James Webb Space Telescope
XML Database and CCSDS XTCE

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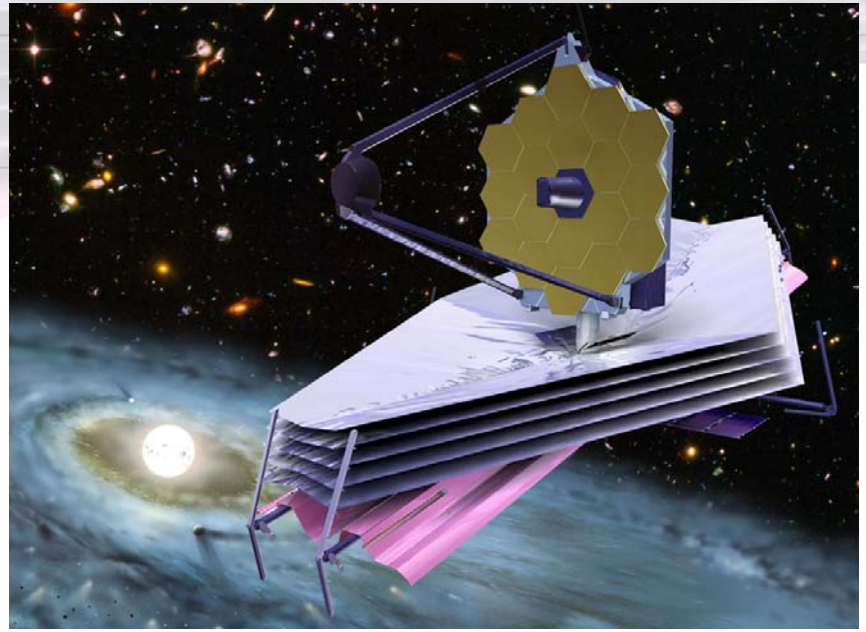
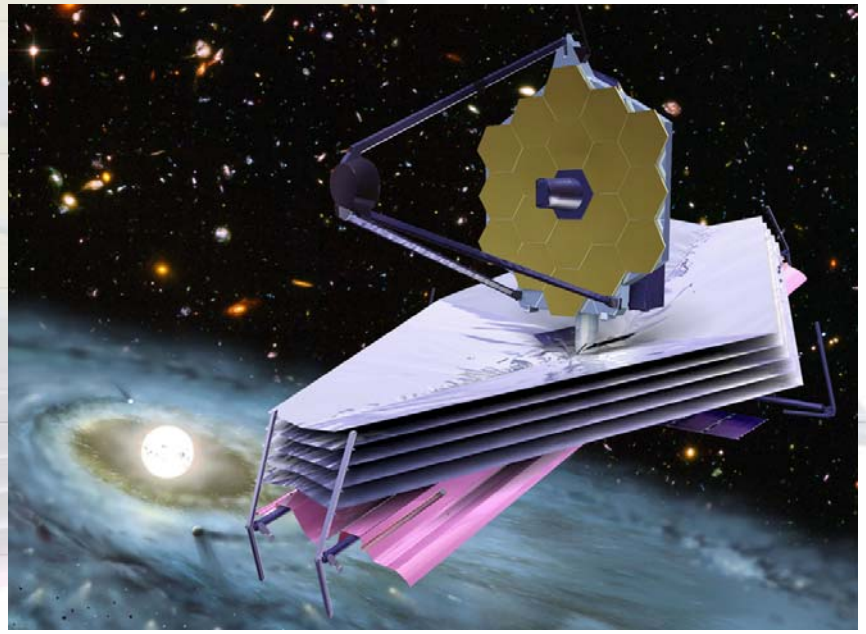
GSAW 2007
March 28



First image on JWST flight
prototype near-infrared detectors

Observatory

- JWST mission under development by NASA (launch planned for 2013) with major contributions from European and Canadian Space Agencies. The mission is designed to address four science themes:
  1. Observation of the first luminous objects after the Big Bang
  2. Assembly of these objects into galaxies
  3. Birth of stars and planetary systems
  4. Formation of planets and origins of life



- The JWST ground segment is **an open adaptable architecture** that will be used to support evolving requirements for a mission with 20-year development and operational cycles, with multiple ground systems in multiple locations.

