



MAST
Users
Group
Meeting

January
14-15,
2016

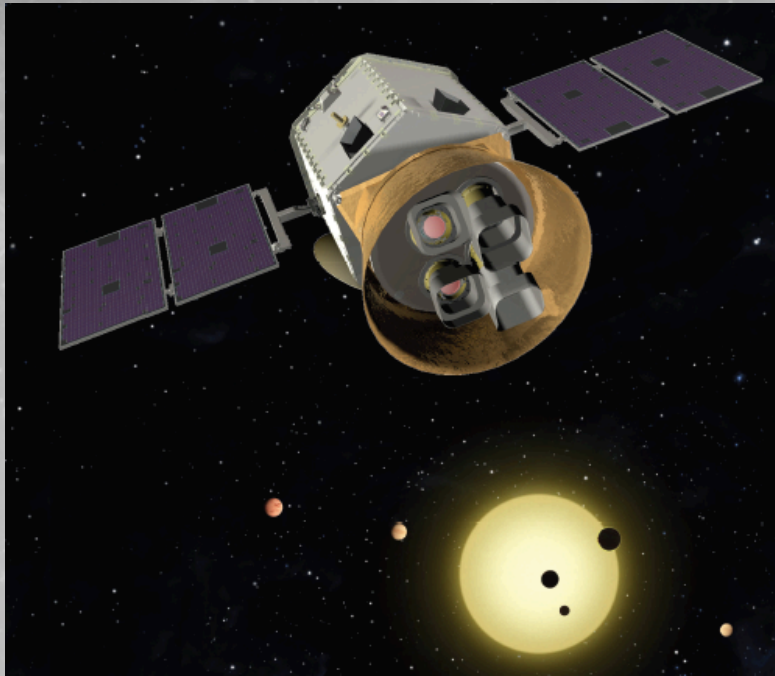
MAST Users Group: TESS

W.B. Sparks
Jan 2016



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Transiting Exoplanet Survey Satellite (TESS)
P.I. George Ricker, MIT

NASA Astrophysics Explorer Mission
Launch : 2017

An (almost) All Sky Survey of Bright Stars: four cameras cover $24^\circ \times 96^\circ$ FOV from ecliptic latitude 6° to the ecliptic pole: 27 days continuous observation per sky sector

Detect transits of Earths / Super-Earths around brightest (I mag < 12) stars with periods < 10 days. $\sim 200,000$ stars uniformly distributed on sky – search local solar neighborhood

- F, G, K dwarfs: 4 to 12 magnitude
- M dwarfs known within ~ 60 pc
- $\sim 200,000$ stars in two years

Omit ecliptic plane to provide continuous viewing of ecliptic pole.

- *Detect transiting Earths in habitable zone of M stars*
- *Targets for JWST continuous viewing zone*

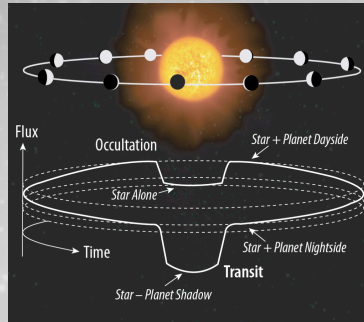
30,000 square degrees observed for at least 27 days; 900 square degrees for more than 300 days



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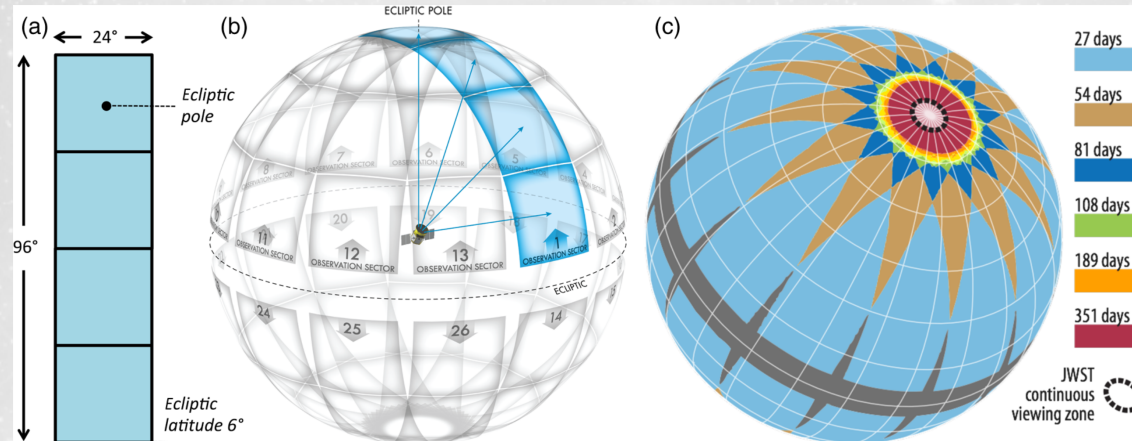
TESS Science Goals



