Wide Field Infrared Survey Telescope (WFIRST) Wide Field Instrument (WFI) Overview

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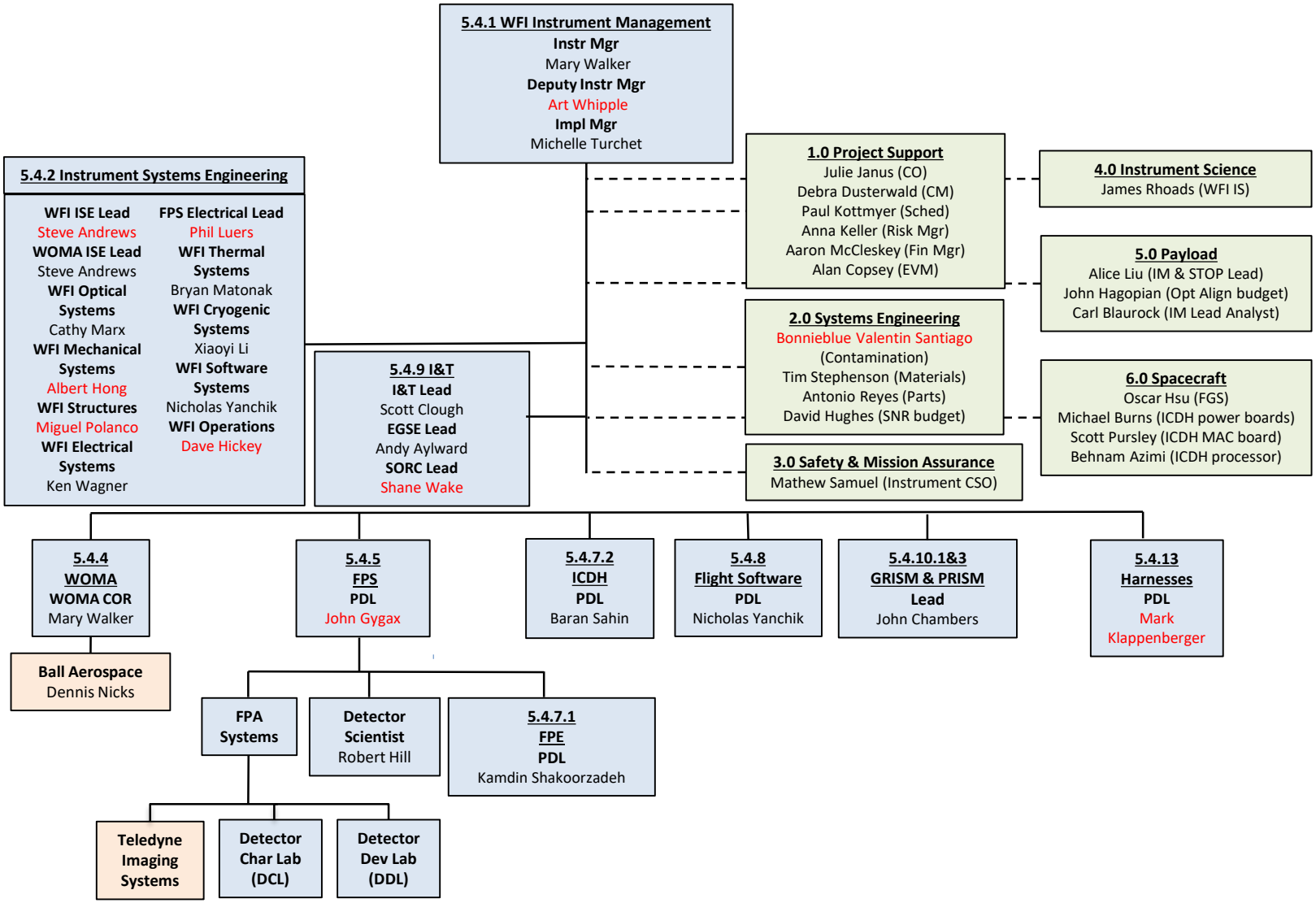
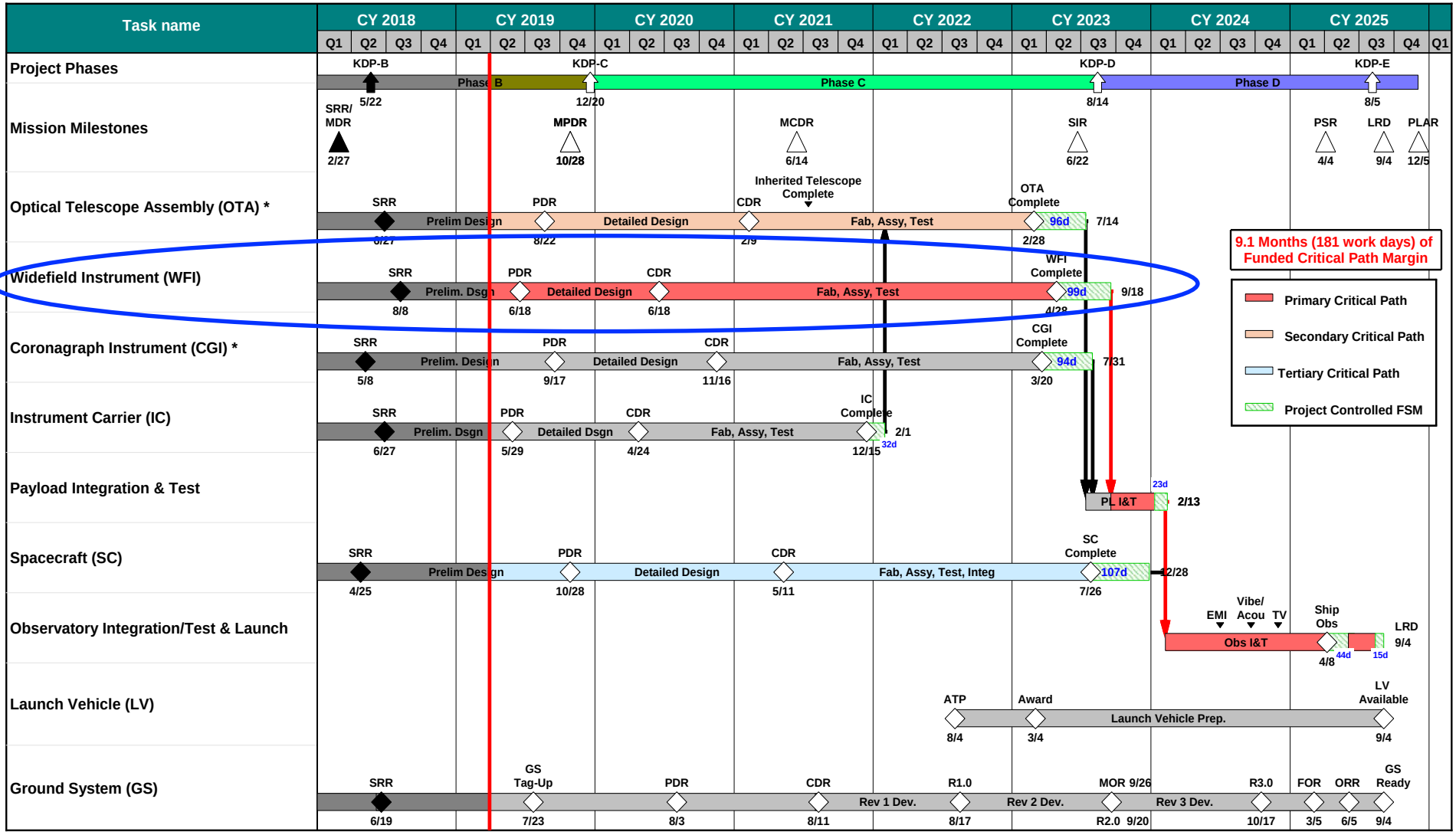
Wide Field Instrument Organization