Full Scale JWST Model

JWST Ops-Business case

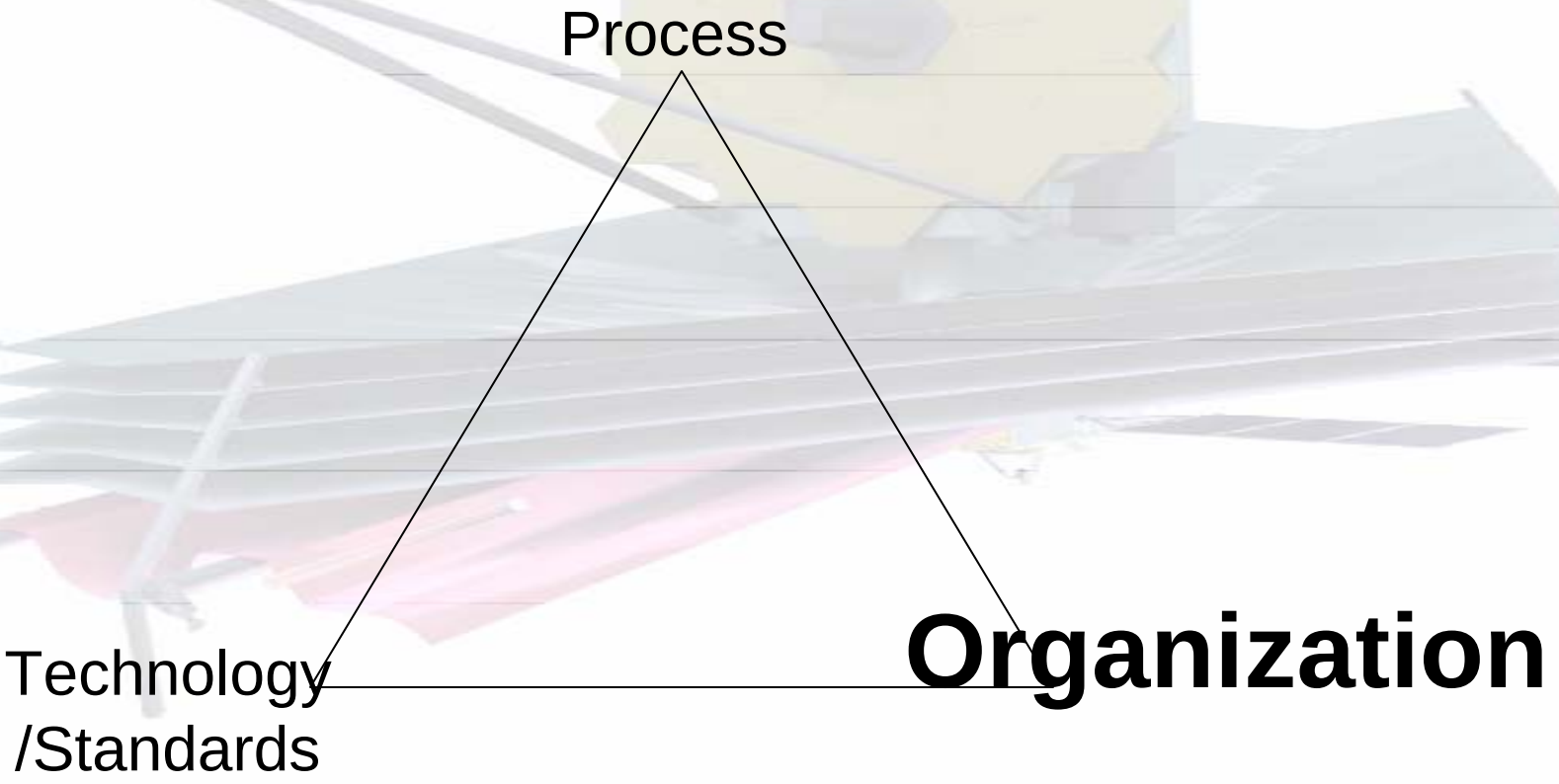
- Ops is critical to JWST success
- Maximize Observing efficiency, by minimizing idle/ overhead time

  Cost to build 4 billion dollars/

  5 year mission with 10 year design goal

  = 2.1 Million dollars a day
- Smooth I&T to Ops transition – Script and data base conversion took up to six months
- I & T cryo is costly, avoid data and script conversion (each conversion can add weeks to I&T schedule)
- Development – Flight Software architecture uses one central Instrument computer, serves 4 instruments to address thermal considerations.
  - PRD used to coordinate between:
    - FSW, On board operational scripts, C&T, other SOC subsystems

