Partnering with Industry: Lessons Learned from the Wide Field Instrument on the Wide Field InfraRed Survey Telescope Mission

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Agenda

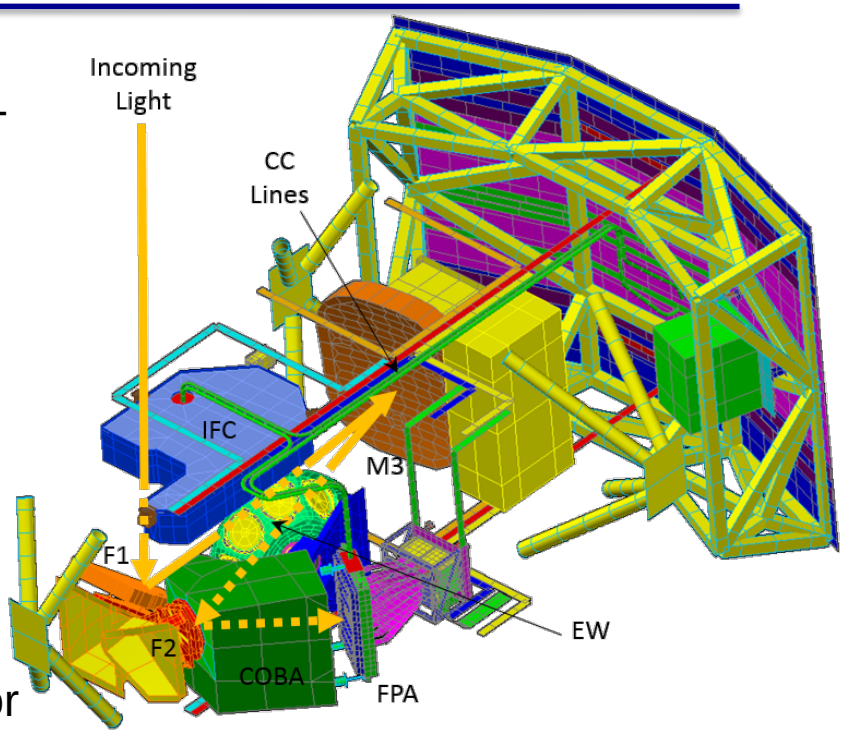
- WFIRST Mission Overview
- Wide Field Instrument (WFI) Design at Mission Concept Review (MCR)
- Introduction of WFI to Industry
  - *Industry Study 1: Familiarization with WFI*
  - *Industry Study 2: Vet Requirements*
  - *Full and Open Competition: Evaluate and Select Vendor*
- Design and Requirements Evolution throughout Procurement
- Procurement Process and Lessons Learned
  - *Drawbacks of the WFI Industry Study Approach*
  - *Benefits of the WFI Industry Study Approach*
- Current WFI Design
- Conclusion

WFIRST Mission Overview

- **Top Ranked large scale space mission in 2010 New Worlds, New Horizons Decadal Survey for Astronomy and Astrophysics**
  - *Measures Dark Energy, Exoplanet Microlensing, and the near InfraRed Sky*
- **Includes a 2.4 m *existing* telescope transferred from elsewhere in Federal Government**
- **Includes two baseline instruments supported by Instrument Carrier**
  - *Wide Field Instrument (WFI) with 2 channels*
    - IR imaging with 3x6 array of H4RG detectors for a field of view (FOV) more than 100x Hubble's Wide Field Camera 3 Instrument
    - Integrating Field Channel using a slicer and spectrograph to provide individual spectra of each slice
  - *CoronaGraph Instrument (CGI)*
    - Imaging and spectroscopic modes to image exoplanets and debris discs around nearby stars

WFI MCR Design

- WFIRST MCR held in December 2015
- WFI is the primary science instrument for WFIRST
- It includes 2 science channels:
  - *WFC: Wide Field Channel*
  - *IFC: Integral Field Channel*
- For the WFC, incoming light reflects off a fold mirror, to a tertiary mirror, through an element wheel, to an adjustable fold mirror, and to the Focal Plane Assembly (a 3x6 array of H4RGs)
  - *The primary and secondary telescope mirrors, along with the tertiary mirror, form a three mirror anastigmat*
- The WFC channel has an Element Wheel (EW) with 6 filters for imaging, a grism (grating-prism) for spectroscopy, and a blank for calibration
- A Cold Optics Baffle Assembly (COBA) surrounds the light after the EW and provides a cold scene for the detectors
- The WFC FPA is actively cooled using a cryocooler
- The IFC is a self contained unit for spectroscopic measurements using a slicer with a smaller FOV. Its FPA is also cooled by the cryocooler.



