



Jet Propulsion Laboratory
California Institute of Technology

CGI Technical Status Functional Testbed and V&V

Timothy Koch

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109

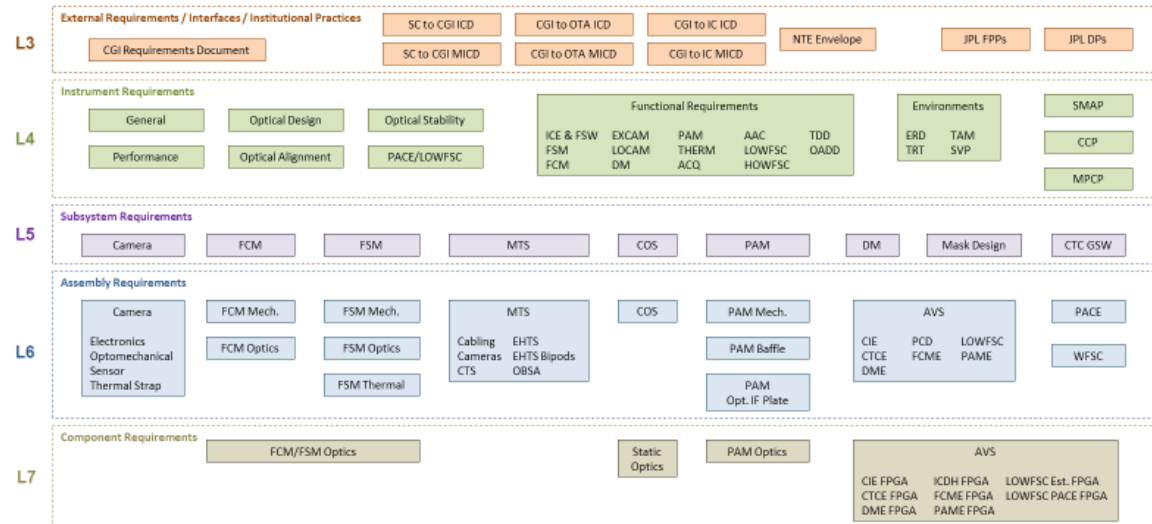
August 26 – 27, 2024

• NASA GODDARD SPACE FLIGHT CENTER • JET PROPULSION LABORATORY •
• L3HARRIS TECHNOLOGIES • BALL AEROSPACE • TELEDYNE • NASA KENNEDY SPACE CENTER •
• SPACE TELESCOPE SCIENCE INSTITUTE • INFRARED PROCESSING AND ANALYSIS CENTER •
• EUROPEAN SPACE AGENCY • JAPAN AEROSPACE EXPLORATION AGENCY •
• CENTRE NATIONAL d'ÉTUDES SPATIALES • MAX PLANCK INSTITUTE FOR ASTRONOMY •

Copyright 2024 California Institute of Technology.
Government sponsorship acknowledged