Organization



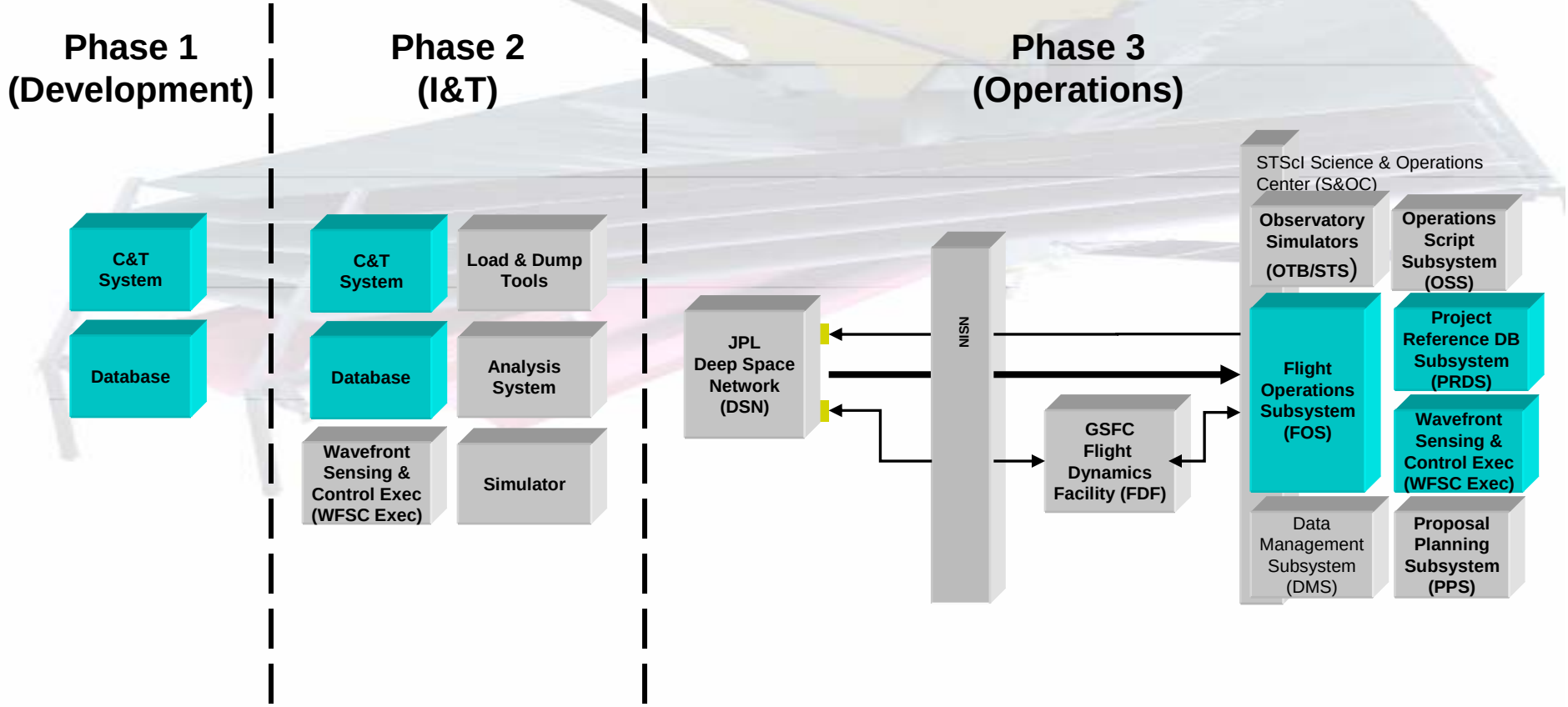
Organization

- Ops included early in life cycle
- Commitment from Project Manager to ops:
  - C&T and PRD are level II requirements issued as part of RFP
  - Provide common SW development environment to Science instruments
- Implement best practices and lesson learned form HST, EOS, and SMEX missions
- Implemented adaptive architecture with follow items:
  - Flight Operations elements used during I&T:
    - command & telemetry
    - engineering decommutation
    - front end processor
    - Science processing
  - On board operations script engine (JAVA script)
  - FSW (Rational Rose)
  - Project reference data (PRD), Used by all above elements

" You are implementing all the things we dream about in other missions"

Evolution of the Ground System

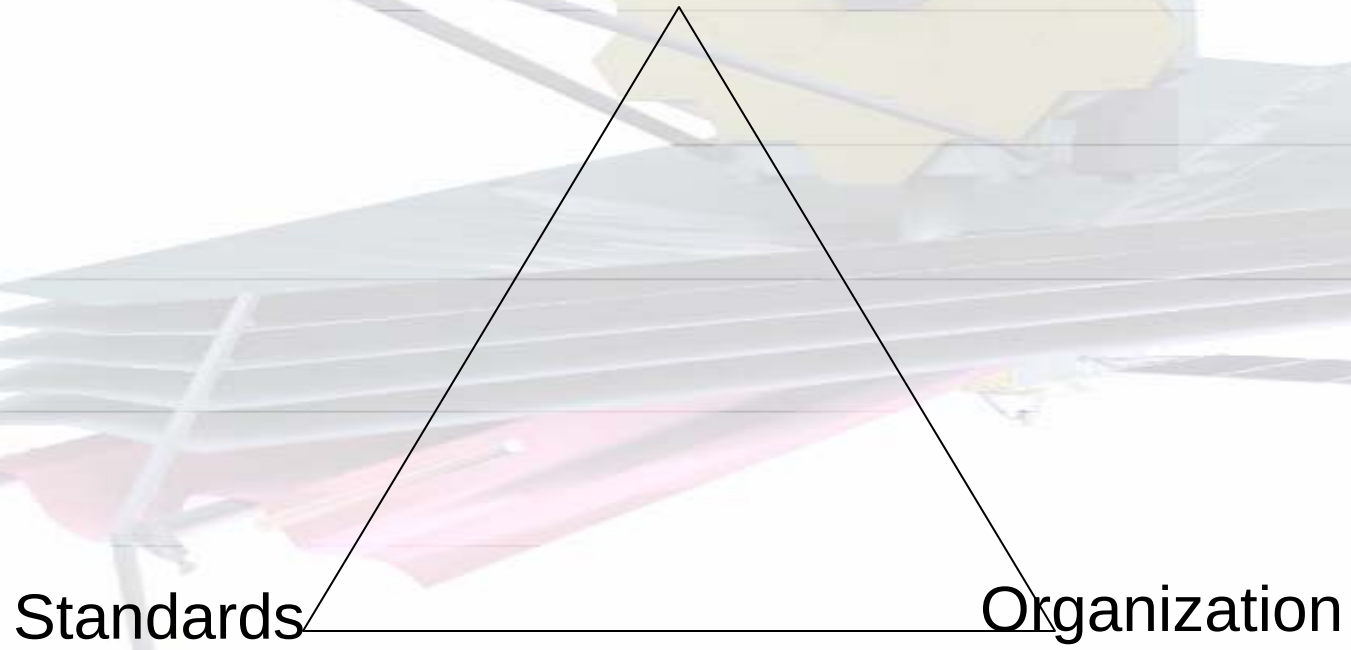
Development and I&T ground systems built around eventual operations core components: Flight Operations System (FOS) and Project Reference Database System (PRDS)