- WFI is also responsible for providing Fine Guiding data to the observatory
  - *WFIRST operates in a Slew-Acquire-Settle-Observe repeating cycle*
  - *Data from the WFC FPA is used to locate guide stars in each of the 18 H4RGs using narrowing windowing*

Shortly after MCR, the project was directed to more substantially involve industry

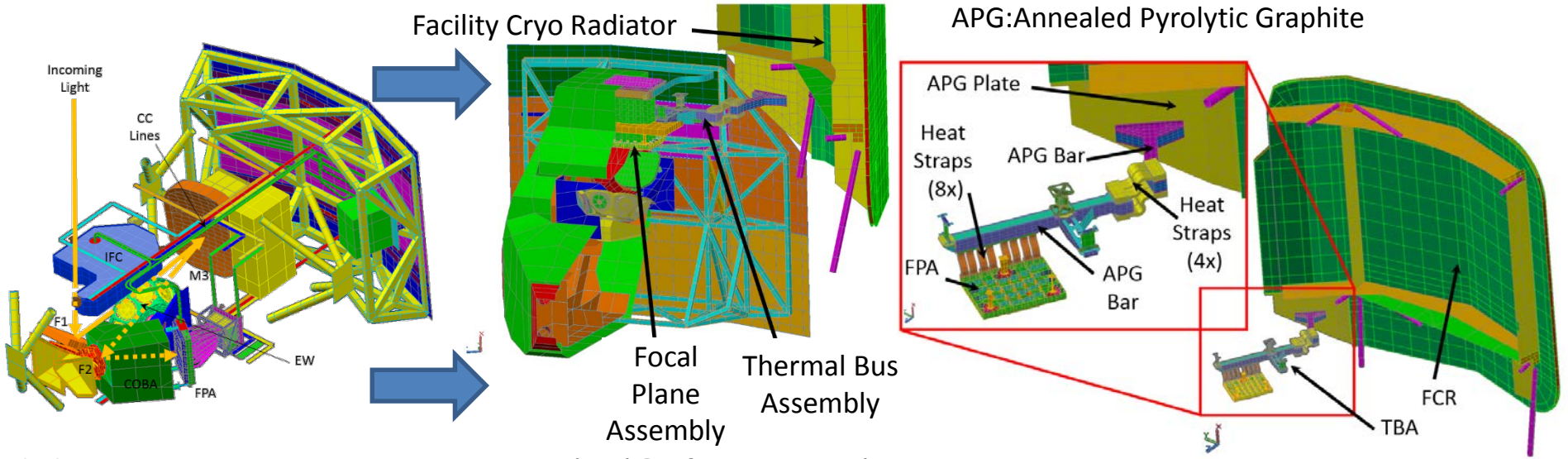
WFI Introduction to Industry

- **With the move from an in-house design to an out-of-house procurement, and the decision coming fairly late in the project life cycle, a 3 step process was envisioned**
  - *First study: 4 months (Request for Proposal (RFP): Jan 2016, Contract Signed: March 2016, Report Due: July 2016). Meet with potential industry partners and present the current MCR design and driving requirements. Result of study is a report documenting their expected cost, schedule, and facilities needed to implement the MCR design:* ***Purpose: reduce learning curve to familiarize potential partners with WFIRST and WFI***
  - *Second study: 6 months, (RFP: August 2016, Contract Signed: November 2016, Report Due: May 2017). Potential industry partners provided with requirements document and requested to provide a report with their own design and the expected cost, schedule, and facilities needed to implement their design.* ***Purpose: vet the requirements document prior to releasing the RFP for a full and open competitive procurement***
  - *Full Competitive Procurement: (RFP: September 2017, Proposals Due: October 2017, Contract Awarded: May 2018). Short duration between RFP and Proposal Due Date enabled by industry studies. Unlikely that vendors who had not participated in studies would have had sufficient time to derive design and determine cost and schedule for implementation in a month.*
- **Total time from first industry study RFP to award of contract was just over 2 years**
  - *Approach had both benefits and drawbacks*