Discover Transiting Earths and SuperEarths orbiting bright, nearby stars

- Rocky planets
- Water worlds
- Habitable zone planets

Discover the “Best” ~1000 Small Exoplanets



(a) The instantaneous combined field of view of the four TESS cameras. (b) Division of the celestial sphere into 26 observation sectors (13 per hemisphere). (c) Duration of observations on the celestial sphere taking into account the overlap between sectors. The dashed black circle enclosing the ecliptic pole shows the region which James Webb Space Telescope will be able to observe at any time.

From: Ricker, G.R., Winn, J.N., Vanderspeck, R. et al, (2015) *J. Astron. Telesc. Instrum. Syst.* 2014;1(1):014003. doi:10.1117/1.JATIS.1.1.014003; *Transiting Exoplanet Survey Satellite*

See also: See Ricker et al (2014) *SPIE 9143, Space Telescopes and Instrumentation 2014: Optical, Infrared, and Millimeter Wave*, 914320 (August 28, 2014); doi:10.1117/12.2063489



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Transiting Exoplanet Survey Satellite (TESS) STScI roles

Project management: Goddard
P.I./Technical: MIT, Lincoln Labs
Data processing: NASA Ames, CfA

STScI:

Science Data Archive: TESS archive system engineer - Daryl Swade (OED)

- Kepler Data Management system heritage at STScI; Kepler pipeline heritage at NASA Ames.
- Archive all raw data, selected engineering data
- Archive all high level science products
- Design and deploy user interface for search and retrieval based on mission-supplied FITS files
- Fully integrate TESS science data into the MAST infrastructure
 - Includes funding in MAST overguide in NASA archives programmatic review

Education/Public Outreach: STScI had been selected to lead E/PO program; now TESS will be implicitly part of (thematic) education element; outreach and communication up to the TESS mission.

GI program, Community follow-on: STScI had proposed science enhancement options: NASA directed Goddard and (in work) NExSci to carry out instead (STScI still hosts TESS-funded follow-up).