Open Ground System Architecture

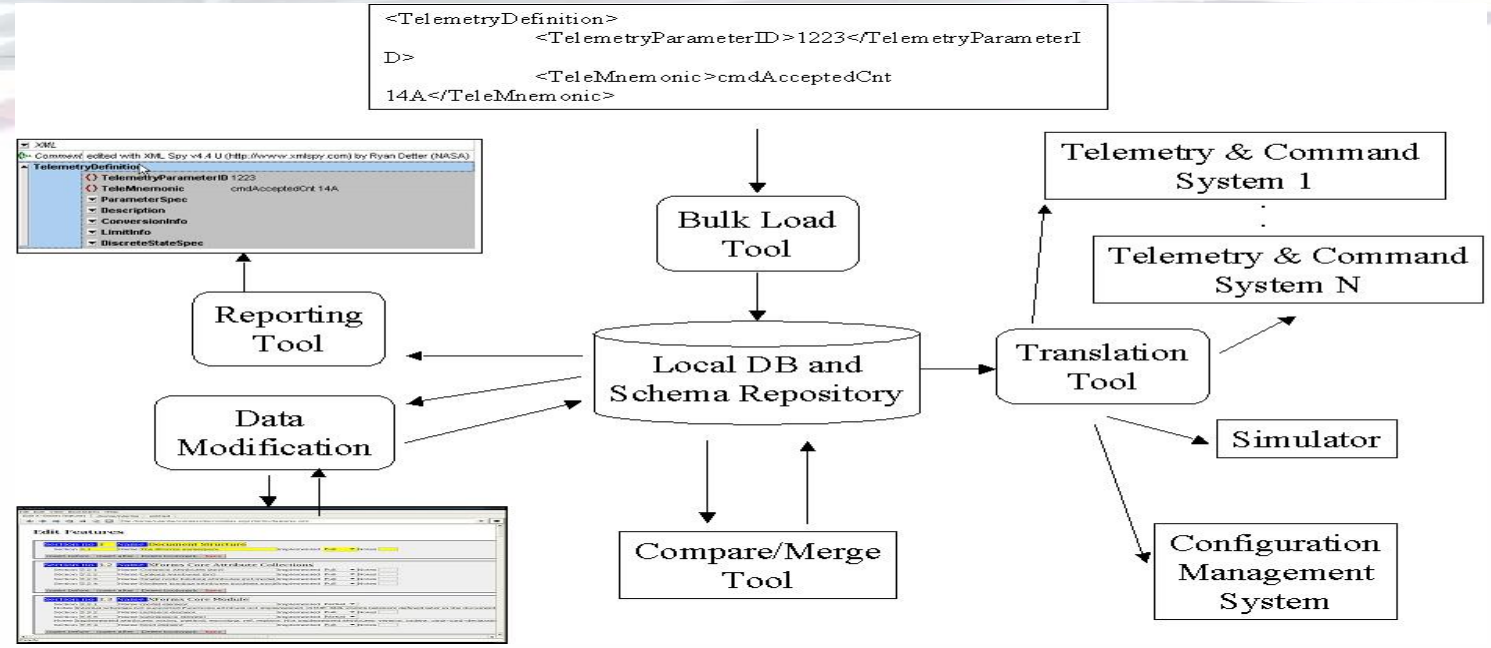
- Open Adaptable Architecture Themes
  - Intent is to ‘test-as-you-fly’ to identify problems early in the lifecycle
  - System will evolve during 10 year development cycle prior to launch
  - Follow industry standards (CCSDS, OMG, IEEE, etc.)
  - Support design upgrades and take advantage of new technologies
    - Each component independent of other components
    - Use ICDs, translators, ingest scripts for interfaces
    - Select best products (real-time, analysis, automation, etc.)
  - Implement using COTS rather than a home grown system
  - Database is application independent
  - Phased approach for evolving ground system
    - Phase 1: Development System (Flight Software support)
    - Phase 2: Integration and Test (I&T) System (GSE)
    - Phase 3: Operations System

Process



JWST Database

- The initial database and ground system elements will be used for 21 years, plus post mission activities.
- Currently 32 diverse ground systems and 24 formal database released. Local PRD systems can create as many databases as needed. Database build time is 7 minutes.
- Planned for 20-30 thousand command and telemetry items, plus many thousand other database items, pages, scripts, calibrations, table loads, etc

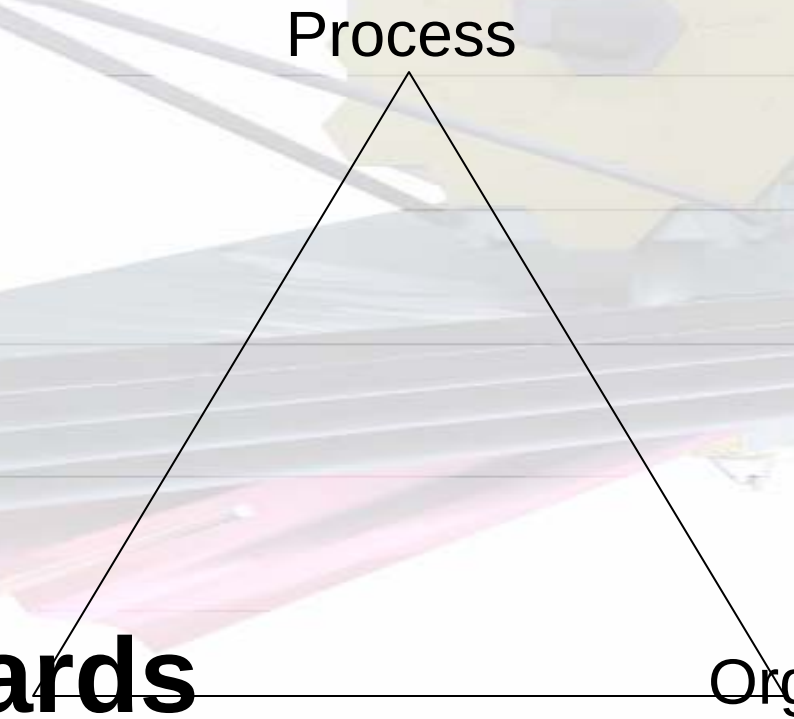


PRD process

- Take control of project data and separate database from Command & telemetry system (we already on our third C&T systems)
- Coordinate PRD between FSW, Onboard scripts and C&T
- To meet I&T requirements Required C&T provider (Raytheon Eclipse) to ingest PRD in less than 10 minutes