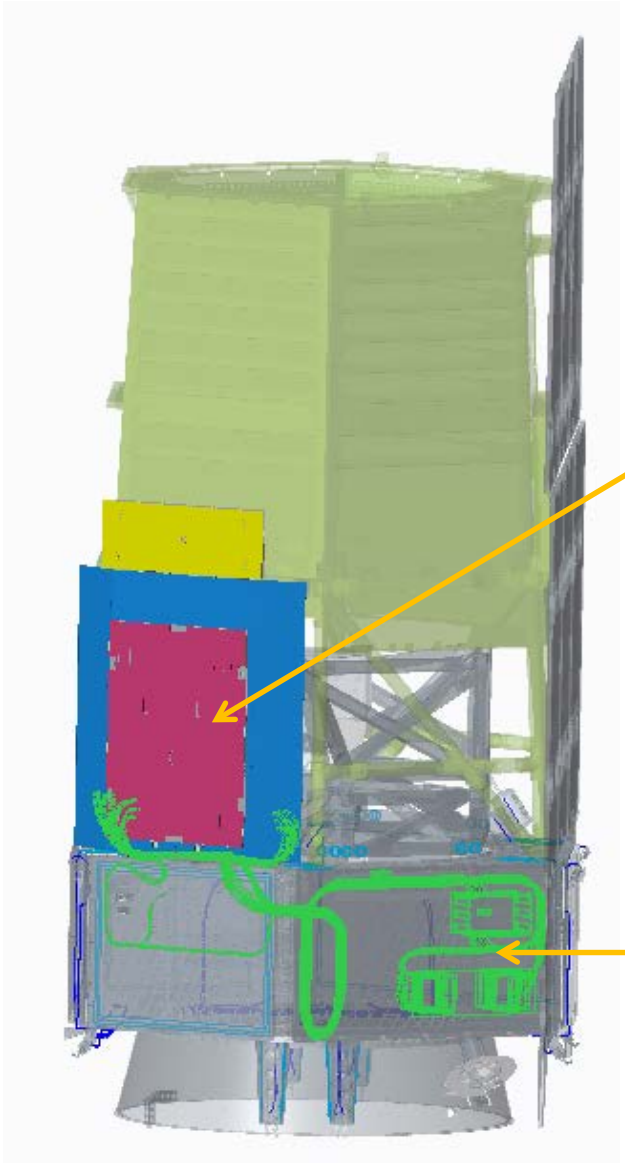
Red = recent change

WFI is Planned to be the WFIRST Critical Path



*Secondary critical path is occupied by the Optical Telescope Assembly (OTA) in lieu of the Coronagraph Instrument (CGI), which is designated as a technology demonstration

WFI in the Observatory Context



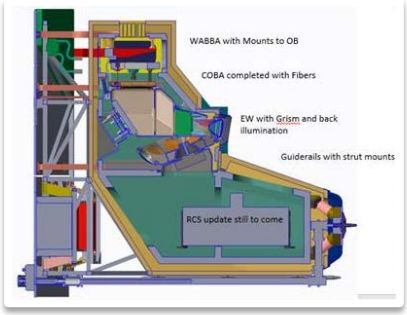
- Cold Sensing Module (CSM) in Instrument Carrier (IC)
  - Alignment Compensation Mechanism (Hexapod)
  - Focal Plane System (FPS)
    - Mosaic Plate Assembly with Detectors/flexures, Harness, Sensor Control Electronics Assembly, Harness, Focal Plane Electronics box
  - Element Wheel Assembly (7 filters, dark, grism, prism, engineering element)
  - Cold Optics Baffle Assembly (COBA)
  - Relative Calibration System (RCS) with electronics
  - Optical Bench (OB) with bipods and latches
  - Outer Enclosure (OE) with electrical connectors
  - Radiators w/Heat Pipes or Thermal Straps: FPE, RCSE, Mosaic Plate Radiator (MPR), Bench Cryo Radiator (BCR)

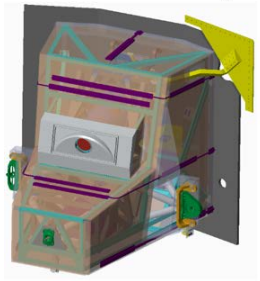
- Warm Electronics in Spacecraft Bay 6
  - Mechanism Control Electronics (MCE)
  - Instrument and Command & Data Handling A & B