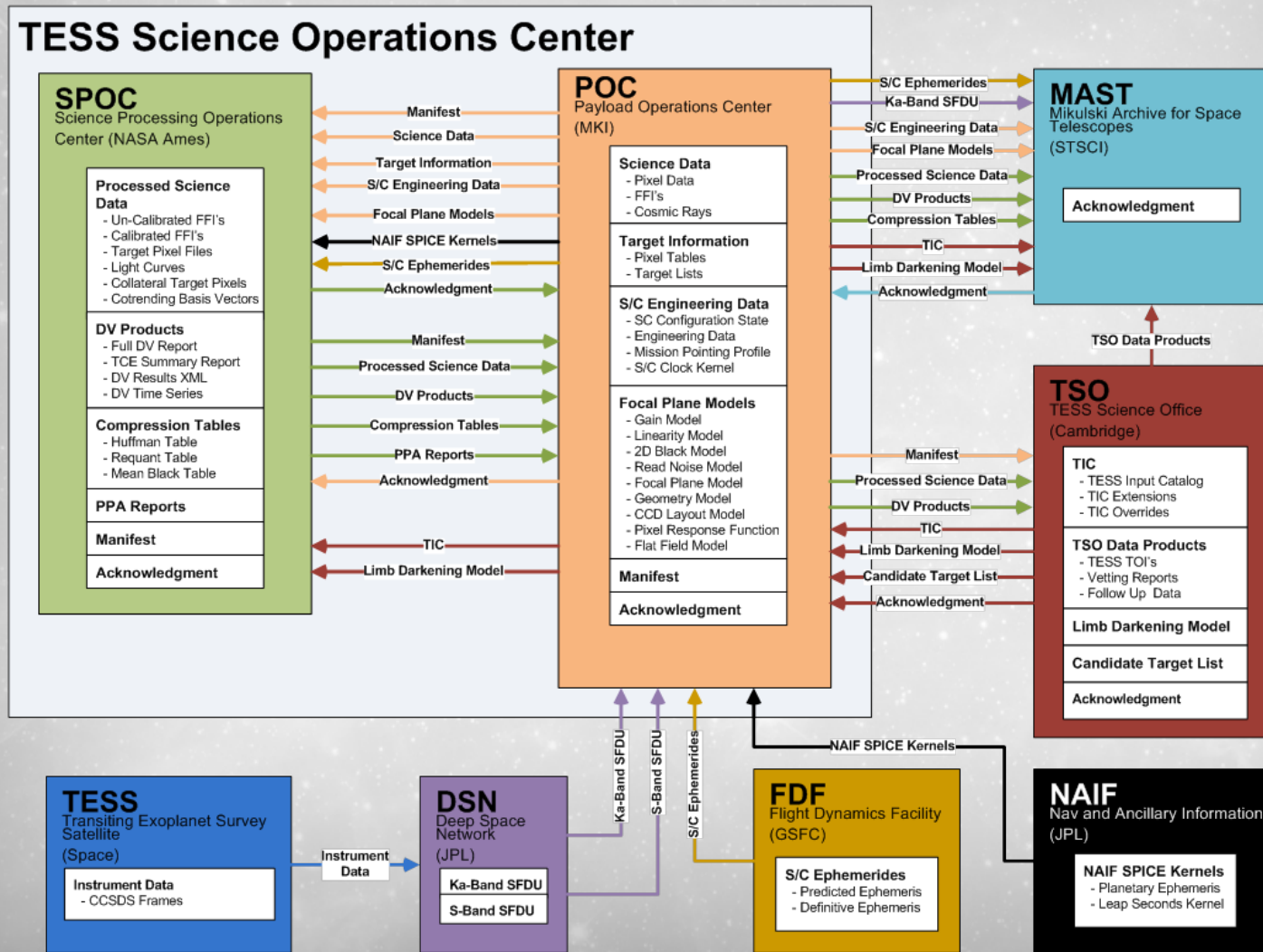
Science Team: Peter McCullough



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MAST Interfaces





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STScI TESS Staff

- ◆ Community Missions Office
 - Marc Postman
 - William Sparks
- ◆ TESS Science Team
 - Peter McCullough
- ◆ Operations and Engineering Division Management
 - Rick White
 - Alessandra Aloisi
- ◆ Systems Engineering
 - Daryl Swade
- ◆ Archive Sciences Branch
 - Karen Levay
 - Scott Fleming
- ◆ Data Systems Branch
 - David Wolfe
- ◆ Data Processing and Archive Services Branch
 - Faith Abney
- ◆ Information Technology Services
 - Patrick Taylor
 - Ron Russell



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Archive Services

Archive services provided by **Mikulski Archive for Space Telescopes (MAST)**:

- **TESS Mission**
 - Data storage
 - Ka-band SFDUs
 - Results of pipeline processing:
 - light curves with 2 min sampling
 - full frame images (FFIs) at 30 min cadence
 - pixel files
 - Calibration and spacecraft monitoring
 - Catalogs
 - including TIC, TOI lists
 - Follow-up data
- **Astronomical user community**
 - Data documentation
 - Metadata query
 - Data search and discovery
 - Data mining
 - Data retrieval and distribution



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Archive Operations Concept

- TESS archiving by sector
 - Target pixel files and light curves generated for each source each sector
- Transferred via network from POC
 - POC is central hub for all science data
 - SFTP site hosted at POC for data distribution
 - TOI lists transferred from TSO
- TESS archive data volume ~38 TB/year
 - Reprocessed data increase transfer data volume, but archive data are superseded.
- No proprietary period on data
 - Data archived and public typically within a few days after receipt from POC
- Primary TESS web site hosted by MIT
 - Links to MAST web site