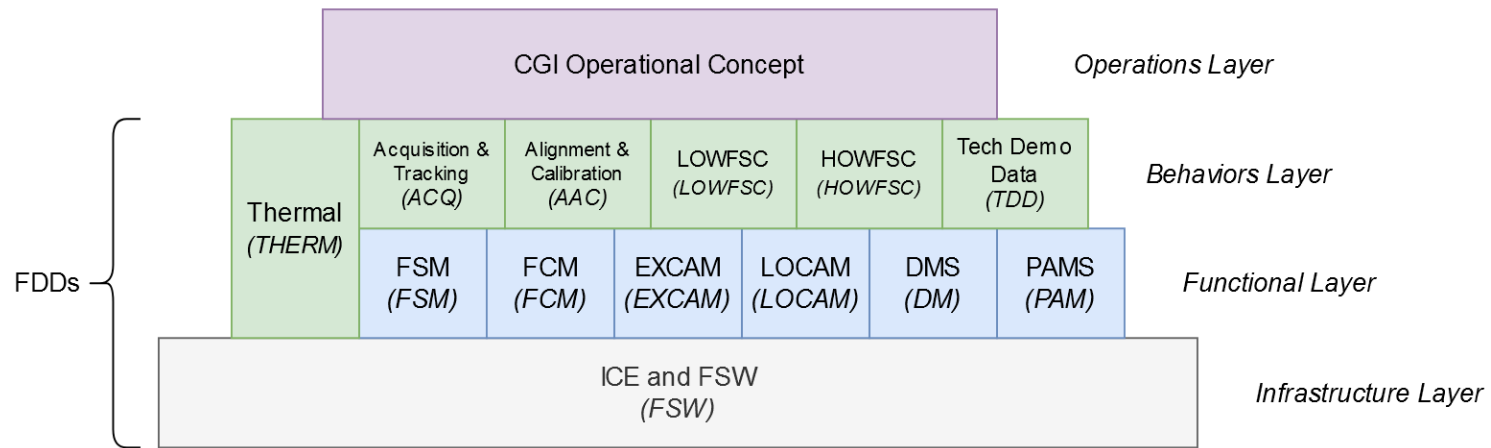
Requirements Taxonomy

- Coronagraphic Performance Requirements
 - Responsive to TTR5 via CGIRD-505
- Functional Requirements
 - Define the functionality and behavior of the instrument in support of performing coronagraphic observations and fault protection
 - Primarily in the L4 iFSW module
- Accommodation Requirements
 - Do No Harm (DNH) requirements
 - Mechanical, thermal, electrical, optical, and interface compatibility with Roman
 - Environmental requirements



L4 Functional Requirements: FDD Context

- Functional Design Descriptions (FDDs)
 - Each FDD contains the requirements and design specification for that functional or behavioral domain



- FTB is the primary venue for Development and V&V of L4-iFSW and L5-iGSW requirements before application on flight

Slide credit: Katie Heydorff

V&V Status: Requirement Burndown

- The CGI testing program was augmented at CDR with the Functional Testbed (FTB) to reduce II&T risk
 - Envisioned as the venue to tactically reconfigure “form, fit, function” Engineering Development Units (EDUs) against iFSW deliveries in support of system-level functional testing/development
 - FTB was run like an I&T activity with daily planning meetings and a shift request process for over 3 years
 - *iFSW: Supported V&V of 564 Requirements; >40 builds; and 11 formal deliveries*
 - *iGSW: Supported V&V of 103 Requirements; and 8 formal deliveries*

- **L3 CGI CGIRD requirements: total 187**
 - 74 “delivery critical” Verification Closure Reports (VCRs) delivered before 4/30/2024
 - 83 VCRs delivered since CGI PSR (5/2/2024)
 - 30 to go:
 - 6 to be delivered by 8/23
 - 2 to be delivered by 8/30
 - 21 depend on correlated thermal model by 10/31 – see status and plan on the next slide
 - 1 (CGIRD-320) depends on final MLI installation in October during IPA I&T

- **L4/L5: 71 outstanding VCRs**
 - 24 to be closed by Sep
 - 22 L5 thermal use correlated model; planned for closure Sep
 - 25 L5 CTC iGSW to be closed in Dec 2024 (R3.0.1) and May 2025 (R3.0.2)

Slide credit: Matt Smith

CGI Functional Testbed (FTB)

- Maintains facilities to allow testing at JPL when other sub-systems are not available
 - Electrical Ground Support Equipment (EGSE)
 - Spacecraft Interface Simulator (SIS or ASIST from Goddard), Consoles, Testbed Data System (TDS), etc.
 - Testbeds
 - FTB1 (following slides), FTB2 (iFSW dev), SSC HPE (GITL) and DAE (DRP) simulation (iGSW V&V)
- FTB continues post-delivery...
 - Support future operations iFSW/iGSW/FSTOL testing, dress rehearsal, anomaly resolutions, etc.
 - Run by JPL's Instrument Operators following JPL processes (activity reports, procedures, etc.)
 - Moving to new dedicated space at JPL in B318-122
- ...with improvements:
 - Install WISP: software simulation of RST spacecraft FSW : now part of FSTOL validation
 - Add Camera TVAC camber : supports in-flight tuning and anomaly resolution
 - Incorporate Prototype Camera Electronics, camera head, and detector to realize a second camera
 - etc.