- Process and working groups
  - IRD between users and PRD
  - IRD between PRD & Command & telemetry system (Eclipse)
  - PRD board to mange data certification process
  - Users have own sand box to make changes using PRD tools at their location
  - Data distribution between elements done using central PRD
  - Integrated CM & XREF capabilities
  - Apriori and pre-coordinated inputs of the T&C inputs ahead of time

Technology/Standards

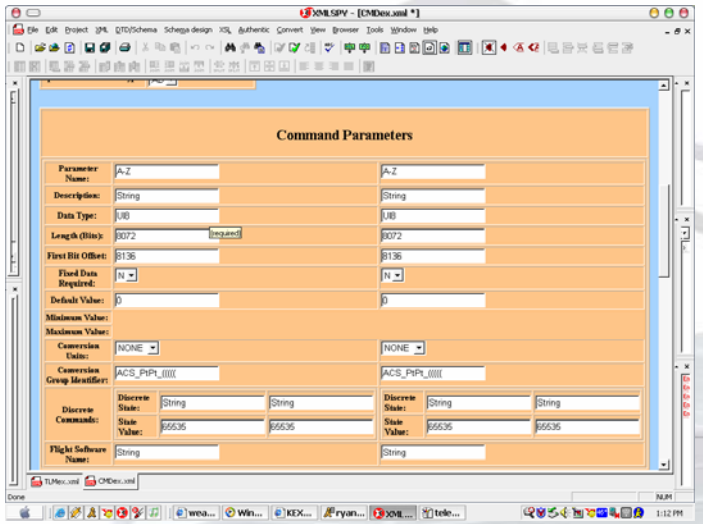


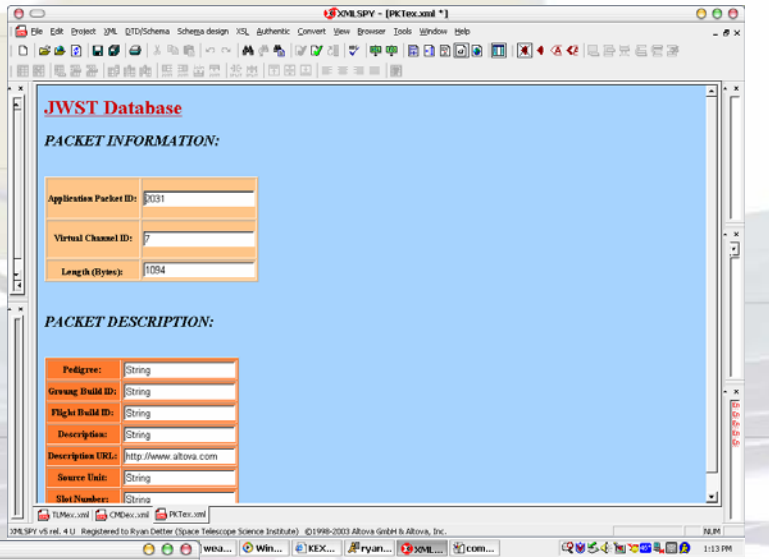
Why XML

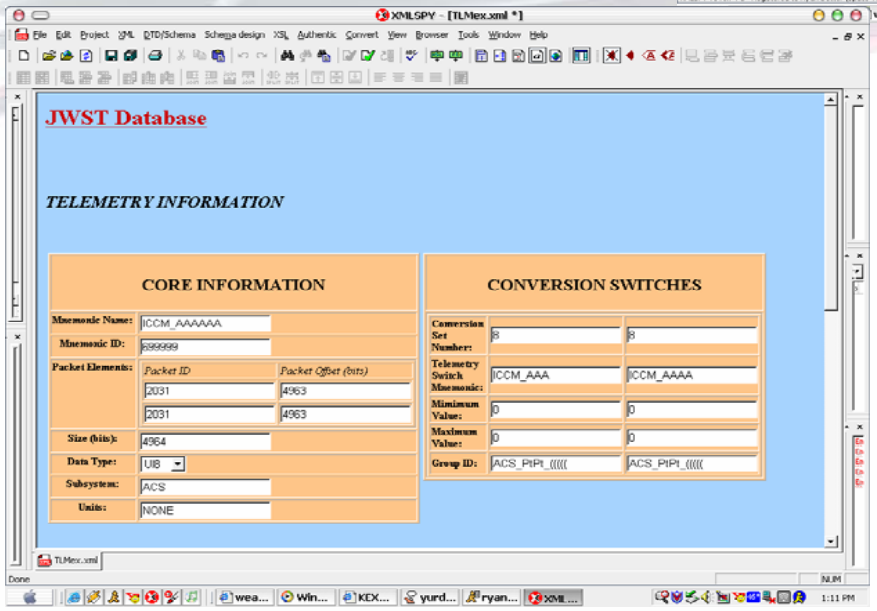
- Trade between relational DB (Oracle/MS–Access) and XML
- Use of XML to:
  - Code controlled by open source not vendor
  - Develop ability to use multiple system formats (ECLIPSE, ASIST, EPOCH, html, ASCII)
  - Create a more descriptive database via attributes, tags, and structure (self documented)
  - Allows to combine other data (CM, comments) with Command and telemetry
  - Easy to change and backward compatible.
- Two advantages of Relational DB
  - Validating relation between “rows” (no duplicated commands, etc)
    - JWST enhanced XML with scripts and XREF
    - Validate the database automatically by schemas and scripts
  - Response time: XML is used for controlling data for systems use proprietary format (Rational Rose, Eclipse)