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Data Volume Estimates

Data Type	Data Volume (GB/sector)	Data Volume (GB/year)	Notes
Ka-band SFDUs	270	3500	Level 0 data for safe keeping
Uncalibrated FFI	530	6900	30 minute cadence
Calibrated FFI	1060	13800	566 MB Full Frame Image file
Target pixel files	980	12800	25000 targets/month, 100 pixels/target, 2 minute cadence
Light curves	50	600	One per target per sector
Total	2890	37600	

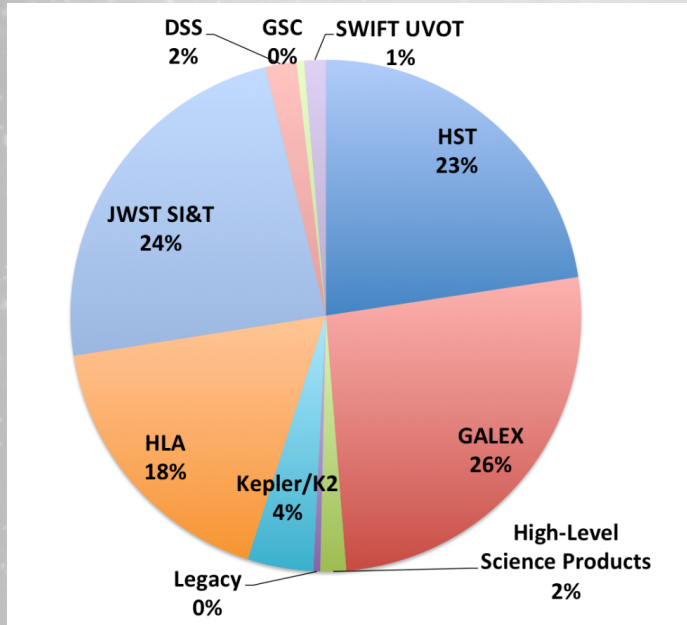
Annual data volume uncompressed except for SFDUs



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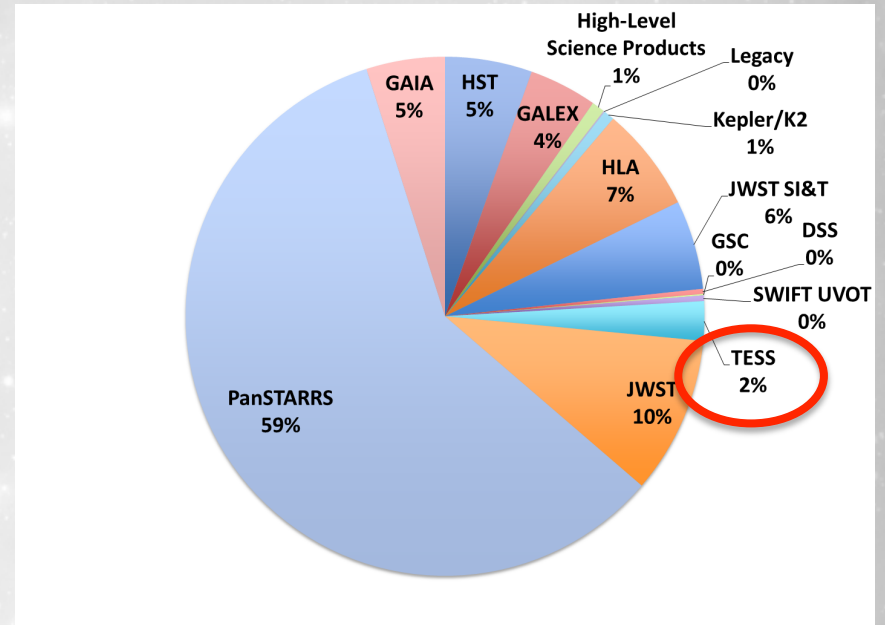
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MAST Data Volume



July 1, 2015

- 496 TB of archive data
- > 2 TB/month – average ingest
- 14 TB/month avg. data distribution
- 2 million average searches/month