SIS – Spacecraft Interface Simulator (hardware)

ASIST – Advanced Spacecraft Integration and System Test (hardware)

FSTOL – Flight Systems Test and Operation Language (scripting language)

DAE – Data Analysis Environment

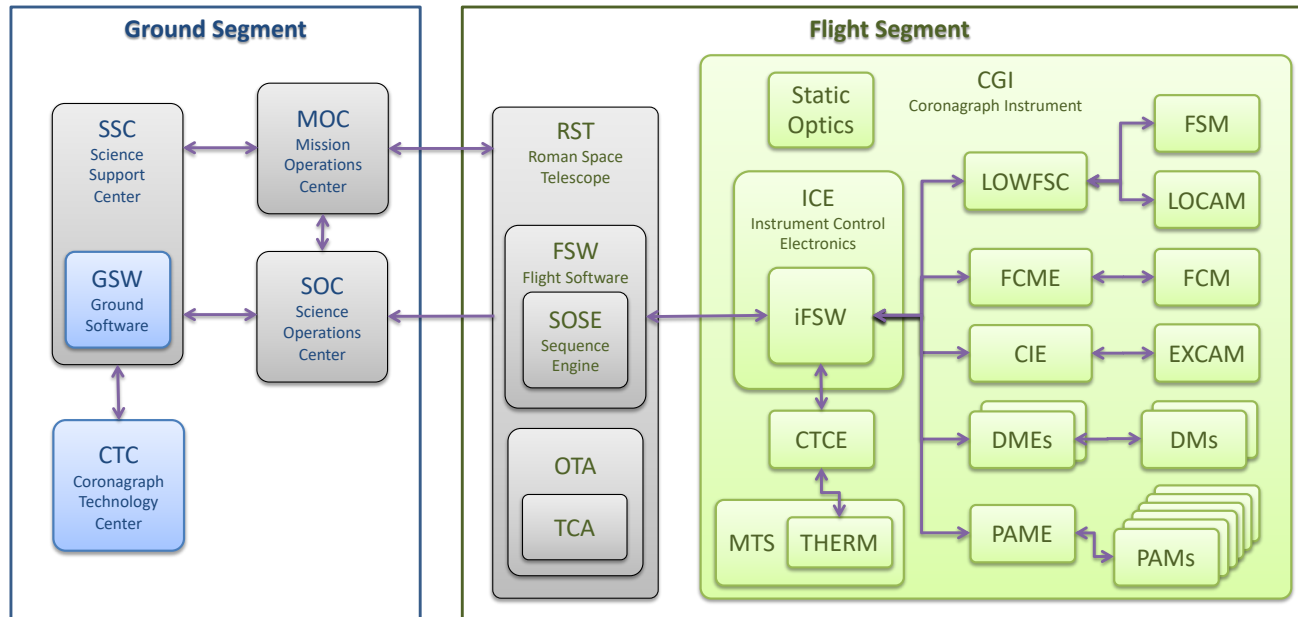
DRP – Data Reduction Pipeline

HPE – HOWFSC GITL Processing Environment (at SSC)

WISP – WFIRST Integrated Simulation Platform

CGI the System – Components and Connections

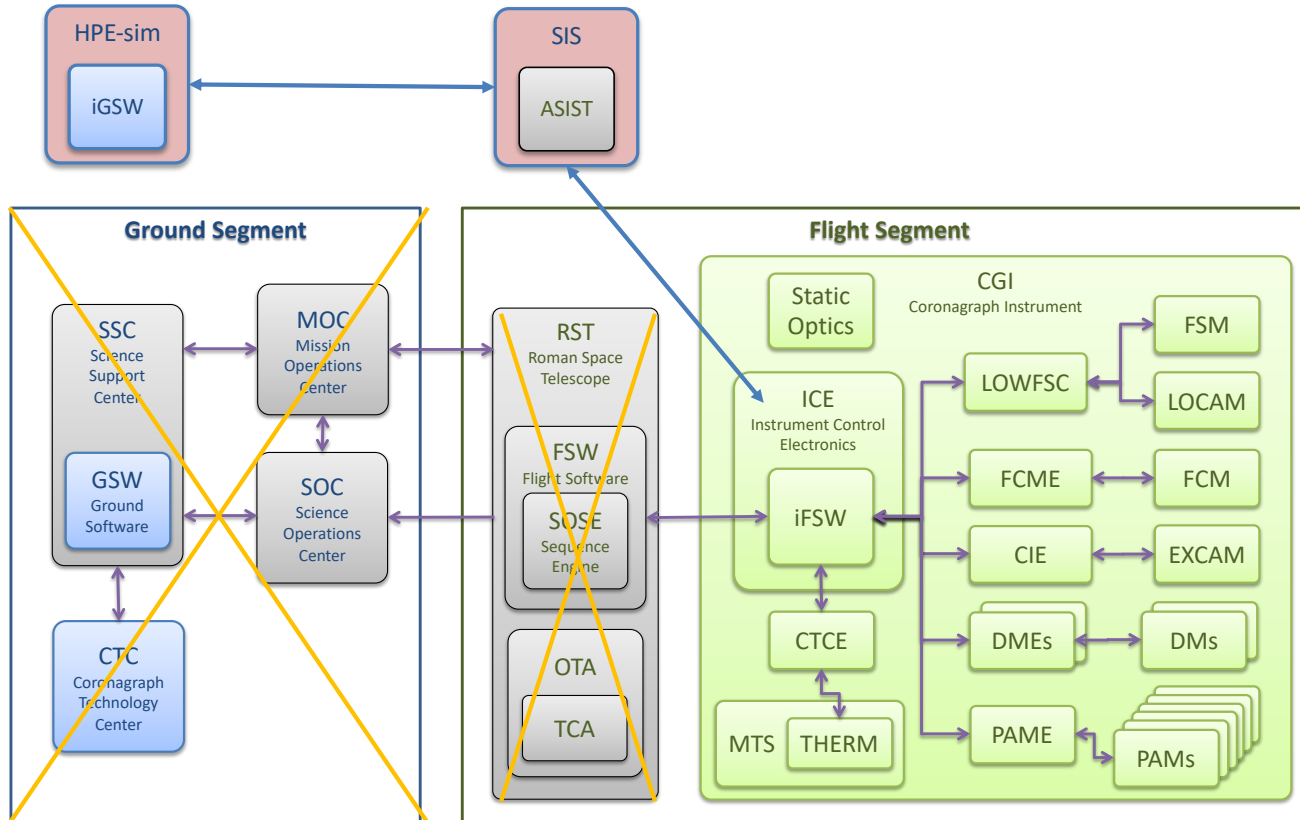
CTCE – CGI Thermal Control Elec
LOWFSC – Low-Order WFSC Elec
FCME – FCM Electronics
CIE – Camera Interface Electronics
DME – DM Electronics
PAME – PAM Electronics