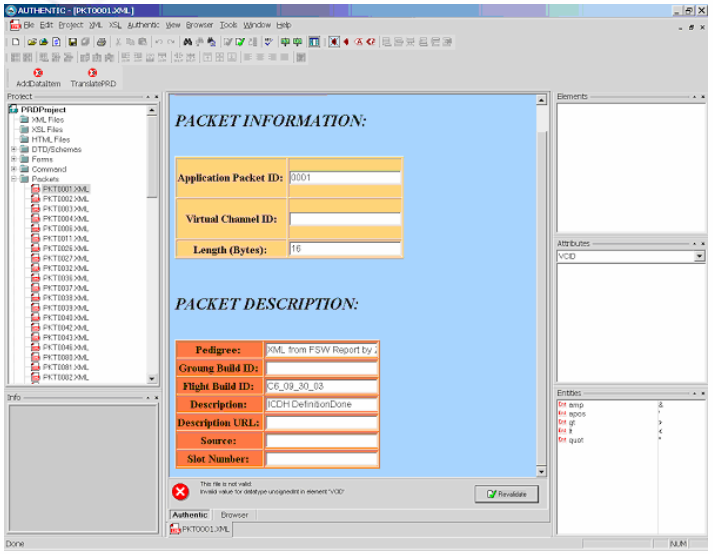
- **and GSAW quote: XML is ASCII of the future**

JWST User Interface









XTCE

- In 2005 OMG baselined XTCE version 1.0
- JWST evaluated XTCE and had major concern of using it.
- JWST worked with JPL and developed a combined XML schema, called JMX
- In CCSDS /OMG meting at Atlanta September 2005 JWST agreed to work within the current standard team and improve XTCE by submitting RFA.
- ESA (Mario Merri) and JWST collaborated on developing the CCSDS Green and Magenta book showing how to use the standard
- While developing the CCSDS Green and Magenta books developed over 120 RFA against XTCE to be incorporated in XTCE version 1.1
- OMG accepted XTCE 1.1 in November meeting
- CCSDS adopted XTCE 1.1 in January 2007 meeting

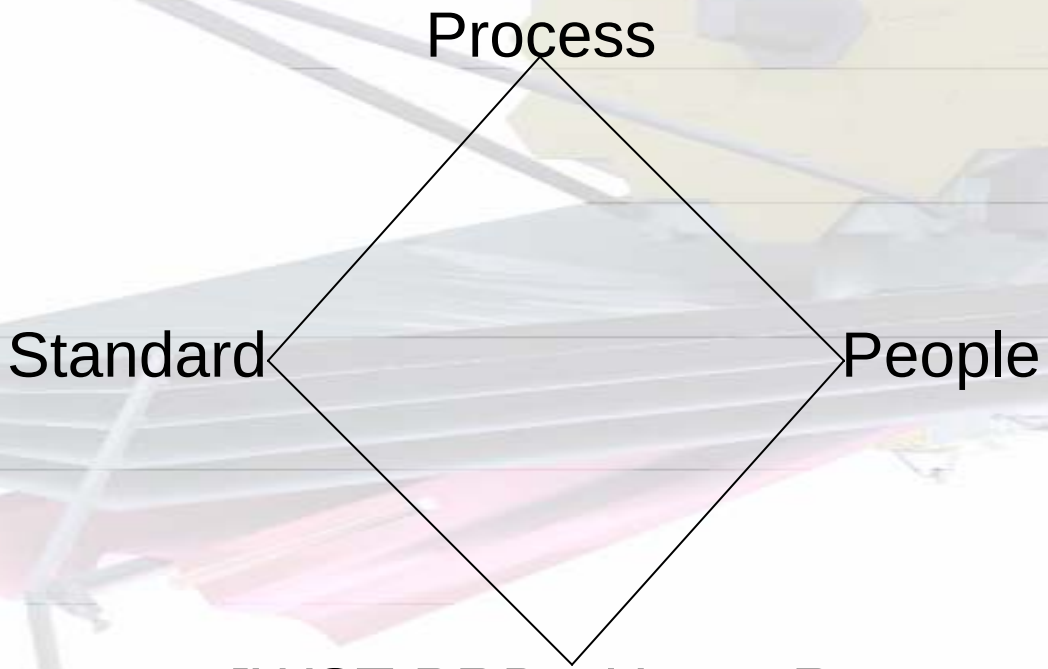
XTCE use by JWST

- JWST will continue using it's XML database schema
- JWST can import export to XTCE and can exchange data with other XTCE systems (e.g. XTCE compatible)

- XTCE has elements to support TDM that are not needed by JWST
- We want our schema to look like our CCSDS commands and telemetry