January 1, 2020 estimate

- 3 PB of archive data
- Two-year TESS mission
- PanSTARRS data release Jan 2016 (est.)
- GAIA – 4 DRs before 2020, final expected 2022



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Archive User Interface

- Makes TESS data available to the astronomical community
 - Web-based query/preview/retrieval interface
- Hosts software tools required to search the TESS archive catalog
 - Explore and discover data through the Data Discovery Portal
 - Search for data products by:
 - Data file name
 - Target name, position or list of positions
 - Other observation parameters (instrument, waveband, program ID, etc.)
- Hosts software tools required to access and retrieve data
 - User account management shared across missions
- Provides data mining, visualization, and correlation with other major mission datasets
 - International Virtual Observatory Alliance (IVOA) standards compliant



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MAST Portal

Select Collection: All MAST Observations
Search: Enter object name or RA and Dec
Examples: M80, 13:29:56.47-13:50:11, More Examples..., Random Search

Start Page | NGC-6791 | Displaying 1465 of 1970 Total Rows | Footprints: All

Filters: Clear Filters | Edit Facets... | Help...
All Checked | Unchecked | Filter All Record Fields

Product Type:
Sort Alphabetically
 spectrum (876 of 876)
 Lightcurve (581 of 796)
 image (8 of 298)

Mission:
Sort Alphabetically
 HST (884 of 884)
 TESS (581 of 581)
 Kepler (0 of 215)
 TESSFF1 (0 of 184)
 KeplerFF1 (0 of 102)
Show 2 more...

Instrument:
Sort Alphabetically
 WFC3/IR (880 of 880)
 TESS (581 of 765)
 Kepler (0 of 317)
 WFC3/UVIS (4 of 4)
 UVOT (0 of 3)
Show 1 more...

Project:
Sort Alphabetically
(884 of 884)

ID	Actions	Preview	Mission	Instrument	Filters	Wav
579			TESS	TESS	TESS	C
580			TESS	TESS	TESS	C
581			TESS	TESS	TESS	C
582			HST	WFC3/IR	F139M	I
583			HST	WFC3/IR	G141	I
584			HST	WFC3/IR	G141	I

AstroView: 19:30:10.445 +47:45:18.04
19:28:59.345 +47:58:10.46
RA DEC
hhmmss/deg

Sample MAST search results showing TESS light curves and HST.



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Archive Schedule

Completion Date	Component	Task
September 2015 (GSIT-1)	Data Receipt	Implement data transfer with SOC
July 2016 (GSIT-2)	Data Receipt	Generate ingest manifest for target pixel data and light curves
July 2016 (GSIT-2)	Data Receipt	Generate ingest manifest for FFIs
July 2016 (GSIT-2)	Ingest	Populate target pixel and light curve archive catalog tables
July 2016 (GSIT-2)	Ingest	Populate FFI archive catalog tables
July 2016 (GSIT-2)	Ingest	Populate TIC and TOI archive catalog tables
July 2016 (GSIT-2)	AUI	Search and retrieve target pixel data and light curves
July 2016 (GSIT-2)	AUI	Search and retrieve FFIs
July 2016 (GSIT-2)	AUI	Query TIC and TIO tables
May 2017 (GSIT-3)	Data Receipt	Generate ingest manifest for DV results and time series
May 2017 (GSIT-3)	Ingest	Populate DV results and time series archive catalog tables
May 2017 (GSIT-3)	AUI	Search and retrieve Transit Planet Search and Data Validation transit-related data
August 2017 (launch)		Develop TESS Archive User's Guide



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BACKUP

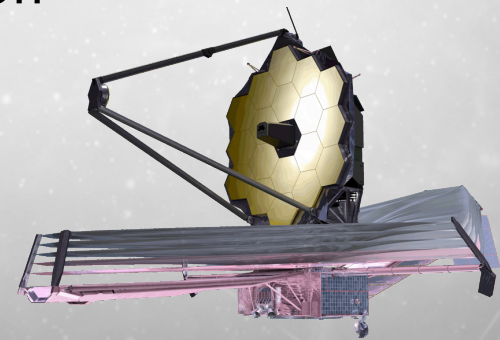


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TESS Science Legacy

- TESS will discover new exoplanets transiting the “best stars” for follow up: the nearest and brightest stars
 - TESS will monitor ~200,000 stars
 - TESS science goals focus on
 - Earths and super-Earths ($<2.0 R_E$)
 - Host stars with stellar types F5 to M5
- TESS aims to provide JWST with the best exoplanet targets for detailed characterization