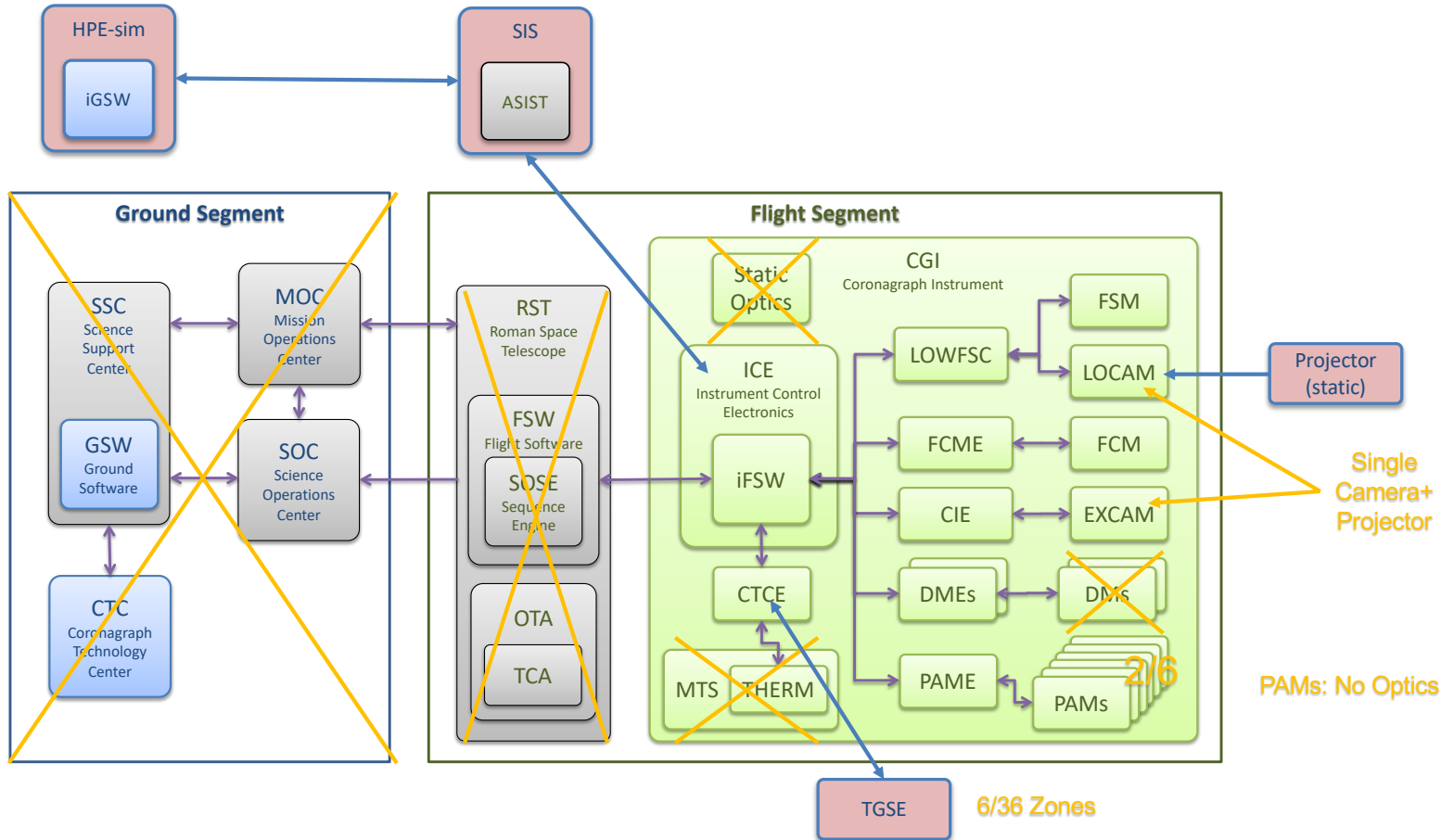


FSM – Fast Steering Mirror
LOCAM – LOWFS Camera
FCM – Focus Control Mechanism
EXCAM – Exoplanet Camera
DM – Deformable Mirror