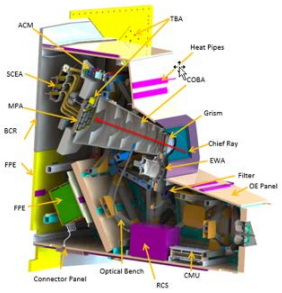
Changes since SRR/SDR in green

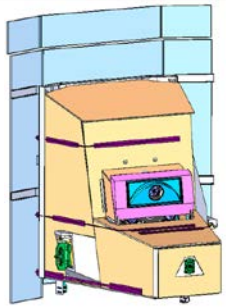
WFI Changes Since SRR/SDR (1,000 ft view) (list of changes on next slide)

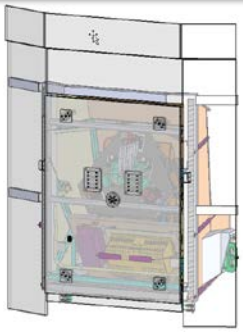
WFI CSM May 2018 → WFI CSM SRR Aug 2018 → WFI CSM MPR Horizontal Latch Sept 2018 → next row



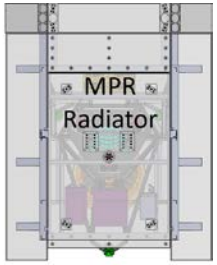


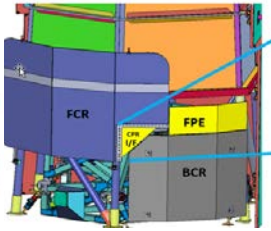


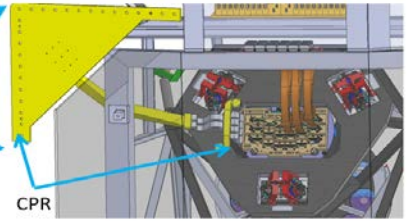


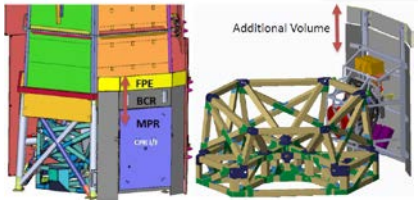


WFI CSM Vertical Latch early Oct 2018 → WFI CSM FCR Mid Oct 2018 → WFI CSM MPR Vertical Latch Oct 2018 → next row

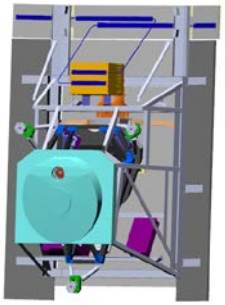


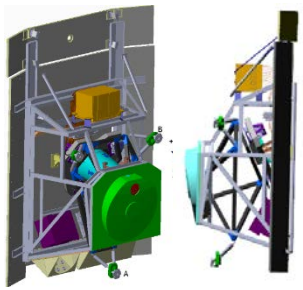


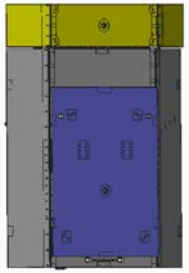


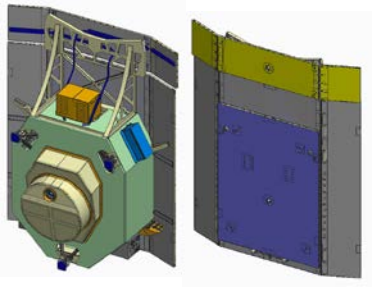


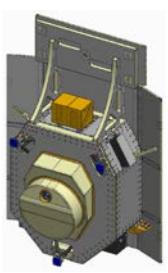
WFI CSM Nov 12 2018 → WFI CSM Dec 10 2018 → WFI CSM Feb 15 2019 → WFI CSM Mar 08 2019 → WFI CSM Apr 05 2019

