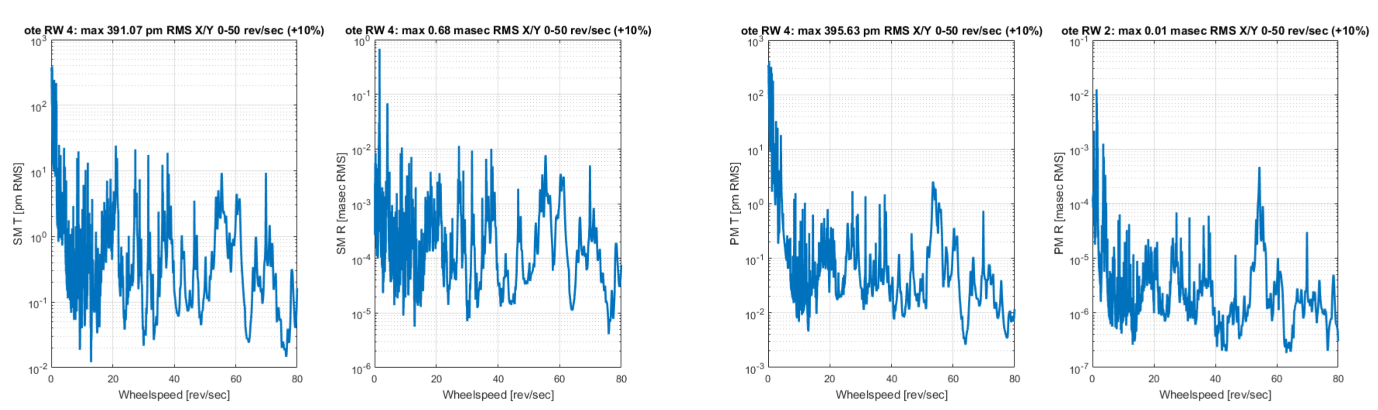
Model Transmissibility: A transmissibility matrix can be formed from the closed-loop dynamics for the payload and spacecraft. Linear trans. shows unity at low frequencies and angular trans. broadband isolation, with a peak angular transmissibility of -45 dB and increasing isolation at low frequency



RESULTS







	Req	CBE
Line-of-Sight Rx RMS Error	0.3 masec	0.04 masec
Line-of-Sight Ry RMS Error	0.3 masec	<0.01 masec
Wavefront Error	10 pm	5.8 pm
Secondary Mirror Translation RMS	--	390 pm
Secondary Mirror Rotation RMS	--	0.68 masec
Primary Mirror Translation RMS	--	396 pm
Primary Mirror Rotation RMS	--	0.01 masec

The results from the integrated model analysis show the reaction wheels perturb the system to acceptable levels over all wheel speeds. The motions of the secondary mirror are expected to contribute to LOS jitter errors and are also shown in the plots. The mirror motions are absolute rigid-body displacements and rotations relative to the undisturbed node locations.

REFERENCES

1. National Aeronautics and Space Administration, Goddard Space Flight Center, "Large UV/Optical/Infrared Surveyor", https://asd.gsfc.nasa.gov/luvoir/.
2. Dewell, L. et al, "Dynamic Stability with the Disturbance-Free Payload Architecture as Applied to the Large UV/Optical/Infrared (LUVOIR) Mission," Proc. SPIE 10398 (2017).
3. Tajdaran, K. et al, "Telescope line-of-sight slew control and agility with non-contact vibration isolation for the large ultraviolet/optical/infrared (LUVOIR) surveyor concept", Proc. SPIE 10698-137 (2018).