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TESS Project Manager Emeritus

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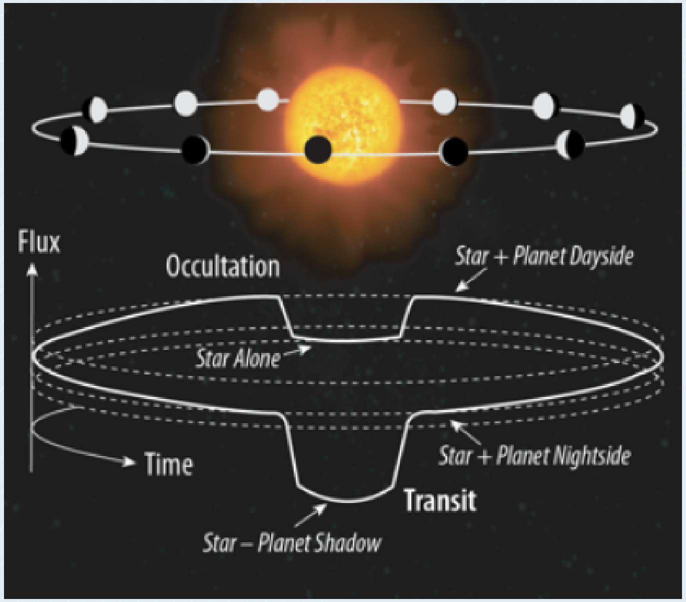
Transiting Exoplanet Survey Satellite (TESS)



Primary Goal: Discover Transiting Earths and Super-Earths Orbiting Bright, Nearby Stars

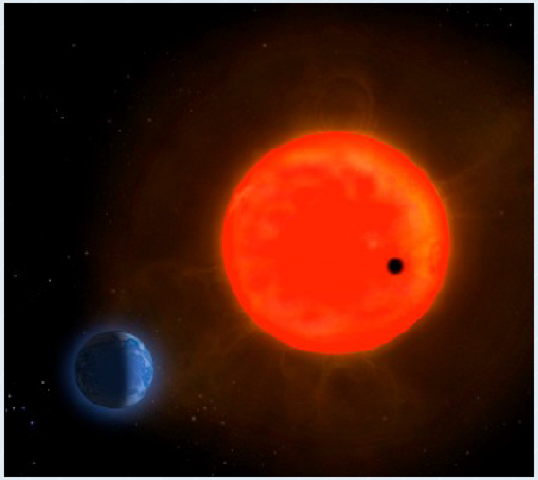
- *Rocky Planets & Water Worlds*
- *Habitable Planets*

Discover the "Best" ~1000 **Small** Exoplanets

- *"Best" Means "Readily Characterizable"*
  - *Bright Host Stars*
  - *Measurable Mass & Atmospheric Properties*
- *Present: <u>Only 3</u> small transiting exoplanets orbiting bright hosts are known*