- XTCE is used for Command and telemetry **exchange** between systems it does not support all mission data
- JWST database has elements (such as configuration management and FSW) that are not part of XTCE

If You build it they will come…



JWST PRD= Home Run

XTCE future users

- JWST is willing to help other programs to adapt XTCE:
  - Worked with Applied Physics Laboratory (APL) summer 2006 and provided schema
  - Met with LMDC (Landsat) January of 2007
    - Landsat is planning to adopt the JWTS PRD implementation
    - It provides standard for S/C vendor to deliver data to mission ops (similar to ESA module)
  - Gave presentation to NASA Constellation (Cx), waiting to hear back to schedule demo at GSFC
  - Raytheon/Eclipse will accept native XML in 2008 version

Take Away

- Need Program Offices to require use of XTCE for data exchange.
- JWST translation tools, processes are available open source to modify as needed
- JWST CM process provides value add to XTCE
- PRD can be core components elements of CGS (common Ground System)
- Improved modularity and interoperability by decoupling data structure from telemetry and command system
- less lock in to proprietary COTS solution : Program data structure retained by Program Office
- Anticipate that any COTS compliant with ESA/SCOS 2000 XTCE integrated with minimal effort (trending, web browser access, batch decom, engineering archive)

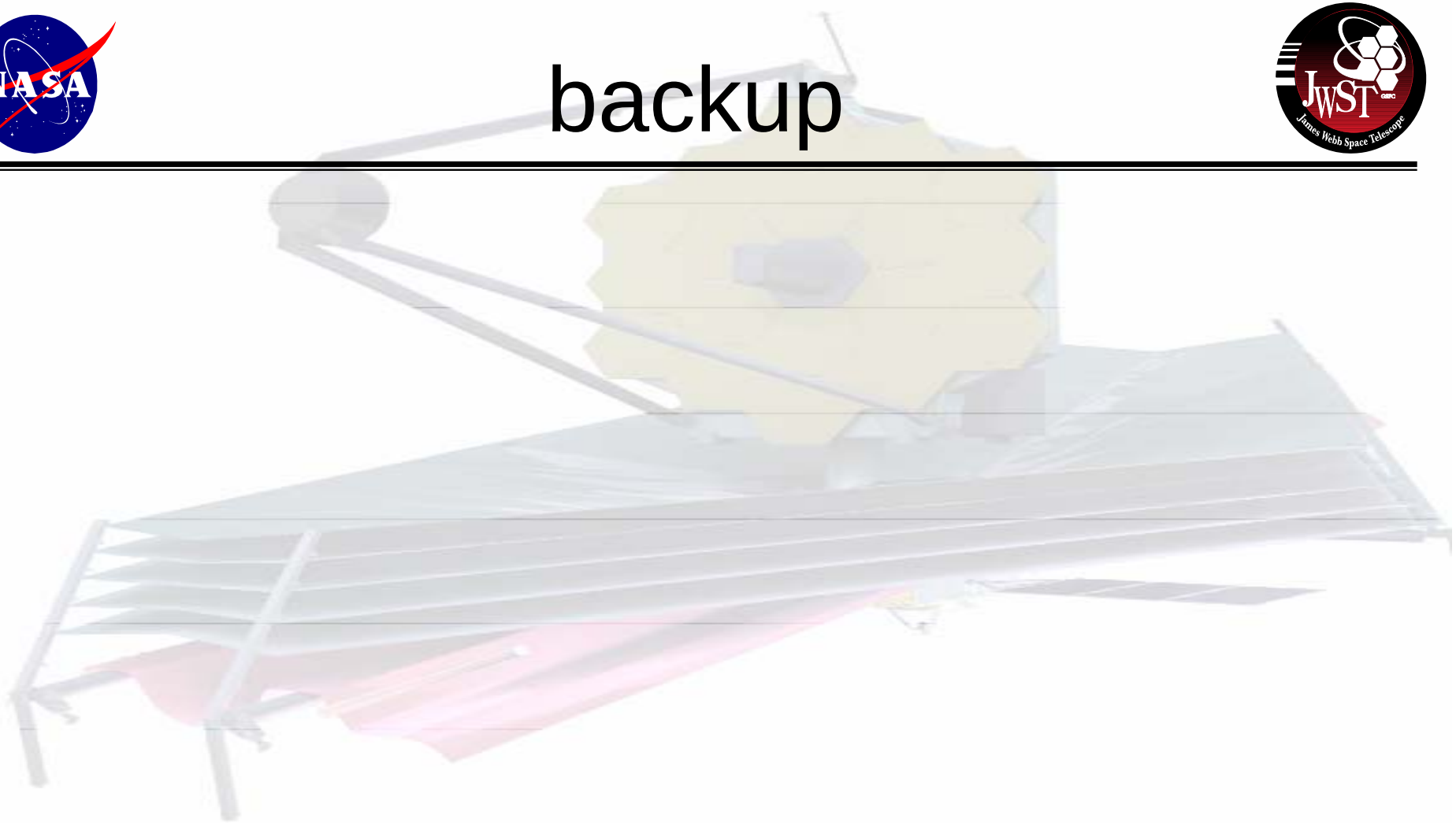
Summary

- Ops plays major role in success of JWST
- To meet mission requirements architected an adaptable and robust flight and ground system
- Mission database is one of major elements of operations architecture
- Organization & process are critical in the success of infusing new-technology/standard
- Hope we got you excited about XTCE !!!