PAM – Precision Alignment Mech

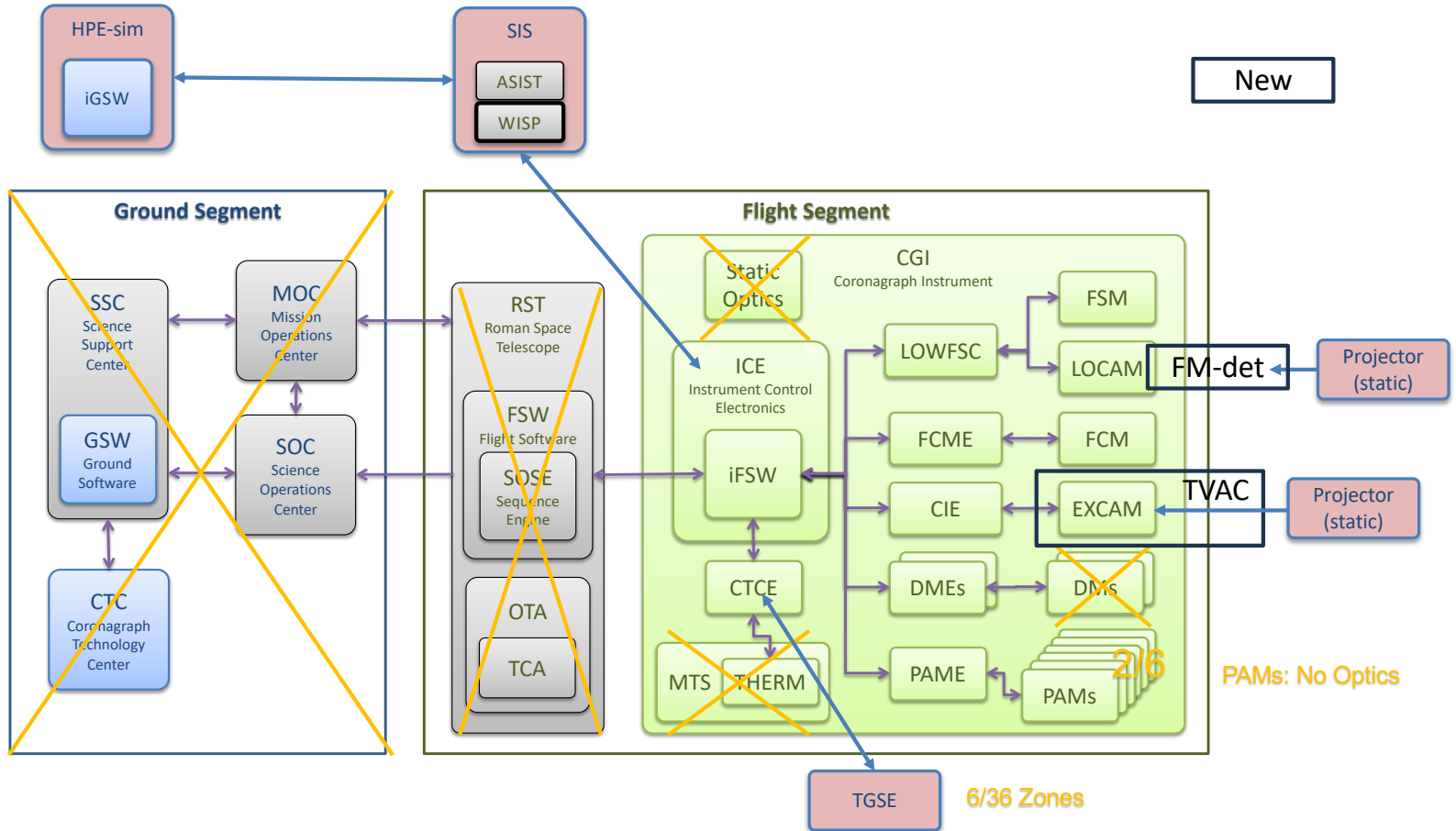
OTA – Optical Telescope Assembly
TCA – Tertiary Collimator Assembly
MTS – Mechanical Thermal Subsystem