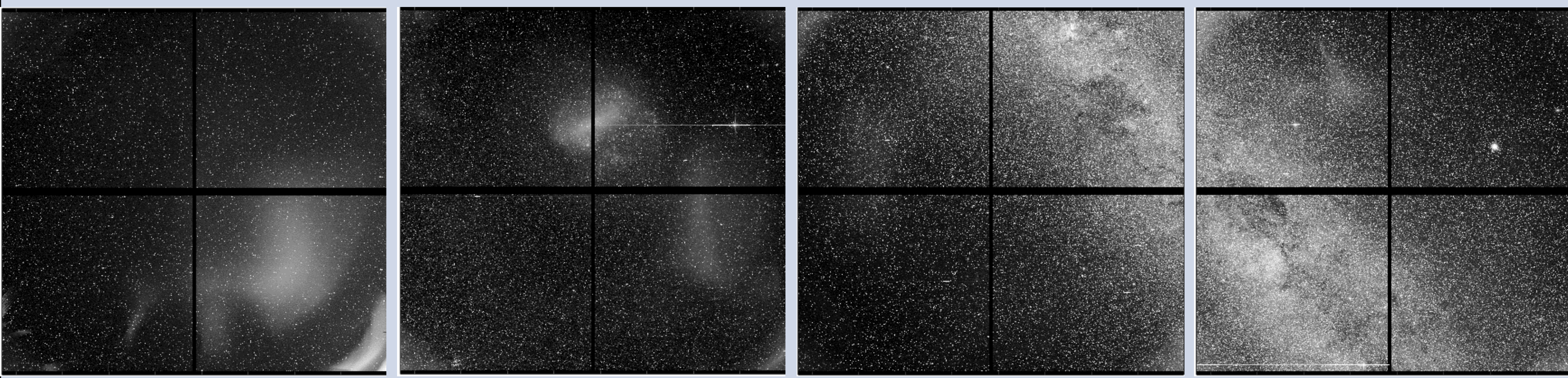
Large Area Survey of Bright Stars

- *Sun-like stars: $I_c \lessapprox 2$ to $I_c = 12$ magnitude*
- *M dwarfs known within ~60 parsecs ($I_c \lessapprox 14$)*
- *"All sky" observations in 2 years:*
  - *> 200,000 target stars at <2 min cadence*
  - *> 20,000,000 stars in full frames at 30 min cadence*



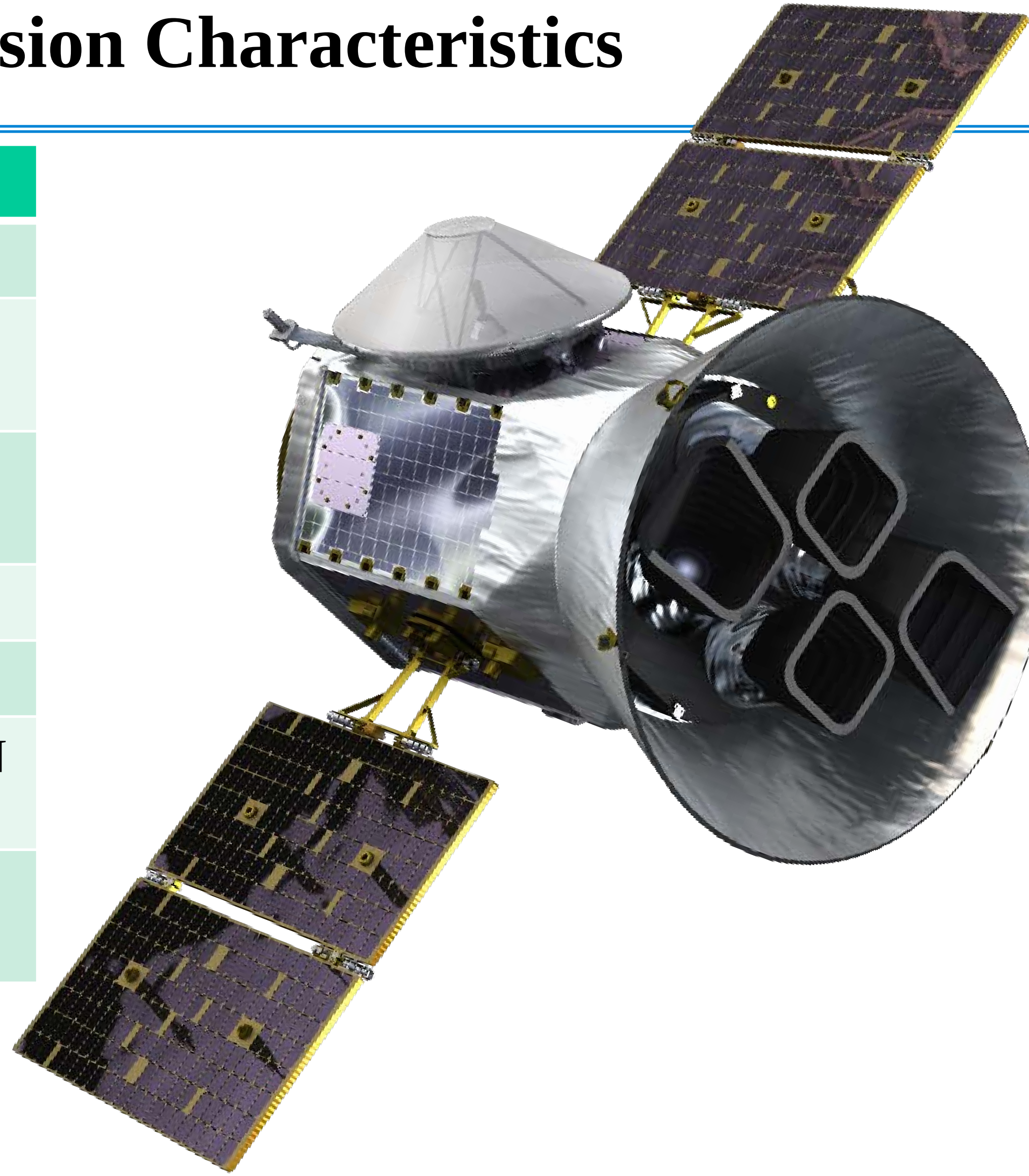
TESS Field-Of-View (24°x96°)