But during this time, the WFI design and requirements were not static…

Design and Requirements Evolution Throughout Procurement

Design Change	Impact on Thermal
Re-layout of Optical design to move tertiary mirror out of WFI optical layout	Allow passive option to be investigated, change in optical bench shape, significant thermal gradient introduced on optics in Element Wheel
Change from active cryocooler to passive radiator for detector cooling	Reduction in instrument power (no cryocooler), increase in radiator size Facility Cryo Radiator (FCR)
Focal Plane Electronics avionics moved from warm spacecraft module to cold instrument module	New radiator needed, isolation needed
Removal of Auxiliary Guider	Removal of cooling need for Auxiliary Guider detectors
Change from Frame to Strongback and Flexures to support MOSAIC plate	Better thermal isolation possible
Introduction of additional cooling requirement on cold optics baffle assembly	Addition of new thermal zone (new radiator and heatpipes). This was enabled by the new optical layout
Change Detector Readout speed	Increased Sensor Chip Electronics power
Lowered Detector Operating Temperature by 5K	Increased parasitics, additional cooling needed
IFC Descoped	Reduced cooling needs
Increase number of elements in Element Wheel	None



Design and Requirements Evolution Throughout Procurement

Event	Vendor	GSFC
Mission Concept Review	Dec 2015	
Study 1 RFP	Jan 2016	
Key Decision Point A		Feb 2016
Study 1 Contract	Mar 2016	
Relocate Focal Plane Electronics to Cold Module		Mar 2016
Introduction of additional cooling requirement on cold optics baffle assembly		May 2016
Change from Frame to Strongback and Flexures to support MOSAIC plate		May 2016
Change Detector Readout Speed		June 2016
Study 1 Report Deliverable	July 2016	
Re-Layout of Optical Design		July 2016
Study 2 RFP	Aug 2016	
Change to Passive Cooling		Oct 2016
Study 2 Contract	Nov 2016	
Study 2 Report Deliverable	May 2017	
Competitive Procurement RFP	Sep 2017	
Proposals Due	Oct 2017	
Lowered Detector Operating Temperature by 5K		Dec 2017
Thermal Engineering Peer Review		Dec 2017
IFC Descoped		Apr 2018
Key Decision Point B		May 2018
Award	May 2018	
WFI System Requirements Review (SRR)	August 2018	

Drawbacks of Procurement Approach

- **The staffing in place for WFI did not increase due to the redirection to involve industry. The same people who were evolving the instrument through the many design changes after MCR were also the same people traveling to and interfacing with potential vendors. The workload for updating the design alone was considerable; adding in the necessary travel for meeting vendors placed additional demands on the team.**

Project schedules and staffing plans that are not adjusted after a major procurement change approach can place considerable strain on project teams with the additional, unplanned workload.

- **As the WFI team became more familiar with potential vendors designs, approaches, and ideas, the need to firewall or safeguard vendors' competitive advantage became challenging. It was critical for the Government to ensure that vendors design features and advantages (no matter how much better than the Government's design) were protected and not introduced in any way into the Government's evolving design. Furthermore, in the deriving of requirements, the Government had to be careful to never include any vendor proprietary techniques or processes that would require recusal under Government regulations.**

Specific intellectual property of the proposers must be carefully guarded and not used to specify requirements in order for the government to maintain a neutral stance during a competitive procurement.

- **One drawback of the study approach employed for WFI was the potential for biasing the proposer's design. Having provided potential industry partners with the Government's solution to the requirements may have inadvertently biased them towards a similar design. This has the potential to hamper innovation since deviations from the provided design must be weighed against the perception that the customer may consider other designs riskier. A proposer may consider a design superior to the provided design and choose to not pursue it further due to perceptions that the customer may consider it risky because it does not closely align with the provided design.**

Providing the customers design solution to a set of requirements may hamper the innovation of the proposers' designs, since deviation from the provided design may appear risky to the customer and proposers would need to weigh that consideration.

- **Shortly after contract award to Ball Aerospace, a trade study to replace the FCR with a cryo radiator located on the instrument was performed. This trade was only made possible by other changes in the design proposed by Ball Aerospace. However, during the nearly 10 months from the RFP to the award, a communications blackout was in place. This prevented the possibility of discussing the viability of this trade for a significant period of time. With the eventual conclusion of the study that an instrument mounted cryo radiator was viable, this resulted in an effective schedule impact on the design to date.**

Long duration contractual blackout periods during the conceptual design phase may reduce the efficiency of the design cycle by delaying the implementation of industry partner's features into the overall observatory design

Benefits of Procurement Approach

- **With multiple potential vendors investigating the design and requirements, weaknesses were better able to be identified. In particular, the need for high fidelity optical simulators drove a new optical layout, which further enabled passive cooling, replacing the schedule driving cryocooler. These design changes were likely made earlier in the program than they would have been otherwise. Furthermore, with the two studies, industry vendors had the opportunity to begin optimization and refinement of their designs rather than responding to a single, heretofore unseen RFP with a less optimized and mature design.**

Having multiple organizations review preliminary requirement sets prior to a competitive procurement results in a more thoroughly vetted set of requirements for a design

Having many design iterations and trade studies completed earlier in the project life cycle reduces the potential for future scope, cost, and schedule growth if the requirements are well established and at least one design identified to meet them.