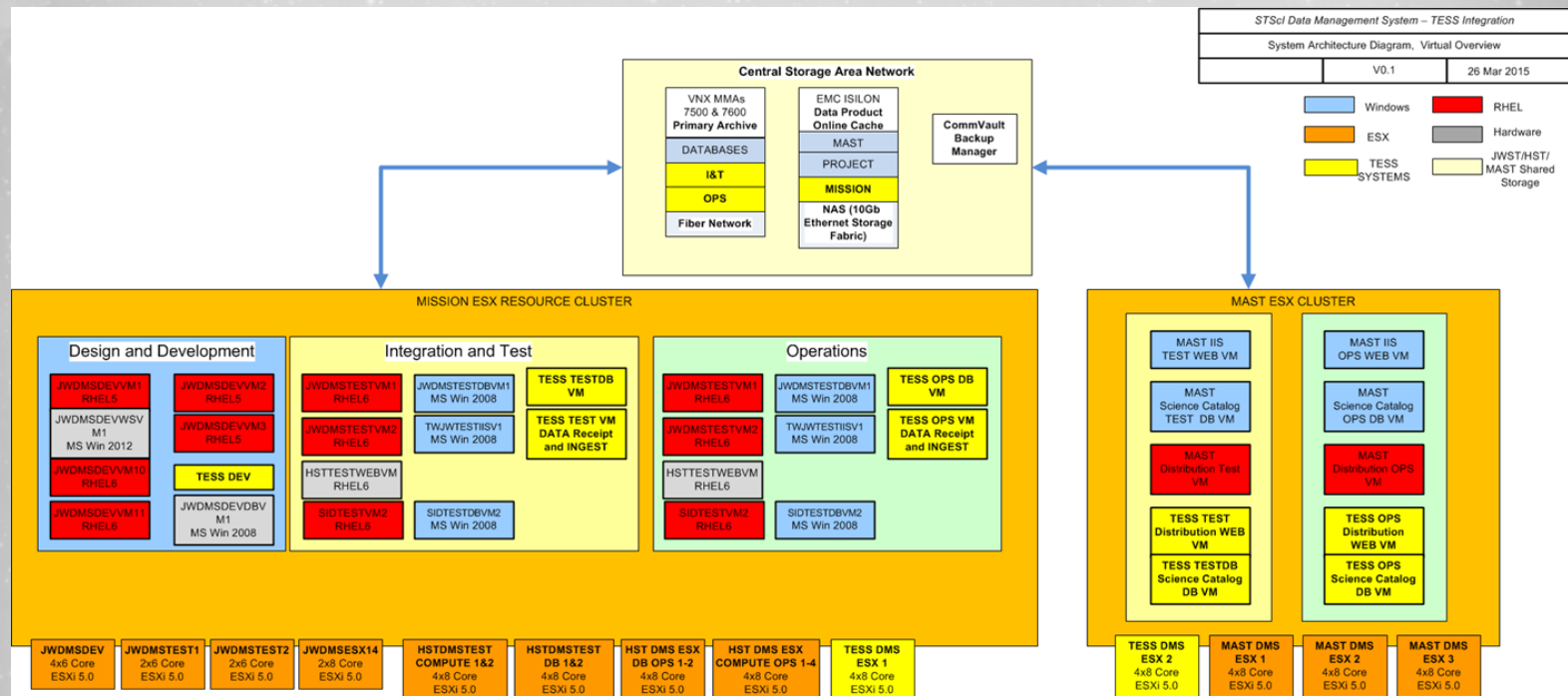




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Hardware Overview



- TESS hardware will be integrated into existing architecture
 - Shared VMWare ESX infrastructure with MAST and mission operations systems
 - Two physical nodes will be deployed in Virtualized Architecture
 - I&T and Operations