TESS

TRANSITING EXOPLANET SURVEY SATELLITE

Under the guidance of Professor Stephen Robinson

Abhinav Kamath | Evan Lange | Inbal Shlesinger | Michael Gonzales | Robert Hodgson

Mission Objectives

High-level:

- Survey 200,000 of the brightest stars near the sun to search for transiting exoplanets
- Use the amount of starlight absorbed by those planets' atmospheres, which could potentially allow us to make spectroscopic observations that can provide details about the planets and their atmospheric compositions.
- Provide us with size measurements of these planets.
- Find ecliptic binary stars
- Cover 400 X larger sky area than Kepler (Span stellar spectral types of F5 to M5)

Timescale:

- Announced for launch on April 5, 2013
- Launched 6:51 pm EDT, April 18, 2018, from Space Launch Complex 40 at Cape Canaveral Air Force Station in Florida
- Planned mission time: 2 years

High-level overall specifications:

- Payload mass: 362 kg
- Dimensions: 1.5 m height, 1.2 m width, 3.7 m width with solar panels extended
- Launcher - SpaceX Falcon 9 Rocket

Description of orbit or trajectory:

The operational orbit chosen for TESS is a highly eccentric, 2:1 lunar resonance orbit of 108,400 by 376,300 km, at an inclination of 37 degrees, timed so that the spacecraft reaches apogee with the moon at a phasing of 90 degrees.

Stakeholders, Requirements and Benefits

Massachusetts Institute of Technology (MIT)

- Mission leader setting the mission objectives
- Operates TESS Science Office for collecting and analyzing data
- Developed camera system on TESS
- Expands exoplanet research for further study by ground based telescopes
- Promotes research by educational research institutions

National Aeronautics and Space Administration (NASA)

- Project management to ensure mission success
- Systems engineering coordination between MIT, Northrop Grumman, SpaceX, and Orbital Sciences Corporation
- Safety and mission assurance for all stakeholders
- Provides launch facility
- Provides venerable space experience and expertise to newer private space corporations

Orbital Sciences Corporation

- Conducts spacecraft operations to fulfill mission objectives
- Gain experience in flight operations from TESS for future missions.

Northrop Grumman

- Designed the LEOStar-2/750 Spacecraft equipped with camera developed by MIT
- Gains knowledge and experience to develop future spacecraft

SpaceX

- Provides launcher for Deploying TESS
- Gains experience and expertise to improve launcher services for future missions

Supplementary Stakeholders

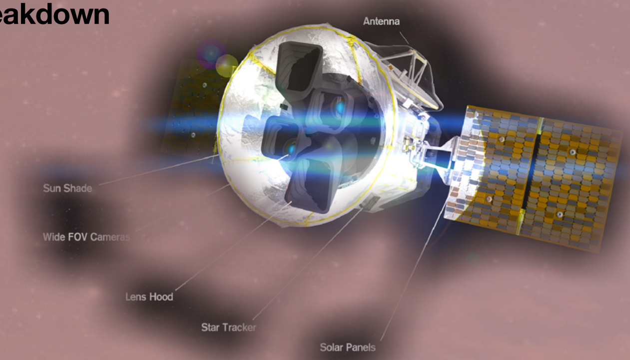
US Taxpayers

- Provide funding to Congress, who allocates tax dollars to NASA for the mission as well as operations and maintenance of launch facilities

Harvard Smithsonian Center For Astrophysics (CFA)

- Analyses the data results from the TESS mission in conjunction with MIT for the TESS Science Office