- **The decision to involve industry, coming just before the Mission Concept Review, represented a major shift from a parallel design/requirements evolution of WFI to a more focused effort on solidifying requirements for the purposes of a competitive procurement. However, with continuous design evolution occurring in parallel to meet the next Key Decision Point, significant effort was expended evolving a design that was abandoned after contract award. Earlier identification of the procurement strategy could have resulted in earlier industry involvement and less effort that was eventually abandoned.**

Decide procurement strategy as early as possible to fully engage industry earlier in the conceptual phase, shorten the overall procurement process, and maximize community support.

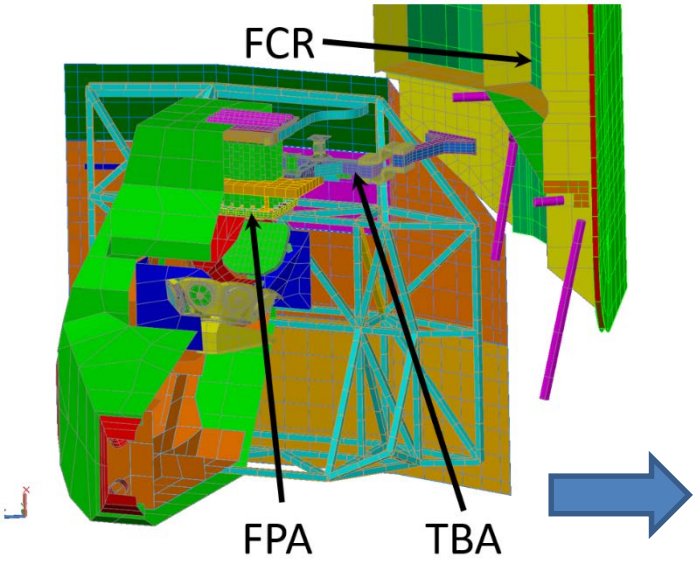
- **The second study, which focused on vetting the requirements, was particularly beneficial as it gave vendors opportunities to more deeply probe the intent behind the requirements. The informal nature of the studies allowed for more open discussions, which is more difficult to do in a competitive procurement environment where any questions asked must be shared with all proposers. Through the two studies, the approach moved from a build-to-print approach to a design-to-requirements approach, which further opened the trade space and allowed industry to bring its considerable depth and talent to the design.**