CGI Undertest at JPL





CTC FTB1 Post-delivery



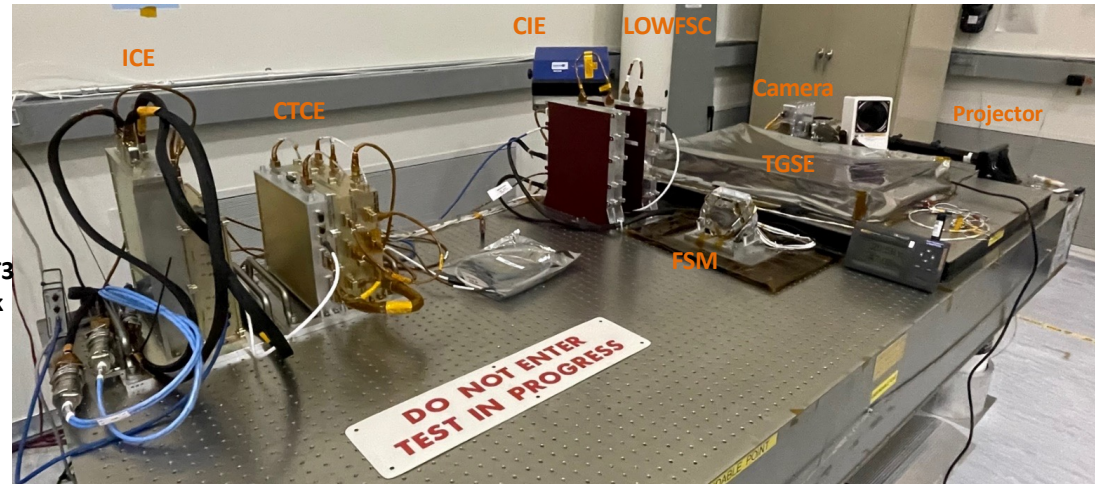
Functional Testbed

FTB1 Operator Console and EGSE Racks



(During SIS Checkout period... Mar 2022)