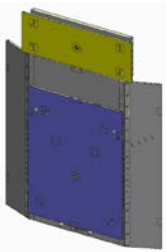












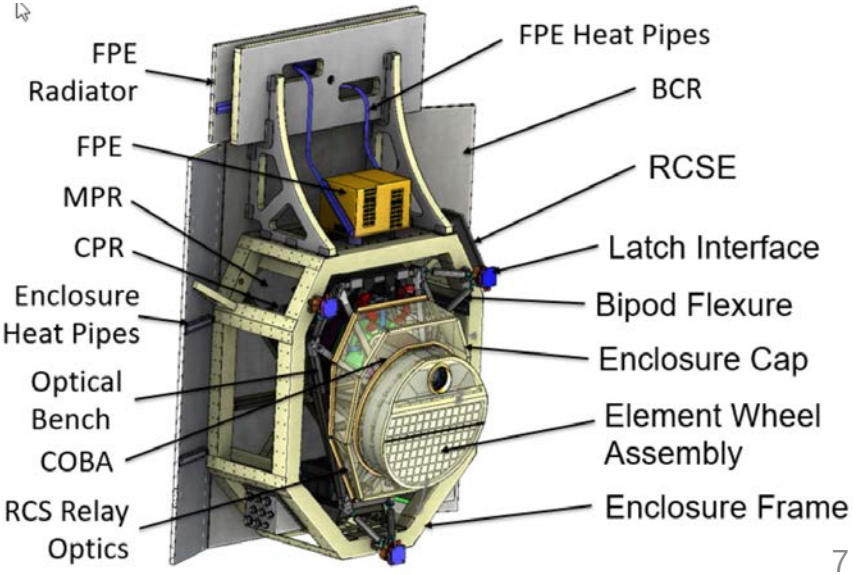
WFI Major Changes since WFI SRR/SDR (Aug 2018)

- Design synched to telescope prescription v8.5.5
  - Pupil mask changed from spherical to flat-tilted
- Facility Cryocooling Radiator eliminated in favor of Mosaic Plate Radiator (MPR)
  - Conduction Path to Radiator (CPR) 2 AlBeMet Conduction bars to MPR with 2 Pyrolytic Graphite (PG) straps from each AlBeMet bar to Mosaic Plate
- Latches to IC changed from horizontal to vertical configuration, 2-2-2 flexure design
- Element Wheel Thermal Assembly added to provide stable filter temperature and gradient in and out of optical beam
- FPE operating (baseplace) temperature increased to ~293 +/- 0.5K
- Sensor Control Electronics Assembly moved off Alignment Compensation Mechanism
- RCS design updated to single aperture between two integrating spheres, free-space projection to diffuser on EW, Light On / Light Off (LOLO) capability added
  - LOLO PDR baseline is reflection off of pupil masks
- Grism designed changed from 4-element to 3-element
- Labyrinth seal at AOM eliminated, cold “snout” with small overlap to Aft Optics Module ring added
- Mosaic plate stray light refinements
  - Rotated central row of SCAs 180° for stray light improvement
  - Individual SCA light shields now only cover wire bonds
  - Mosaic plate gold (stray light analysis showed black over-coat not required)
- Optical Bench and cold Enclosure changed from rectangular to octagonal geometry
- WFI-SC connector panel separated into 2 cold, 1 warm panel
- 2-element low resolution prism added for supernova redshifts and classification