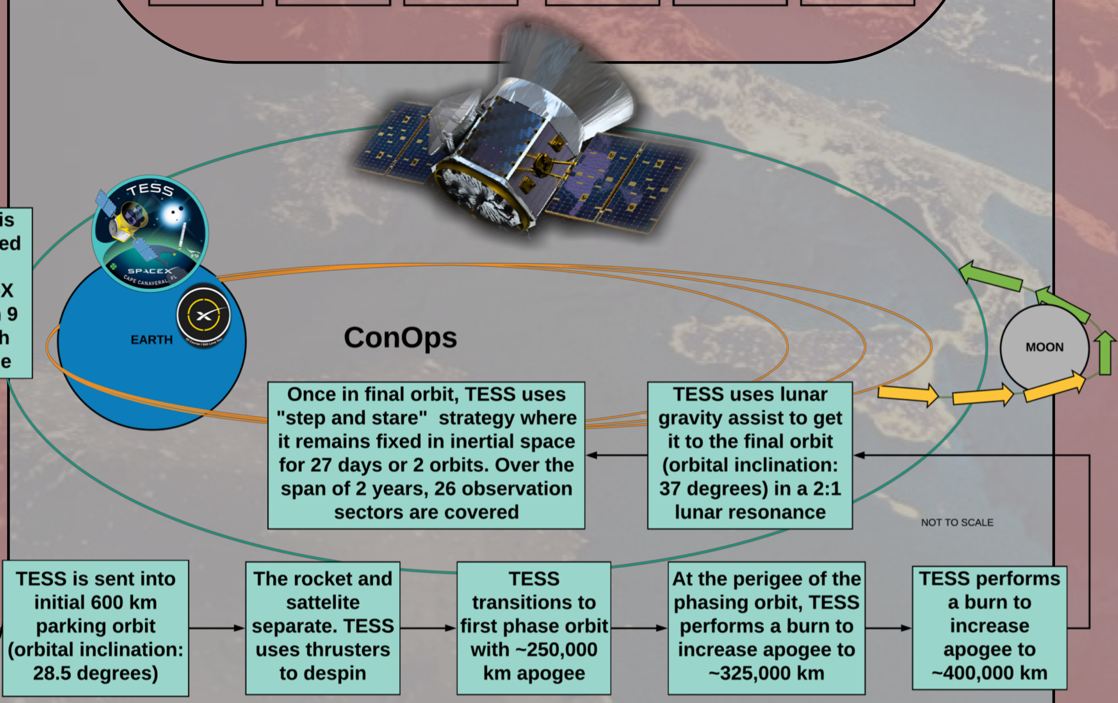
Product Breakdown



TESS

- Launch Vehicle: SpaceX Falcon 9; Hexagonal Body
- Structure: Payload Interface Module
- Power System: Solar Array; Batteries; Power Bus
- CCD Array: Detector; Lens Assembly; Lens Hood; Sun Shield
- ADCS: Star Tracker; 4 Gyroscopes & 4 Sun Sensors; 4 Reaction Wheels; Hydrazine Monopropellant System
- Communications: Ka-Band Antenna Dish; Two S-Band Antennas; Radio Transceiver
- Computation: Data Handling Unit; Master Avionics Unit; Image Processing Board

ConOps



Mission Requirements

- **Power**
  - Maintain power for a minimum of two years
  - Capable of distributing power to instruments
- **Travel**
  - Fit on the Falcon 9 Launch Vehicle
  - Change orbital apogee from 100M to 400M meters
- **Controls**
  - Communicate with mission control on Earth
  - Know where it is and where it's pointing
  - Move with accuracy of up to 1/10th of a degree
- **Observation**
  - Detect a minimum 100ppm change in starlight intensity
  - Switch orientation and not confuse data
  - Derive planetary composition, mass, and size

Potential Improvements

Advanced Communication System:

Increasing the sky coverage to account for the patches currently left out: upgrading the communication system to increase the transmission rate in order to reduce the downlink duration, would give TESS more time for scientific operations without altering the total mission time. As an added advantage, the effects of attenuation on the downlink signal due to atmospheric conditions could be reduced. Also, the signals could be made more secure and immune to attempts of jamming.

Piezoelectric Attitude Control System:

Replacing the existing reaction wheels by a piezoelectric system would reduce the mass of TESS and increase its holding capacity substantially. This would give room for additional instruments in the spacecraft for added functionality (eg: a lunar probe), as well as cutting the cost of launch by allowing other companies to "piggy back" on the launch vehicle.

Camera Reorientation for Intersolar System Survey:

Adjusting the orientation of TESS to survey and map the solar system for future government and private space missions as a residual capability.

Potential Analyses

- In-depth study of the astrodynamics involved in the TESS mission, including the choice of the final orbit and all of TESS' orbital maneuvers to reach it (including the lunar flyby), and calculations regarding the observation sectors, in order to deduce the additional time that would be required to cover the parts of the sky that are currently excluded.
- Optimizing the downlink duration to account for this additional time & to keep the total mission time unaltered: detailed description and analysis of the processes involved with the upgraded communication system, including optimal schemes for coding, modulation and multiplexing of the substantial image data collected, in order to increase the rate of transmission.
- Analysis of the optimal spread spectrum technique to be implemented in order to prevent the fading of transmitted signals due to channel conditions (space and the Earth's atmosphere) that could result in loss of critical data, and also to make the signals more secure and immune to jamming.