FTB1 Bench

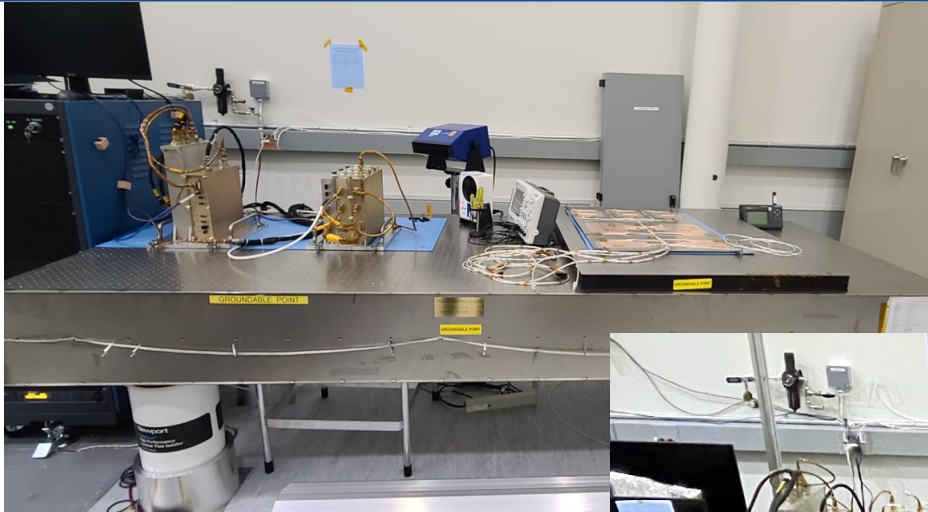


FTB2 and mEGSE2



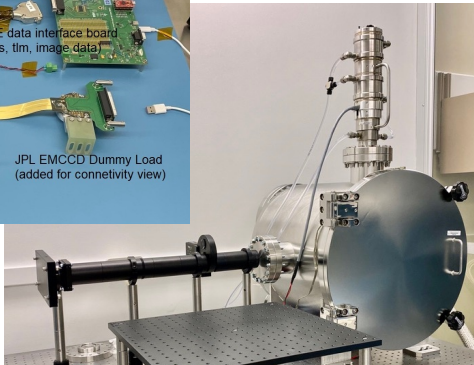
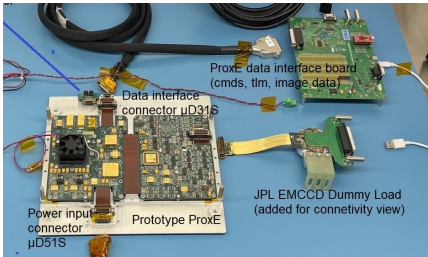
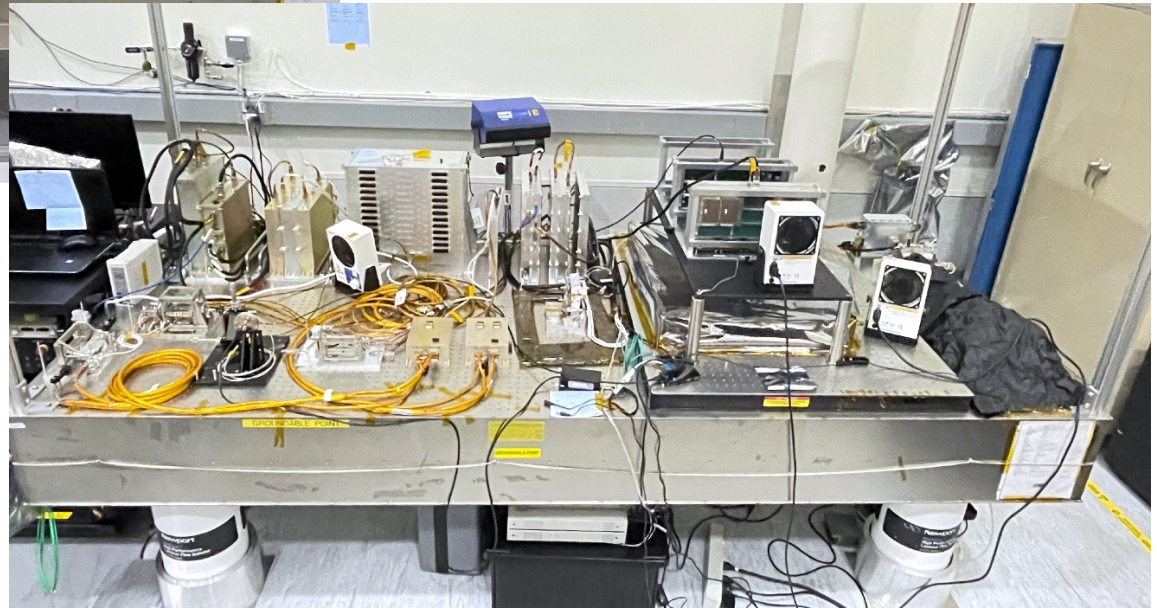
Slide credit: Tim Koch

