HabEx Optical Telescope Technology Working Group

K-T Matrix Questions

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Purpose

STDT has asked the Telescope Technology Working Group a series of questions to assess K-T Matrix Architectures.

A) Key Questions for assessing K-T Matrix Architectures
- What are the packaging/fairing options for a 4m on-axis vs off-axis?
- What are the packaging/fairing options for a 6.5m on-axis vs off-axis?
- Does a deployable segmented telescope have to be on-axis?
- UV coating technology for large mirrors, polarization and reflectivity characteristics vs lambda
- Number of UV coated mirrors required for on-axis vs off-axis designs (assuming UV observations)
- Any minimum operating temperature requirement
- Is low order starlight based LOWFS enough when/if operating a coronagraph? or is LASER metrology required? If yes, is it limited to M2 stabilization?

B) Associated questions
- Mirror material (ULE vs Zerodur vs beryllium etc)
- TRL level of different primary mirror options?

Question 1

What are packaging/fairing options for a 4m on-axis vs off-axis?

Findings:

1. Either an on-axis/obscured or off-axis/unobscured 4-m monolithic primary mirror requires an 8.4-m SLS fairing. Neither can be packaged into a 5-m EELV fairing.
2. The largest potential on-axis/obscured monolithic aperture that can be packaged in a 5-m EELV fairing is 3.8-m (per THEIA proposal). The largest proven on-axis/obscured monolithic aperture is 3.5-m (per Herschel).
3. The largest potential off-axis/unobscured monolithic aperture that can be packaged in a 5-m faring is 2.4-m (per Exo-C Extended study).

Question 2

What are packaging/fairing options for 6.5m on-axis vs off-axis?

Findings:

1. Either an on-axis/obscured or off-axis/unobscured 6.5-m monolithic primary mirror requires an 8.4-m SLS fairing.
2. Either an on-axis/obscured or off-axis/unobscured 6.5-m segmented primary mirror may be packaged in a 5-m fairing. But, design work is required to determine if the mirror support structure stiffness (constrained by the fairing volume) will be sufficient for a UVOIR telescope.

Question 3

Does a deployable segmented telescope have to be on-axis?

Finding:

1. No

Question 4

UV coating technology for large mirrors, polarization and reflectivity characteristics vs lambda?

Findings:

1. There should be no discriminator between candidate telescope architectures based on UV coating technology.
2. But, there may be unknown implementation differences between the candidate coating processes at the 1.5m and 4m scale.
3. Based on current understanding of the candidate mirror coating processes and how these processes scale-up, it is not possible to state whether better system-level coating performance would be achieved from a single 4m class monolithic mirror or from a 6.5-m class segmented aperture telescope composed of multiple 1.5m mirrors.

Question 5

Number of UV coated mirrors required for on-axis vs off-axis designs (assuming UV observations)?

Findings:

1. There is no difference in the number of UV coated mirrors before a UV instrument as a function of telescope architecture, including: on- versus off-axis, monolithic versus segmented, 4-m versus 6.5-m diameter, assuming segmented primary as one mirror.

Question 6

Any minimum operating temperature requirement?

Findings

1. If HabEx is to operate in the UV, it must avoid molecular and particulate contamination on its UV coated mirrors to maintain throughput and minimize scattering. This requirement is independent of aperture size and of whether HabEx is on-axis or off-axis telescope.
2. Per Dr. Scowen's concurrence with LUVOIR Tech Note https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20160011356.pdf, the minimum operating temperature for UV is 258K.
3. If for other reasons, it is necessary to operate HabEx below 258K, it may be necessary to anneal deposited contaminants off of the UV coated optical components. Based on HST experience (www.stsci.edu/instruments/wfpc2/Wfpc2_isr/wfpc2-status.ps), this requires an operating temperature of 300K

Question 7

Is low order starlight based LOWFS enough when/if operating a coronagraph? Or is LASER metrology required? If yes, is it limited to M2 stabilization?

Findings:

1. This is an area of on-going analysis. It depends upon the coronagraph's wavefront stability specification.
2. Preliminary analysis indicates that Line of Sight stability specification may be harder to achieve than Wavefront stability specification.
3. Preliminary analysis indicates – assuming JWST's specified reaction wheel assembly vibration spectrum and passive vibration isolation – that the 'baseline' HabEx-4 structural design 'may' achieve the necessary stability for the HabEx F/2.5 off-axis optical design. NOTE: these tolerances become significantly harder for the F/2 and F/1.5 designs.
4. More analysis is required to determine if a LOWFS will be required.
5. More analysis is required to determine whether or not a laser metrology system will be required to sense and control secondary mirror or primary mirror rigid body alignment.
6. If the primary mirror is segmented, it is most likely that a laser metrology system will be required to align and phase the primary mirror segments.

Question 8

Mirror material (ULE vs Zerodur vs beryllium etc)?

Findings:

1. ULE or Zerodur are equally viable for either a 4-meter monolithic primary mirror (on-axis or off-axis) or a 6.5-meter segmented primary mirror (on-axis or off-axis).
2. ULE and Zerodur are the most preferred mirror materials because of their ultra-low coefficients of thermal expansion (CTE) over the expected thermal operating range (250K to 300K).
3. Beryllium is not a preferred material because of its very large CTE over the expected temperature operating range. Also, the largest mirror that can be made from Be is approximately 1.5m. And, Be is more expensive and harder to manufacture than glass.
4. Silicon Carbide has a TBD recommendation. SiC mirrors have been manufactured to dimensions as large as 3.5m (Herschel). But, similar to Be, SiC has a large CTE over the expected temperature operating range.

Question 9

TRL level of different primary mirror options?

Findings:

1. The TRL of the primary mirror is independent of whether HabEx is on-axis or off-axis.
2. The TTWG finds that the TRL of a monolithic primary mirror is higher than of a segmented primary mirror. However, there is a minority opinion that believes that segmented primary mirror is at least as mature as monolithic primary mirrors.