Kepler Field-of-View



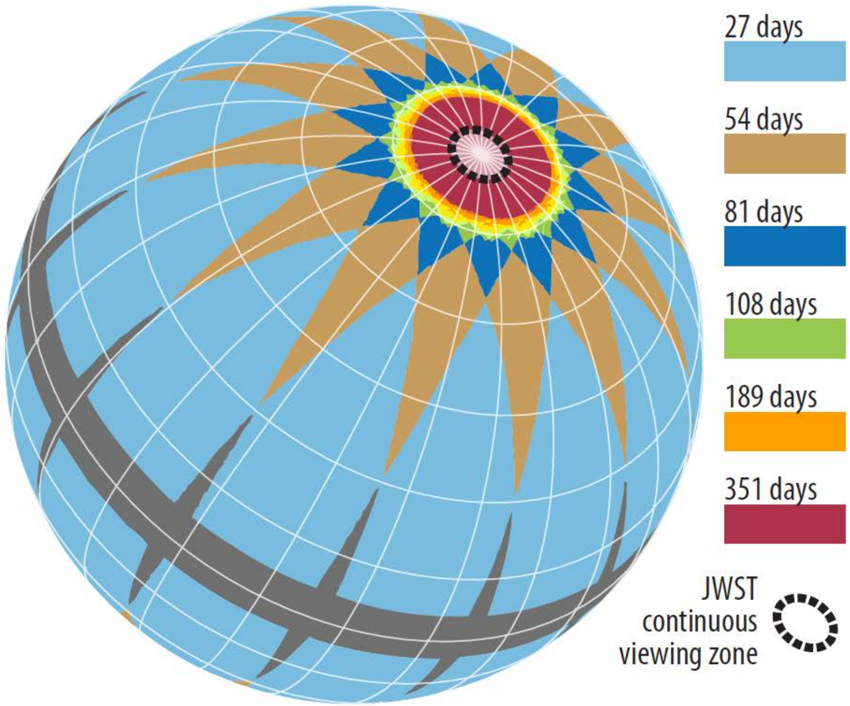
TESS Mission Characteristics

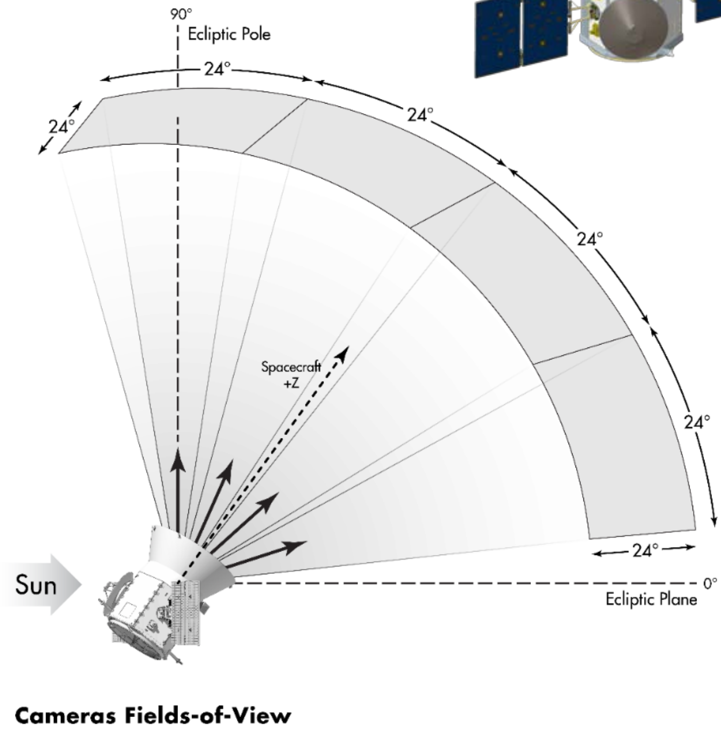
Mission Summary	
PI Cost Cap	$246 M (RY$)
Launch Vehicle	SpaceX Falcon 9 from KSC/CCAFS
Spacecraft	Orbital ATK (OA) LEOStar-2
Launch	April 18, 2018
Orbit	Lunar resonant P/2
Ground Terminal	SN (early orbit) & DSN
Mission & Science Ops	24 months Phase E Operated from OA

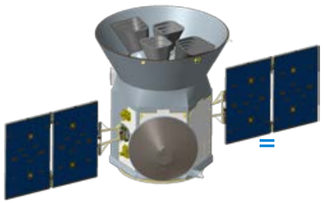


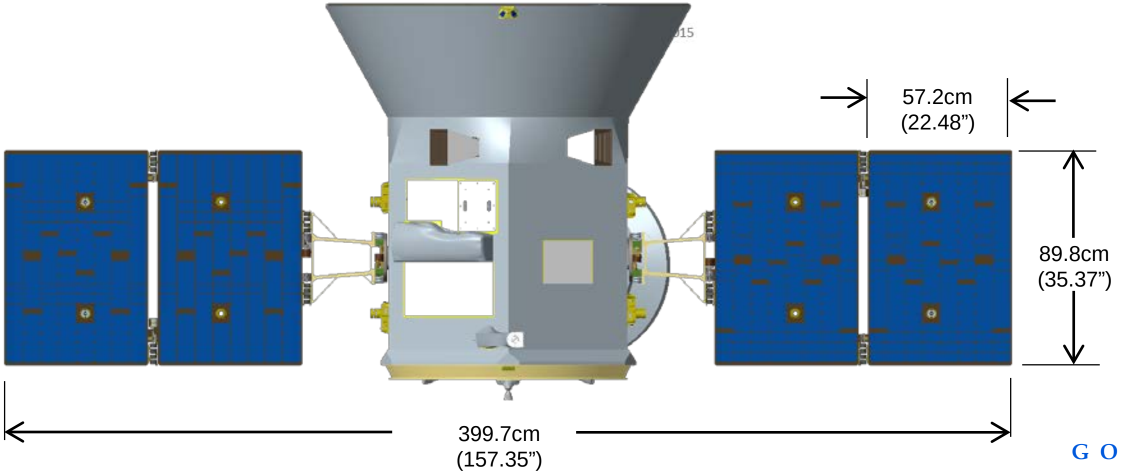
The TESS mission was managed by the Explorers Program Office at NASA Goddard Space Flight Center (GSFC)

Observatory Design & Operations









PI Cost Cap: $200M
Dry Mass: 385 Kg
Power: 479 W

TESS Lessons Learned – Technical Maturity

- Evaluate TRL6 issues and required investments – that's the easy part
- Evaluate flight heritage claims and make sure you understand:
  - How early you will need to start work on key components based on risk level
  - What components will require prototypes/risk reduction units to be built/tested
  - When fixed price vendor contracts are appropriate and when they are not.
  - What your back up plans would be if you run into trouble maturing baseline components
  - When can you declare "enough" success on risk reduction efforts if they fall behind schedule
- Make sure requirements for lower maturity areas are worked early and in great detail
- Make sure the teams working low maturity areas are "deep" enough to handle unknowns
- Don't take on maturity challenges if you don't need them to meet requirements
- Communicate early regarding where variations from the standard NASA linear system engineering process should be considered (rapid prototyping, spiral development, etc.)