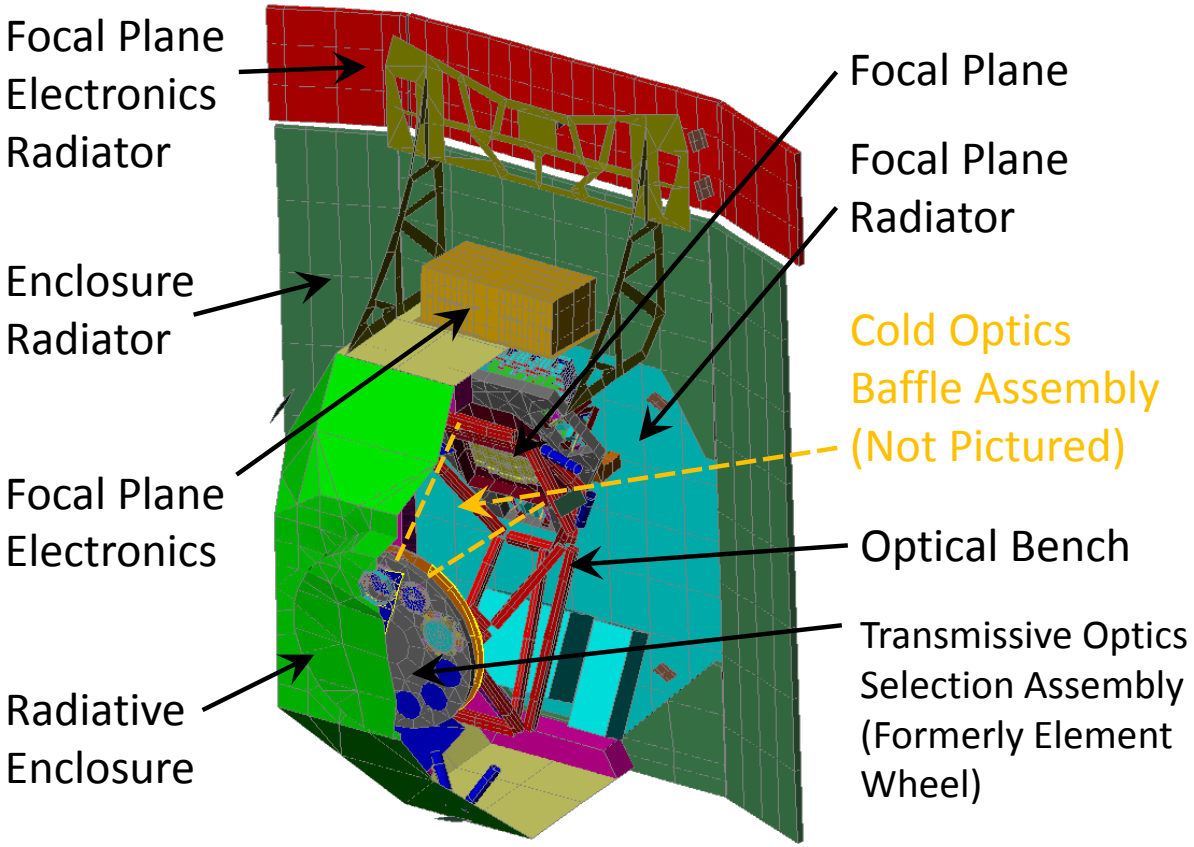
To fully take advantage of a competitive study and organizational diversity of thought, a performance based requirements document is required as opposed to a build-to-print specification based on a particular point design.

- **The studies also considerably reduced the time needed for industry partners to become knowledgeable enough to make significant contributions. Since one of the study participants was selected as the industry partner, the knowledge gained about the requirements and design evolution to date during the studies helped to reduce the time to come up to speed. With a very short 11 weeks between contract award and instrument System Requirements Review, the experience gained during the studies allowed for a quick assimilation of the new industry partner into the larger WFI team.**

The study process reduces the time on the learning curve after final contract award for the chosen industry partner.

Current WFI Design





Major Design Changes

- *Radiative enclosure*
- *Composite tube optical bench*
- *No IFC*
- *FPA Radiator now part of WFI*
  - *No FCR, short TBA*
- *EW Changed from Bowl to Disc*
- *Actuated FPA*
  - *No Fold 1*
- *FPE relocated*

Conclusions

- **While the move to involve an industry partner was not originally planned, the approach utilized by the project did result in a superior design to what was presented at the Mission Concept Review**
  - ***Discussions with potential industry partners identified design weaknesses, specifically in the area of verification***
  - ***This necessitated the difficult, but necessary, redesign of the optical system and thermal system to produce a design that was better able to be tested and verified***
  - ***Inclusion of industry also helped to solidify the design requirements to ensure that they were well vetted in advance of the System Requirement Review***
  - ***While the strain was considerable on the WFI team to evolve the in-house design in parallel to working with industry and evaluating the submitted proposals, the resulting proposals were all superior designs to that presented at MCR.***

- **The contract was eventually awarded to Ball Aerospace and WFI successfully passed the System Requirements Review in August 2018**
  - ***Shortly after SRR, Ball performed a trade study to replace the Facility Cryo Radiator with an instrument mounted Cryo radiator***
  - ***Without the previous study efforts and the experience gained during those studies, it is unlikely that this design change would have been contemplated and executed in the timeframe***

- **The WFI Preliminary Design Review was successfully passed in June 2019 and the WFI design continues on with a planned WFIRST launch in 2025 to answer key questions about dark energy and the expansion of the universe**

Lessons Learned

- Project schedules and staffing plans that are not adjusted after a major procurement change approach can place considerable strain on project teams with the additional, unplanned workload.

- Specific intellectual property of the proposers must be carefully guarded and not used to specify requirements in order for the government to maintain a neutral stance during a competitive procurement.

- Providing the customers design solution to a set of requirements may hamper the innovation of the proposers' designs, since deviation from the provided design may appear risky to the customer and proposers would need to weigh that consideration.

- Long duration contractual blackout periods during the conceptual design phase may reduce the efficiency of the design cycle by delaying the implementation of industry partner's features into the overall observatory design.

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