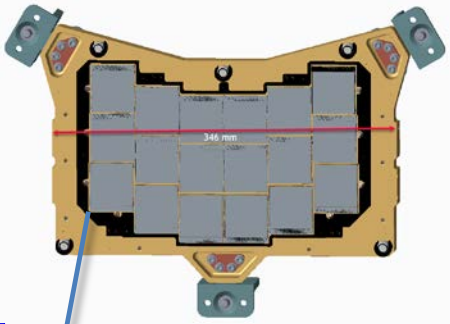
WFI Hardware PDR Baseline

GSFC products shown in blue
Ball products shown in black

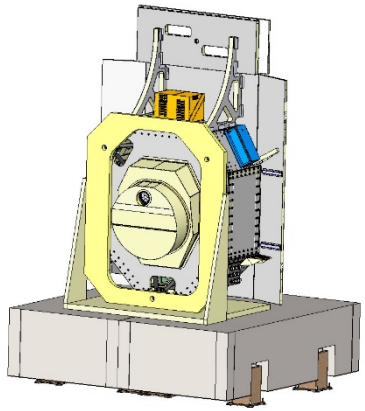
- Cold Sensing Module (CSM)
  - Element Wheel Assembly (EWA)
    - Grism, Prism and Filters
  - Focal Plane System (FPS) consisting of:
    - Mosaic Plate (MPA), Sensor Control Electronics Assembly (SCEA), Focal Plane Electronics (FPE)
  - Alignment Control Mechanism (ACM)
  - Optical Bench, Cold Optical Baffle Assembly (COBA)
  - Latches, Outer Enclosure (OE) with Yoke frame
  - Bench Cryo Radiator (BCR), Mosaic Plate Radiator (MPR), Focal Plane Electronics Radiator (FPER)
  - Relative Calibration System (RCS) and Electronics
  - Connector Panels 1 cold, 2 warm, 1 fibers
  - Cold "Snout" to Aft Optics Module
- Warm Electronics
  - Instrument Command & Data Handling (ICDH)
  - Mechanism Control Electronics (MCE)

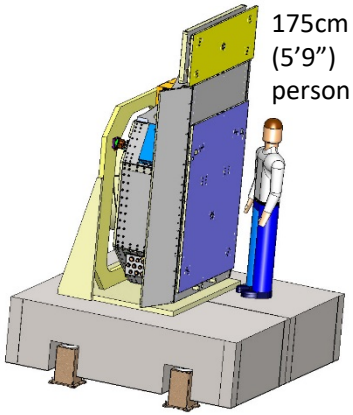


WFI Cold Sensing Module



Mosaic Plate Assembly (MPA)
Larger detector area than an iPad display





175cm (5'9") person

Focal Plane Electronics (FPE)

Sensor Cold Electronics Assembly (SCEA)

293K

150K

Telescope Aft Optics Module

140K

220K

95K

Alignment Compensation Mechanism (ACM)

180K

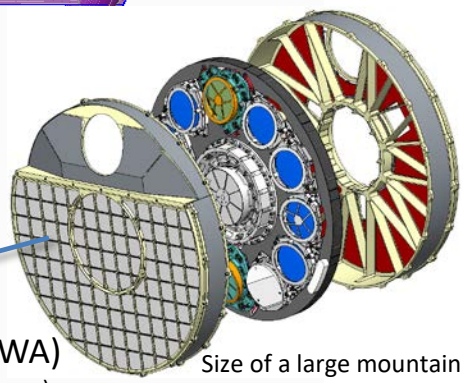
RCS Projection Optics

Relative Calibration System (RCS)

WFI NTE Envelope

140K

220K



Element Wheel Assembly (EWA)
7 sci filters, phase retrieval filter, grism, prism, dark (~∅100mm)

Size of a large mountain bike wheel

WFI Design is Compact and Efficient

WFI PDR was Successful!

- WFI PDR held June 18-21, 2019 at Ball
- Review team noted several important strengths:
  - Experienced teams at both GSFC and Ball, good coordination, working well together
  - Use of existing designs from recent projects
  - Leveraging from JWST for Alignment Compensation Mechanism (ACM) experience
  - Very simple and straightforward optical system
  - Required detector performance has been demonstrated on multiple devices
- 8 Requests for Action, 15 Advisories; main issues and concerns:
  - Wavefront error stability not meeting requirements
  - Prism immaturity
  - Stimulus of Ray Cones (SORC) was not at PDR level of maturity
  - ACM requirements for range of motion and total lifetime usage (at ambient and at vacuum) should be clarified
- Overall, Goddard System Review Team recommended that WFI proceed to critical design
  - CDR planned for 6/16-18/2020