TESS Lessons Learned – Working With NASA

- Build a good working relationship with NASA from the start
- Staffing
  - – Make sure you have key team members who understand government contracting
  - – Make sure you have adequately staffed functions required by government contracting and have the tools to support government requirements in areas such as:
    - Financial reporting and analysis
    - Technical reporting and reviews
    - EVM if appropriate
    - Schedule development and maintenance
    - IT Security
    - Contract management
    - Project lifecycle product development as defined in NASA 7120 and other resources
  - – Make sure you understand the FAR, the flexibility available in applying specific FAR clauses, and the implications on your effort – especially in areas such as:
    - IT security
    - Data Rights

Misunderstandings or efforts to radically change government regulations and processes after you get started – can cause significant delays in contract awards and technical work

TESS Lessons Learned – Build What You Propose

- Explorer missions move through the lifecycle fast and there is limited time – even in Phase-B - to "improve" the concept you developed in Phase-A

- "Improving" the mission so that it can achieve science beyond the Level-1 requirements, should be discussed with NASA before being considered

- Phase-B should be primarily focused on:
  - Getting a head start on the low maturity areas of your design
  - Thoroughly documenting requirements (driving down to low level requirements in the low maturity areas)
  - Defining and initiating long lead procurements (with NASA approval)
  - Building and testing prototypes and risk reduction units

- Don't underestimate the time and challenges of "cranking the crank" on the myriad of power, thermal, mechanical, STOP, etc., analyses that need to get done on the final design.
  - Every time you "tweak" the design – you may reset the analysis cycle by 4 to 6 months
  - Many analyses also drive launch Vehicle requirements – make sure these are done early enough to impact the LV procurement specifications

TESS Lessons Learned – Make Vs. Buy

- Buy:
  - Make sure you have team members with the skills to manage vendor contracts – starting with being able to build a strong specification, laying out a payment structure that incentivizes the vendor to support your needs, and laying out a review schedule that will ensure you can closely track progress
  - Evaluate the maturity level of what you are buying and ensure that the contract structure and terms are appropriate for the maturity level of the product
  - Make sure the contractor has adequate bench strength if you are procuring a system without flight heritage since technical challenges are bound to come up

- Make:
  - Make sure you have a workforce with the skills/expertise/experience to take on this responsibility
  - Make sure you have the technical bench strength if you are building a system without flight heritage
  - Think about what you would do if you start to fall behind schedule – do you have surge capability available – if not – where can you get some from

TESS Lessons Learned – Schedule Adherence

- Focus early on ensuring you have a plan for bringing on team members with the skills required to meet each set of challenges as you progress through the schedule.
  - Don't trying posting requisitions and doing job searches right before you need to bring on a specific skill
  - Ensure that you are staffing with team members who have experience in delivering flight hardware
  - Leverage NASA expertise and experience to augment your bench strength as necessary – don't perceive you need to solve every problem yourselves
- Falling behind in some areas can have significant ripple impacts as the slow to mature area may require changes in resources or interfaces that require rework in areas that have matured more quickly
- Develop a strong schedule early, get the team members to buy into the schedule, and track progress closely – applying additional resources or making other modifications to the plan if some work starts to fall behind
- Identification of long lead procurement needs and low maturity development needs should be done early to ensure that these areas are properly resourced
- Establish reasonable descopes early on to allow for some flexibility during execution
- Identify and work to mitigate key risks that could result in significant schedule impacts