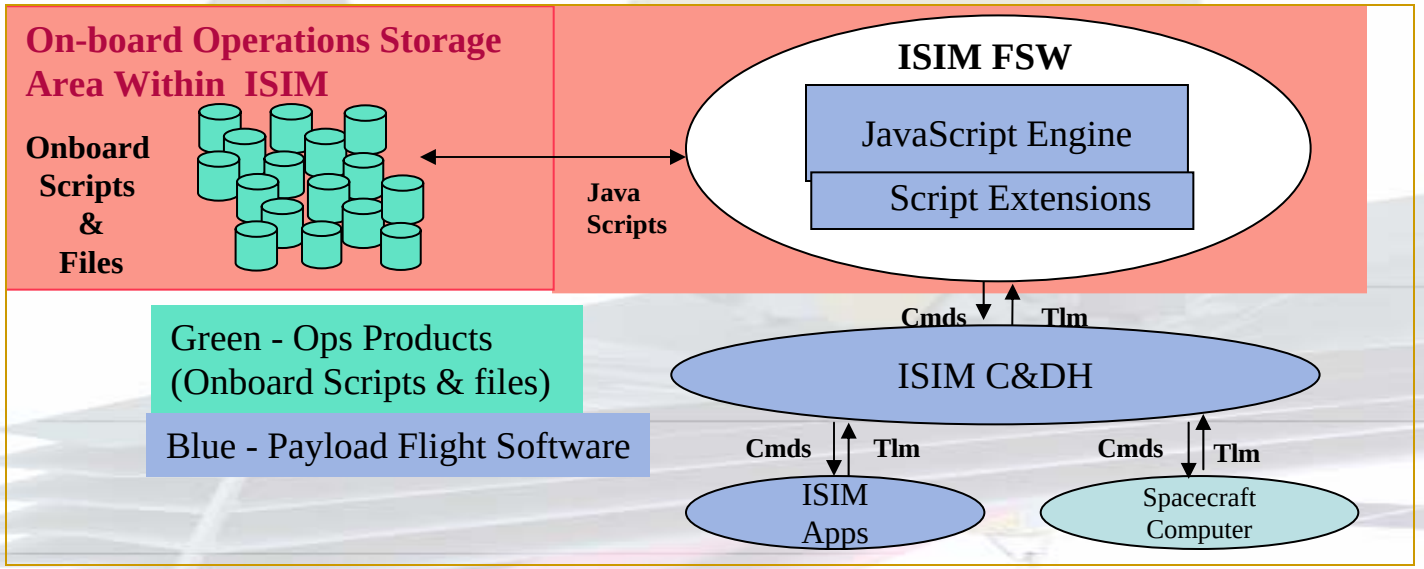
GSAW Quotes

- **Quotes from previous GSAW conferences applicable to this paper:**
  - **Ground is the key to flexibility**
  - **Use of frameworks for adaptive design/architecture**
  - **XML is ASCII of the future**
- **This years quote:**
  - **Excited about XTCE**

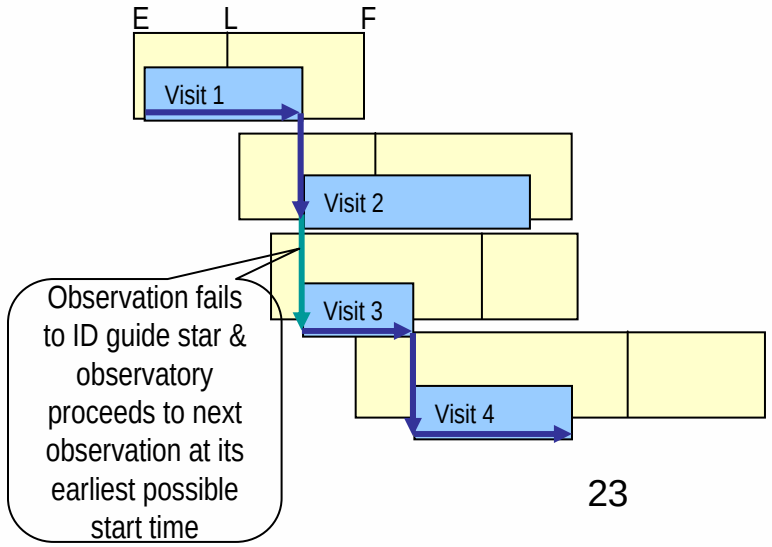
backup



On Board Script Operations



- STScI provides onboard scripts to:
  - manage the event driven sequencing of activities(Operations Plan Executive – OPE)
  - issue the commands to the science instruments FSW, ISIM FSW, and the spacecraft to accomplish the intended objective
  - calculate spacecraft offsets including removal of optical distortions and performing coordinate transformations
- Scripts are organized into a set of "Visit" Files: A sequence of observations specified by earliest start time, latest start time and finish times is uploaded.
- Ground system can ensure that start & finish times in list do not violate any constraints.



JWST Ground System Implementation Decisions

- Use the operational command and telemetry system for development and I&T (CCSDS standard for packets)
  - Use the same data and interfaces throughout the life of JWST
- Project Reference Database (CCSDS XTCE compatible)
  - Common area for all mission-related information
  - Data independent of any system
- CCSDS File Delivery Protocol (CCSDS CFDP)
  - Increase data reliability by providing a reliable file downlink protocol
- Onboard scripts
  - Use modular and common components onboard (JAVAScripts)
- Batch decommutated data separate from C&T
  - Common generic format for all engineering data
- Engineering archive and trending
  - Common engineering data store for the life of the mission