FTB1 History



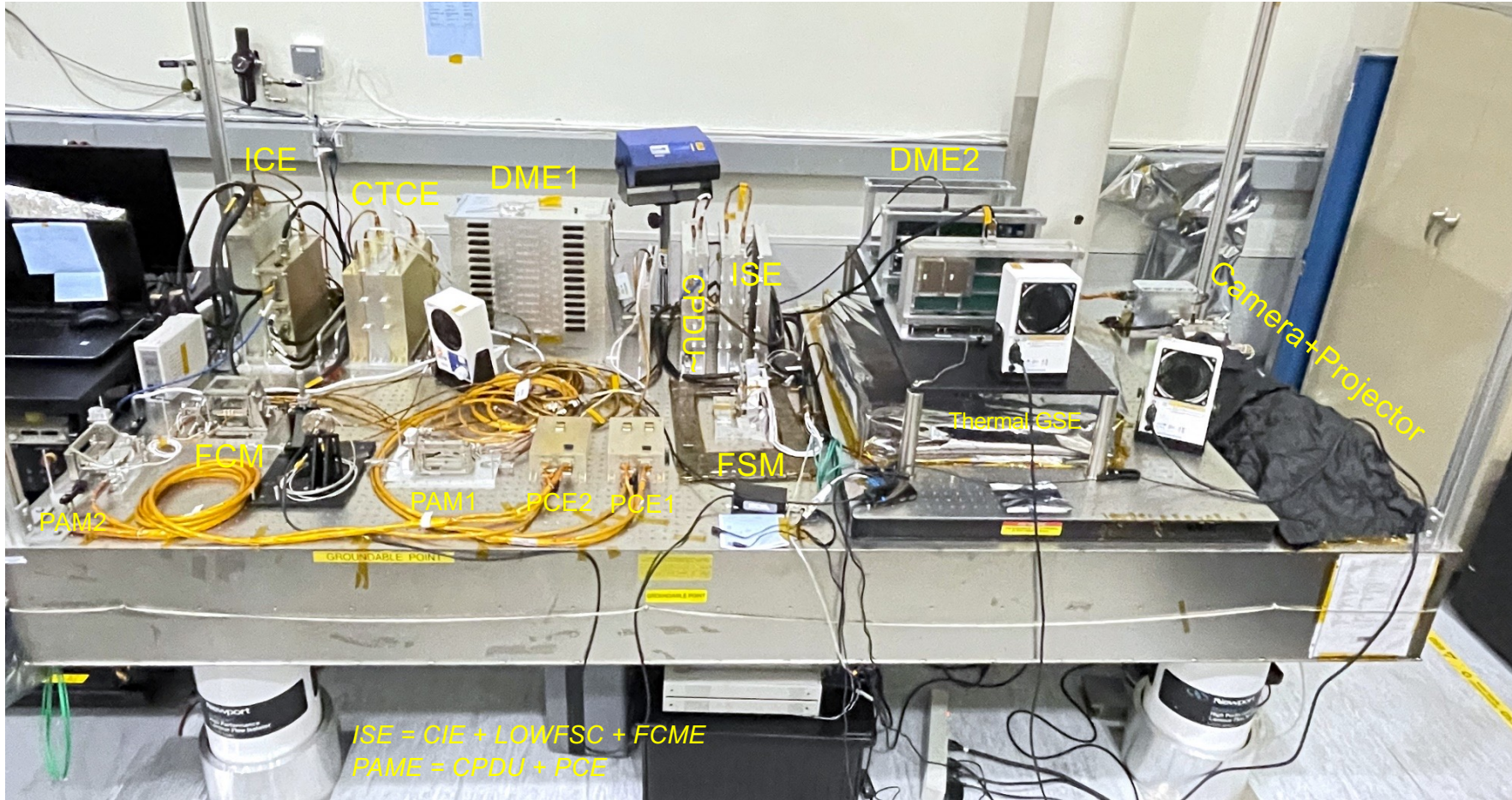
Aug 2021

Oct 2023



Jan 2024

FTB1 (Oct 2023)



Summary

- FTB became more than a JPL “System Testbed”
 - The place where flight representative hardware is first being exercised with FSW
 - i.e. primary venue for testing L4-iFSW and L5-iGSW validation
- FTB also provided Avionics interface/compatibility testing in lieu of a full Engineering Model
 - Allowed Avionics interactions to be debugged using Engineering Development Units (EDUs)
 - e.g. Camera grounding or SpaceWire monitoring
- Plus performance focused risk reduction activities
 - Projector to put images on the Camera
 - Line-of-Sight (LOS) special test configuration
 - Thermal control demonstration
- And provided the venue to discover emergent behavior before II&T (ref risk CGI-62)
 - In a flexible, controlled but non-flight environment which allowed for more invasive/thorough testing
 - Included multiple venues of varying fidelity
 - e.g. FTB2 was invaluable for direct iFSW development and parallel iFSW PAM testing
 - Developed EGSE and data management systems
 - Validated all procedures and scripts before running on flight
- Post-delivery
 - FTB is the only CGI “show” in Pasadena (and the last CGI show on Earth for Ops)
 - Will continue to support Roman I&T, Roman Ground System, and Operations