WFI Upcoming Trades and Open Work

- Post-PDR Trades
  - CSM survival heater architecture to avoid battery draw before sun capture
    - Switched spacecraft service is an option
  - Possible change of EW from composite to solid metal (e.g. Be or Ti) to improve manufacturability and/or reduce mass
  - Possible change of ACM strongback from composite to solid metal (e.g. Ti)
  - Possible elimination of Enclosure heat pipes
- Post-PDR Open Work
  - Optimization of Instrument Carrier interface and latches
  - Assess impacts from possible elevated AOM temperature (~5K)
  - Update spacecraft-WFI wire harness to ensure PRT accuracy while minimizing thermal parasitics
  - Update stray light and thermal analysis for CDR pupil masks
  - Update thermal control to allow SCE ASIC additional 100mW, per SCE to improve Differential Non-Linearity
  - Revisit electrical isolation between FPE and FPE radiator
  - Revisit use of Point-of-Loads converters in FPE
  - Respond to new requirements for surface charging protection
  - Respond to new Design Limit Loads, if necessary, due to Integrated Payload Assembly axial mode

WFI Breakout Session Will Go into More Detail

- SN prism properties
- Filter ripple spec re-assessment
- SNR performance
- Calibration plans, including Relative Calibration System
- Detector status
- Data compression
- Wavefront error stability

Backup Material

Acronyms

A

ACM - Alignment Compensation Mechanism
AFIP – Alignment Focal Plane Interface Plate
AI&T - Assembly, Integration and Test
AOM – Aft Optics Module

B

BCR – Bench Cryo Radiator
BF- Burst Factor

C

CAD – Computer Aided Design
CDR – Critical Design Review
CM – Configuration Management
CME – Cold Module Electronics
CMU-Cryo Multiplexer Unit
COBA – Cold Optics Baffle Assembly
CPR – Conductive Path to Radiator
CSM – Cold Sensing Module
CTE – Coefficient of Thermal Expansion

D

DLL – Design Limit Load
DOF – Degree of Freedom

E

EPR - Engineering Peer Review
EW – Element Wheel
EWA – Element Wheel Assembly

F

FCP- Fracture Control Plan
FCR – Facility Cryogenic Radiator
FEA – Finite Element Analysis
FEM – Finite Element Model
FPA – Focal Plane Assembly
FPE – Focal Plane Electronics
FPS – Focal Plane System

Acronyms

G

GCE – Gimbal Control Electronics
GFE – Government Furnished Equipment
GFP – Government Furnished Property
GPR – Goddard Procedural Requirements
GSE – Ground Support Equipment

I

IC - Instrument Carrier
ICD – Interface Control Document
ICDH – Instrument Command & Data Handling
IM – Integrated Modeling

M

MAC – Mass Acceleration Curve
MCE – Mechanism Control Electronics
MGSE – Mechanical Ground Support Equipment
MICD – Mechanical Interface Control Document
MP – Mosaic Plate
MPA - Mosaic Plate Assembly
MPR – Mosaic Plate Radiator

N

NTE – Not to Exceed

O

OB - Optical Bench
OBA – Optical Bench Assembly
OE – Outer Enclosure
OM- Output Module
OTA – Optical Telescope Assembly

P

PCS – Payload Coordinate System
PDR – Preliminary Design Review
PDU – Power Distribution Unit
POC – Point Of Contact
PSE – Power System Electronics
PSF – Point Spread Function

Acronyms

R

RCS – Relative Calibration System
RCSE – Relative Calibration System Electronics
RFA – Request for Action
RWA – Reaction Wheel Assembly

S

S/C – Spacecraft
SCEA – Sensor Cold Electronics Assembly
SDR – System Design Review
SERDES - Serializer/Deserializer
SMR – Spherical Mounted Retro-reflector
SRR – System Requirements Review
SRS – Shock Response Spectrum
STOP – Structural, Thermal, Optical Performance

T

TBA –Thermal Bus Assembly
TCE – Telescope Control Electronics

W

WBS – Work Breakdown Structure
WCE - WOMA Control Electronics
WCP – WFI Connector Panel
WDE – Wheel Drive Electronics
WEM – Warm Electronics Module
WFI – Wide Field Instrument
WFIRST – Wide–Field Infrared Survey Telescope
WOMA – WFI Opto-Mechanical Assembly
WIAT – WOMA Interface Alignment Tool