National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, MD 20771

Reply to Attn of: 460

MEMORANDUM FOR THE RECORD

The National Environmental Policy Act Compliance for Transiting Exoplanet Survey Satellite

1.0 Introduction

The National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321, *et seq.*), requires federal agencies to consider the environmental impacts of a project in their decision making process. To comply with NEPA and associated regulations (the council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA [40 CFR Parts 1500-1508] and National Aeronautics Space Administration (NASA) policy and procedures [14 CFR, Part 1216, Subpart 1216.3]), NASA has prepared an environmental assessment (EA) for routine payloads launched on expendable launch vehicles (Ref: *Environmental Assessment for Launch of NASA Routine Payloads*, November 2011). The 2011 NASA Routine Payload Environmental Assessment (NRPEA) assesses the environmental impacts of missions launched with spacecraft that are considered routine payloads from existing launch facilities at: Cape Canaveral Air Force Station (CCAFS), Florida; Vandenberg Air Force Base (VAFB), California; the United States Army Kwajalein Atoll/Reagan Test Site (USAKA/RTS), Republic of the Marshall Islands; Wallops Flight Facility (WFF), Virginia; and the Kodiak Launch Complex (KLC), Alaska.

Spacecraft defined as routine payloads utilize materials, quantities of materials, launch vehicles, launch sites, and operational characteristics that are consistent with normal and routine spacecraft preparation and flight activities at CCAFS, VAFB, USAKA/RTS, WFF, KLC, and Kennedy Space Center. The environmental impacts of launching routine payloads from the launch sites fall within the range of routine, ongoing, and previously documented impacts that have been determined not to be significant. Spacecraft within the scope of this EA meet specific criteria ensuring that the spacecraft, its operation and decommissioning, do not present any new, or substantial environmental or safety concerns.

To determine the applicability of a routine payload classification for a mission, the mission is evaluated against the criteria defined in the EA using the routine payload checklist (RPC.)

2.0 Mission Description

Transiting Exoplanet Survey Satellite (TESS) will discover thousands of exoplanets in orbit around the brightest stars in the sky. In a two-year survey of the solar neighborhood, TESS

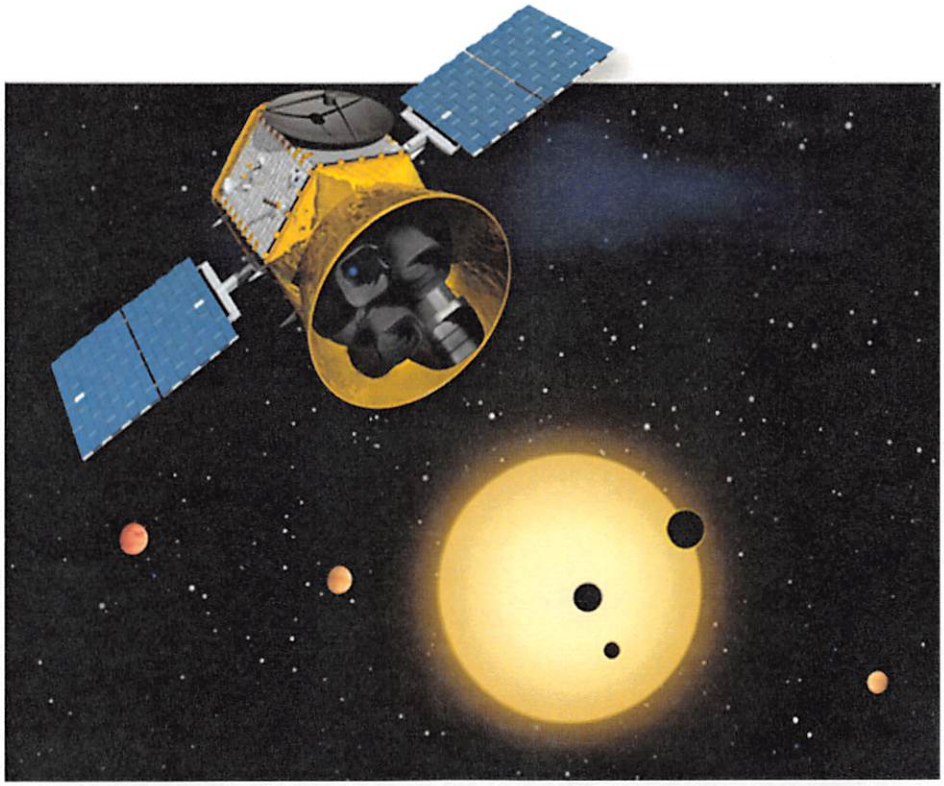
will monitor more than 500,000 stars for temporary drops in brightness caused by planetary transits. Transits occur when a planet's orbit carries it directly in front of its parent star as viewed from Earth. This first-ever space-borne all-sky transit survey will identify planets ranging from Earth-sized to gas giants, around a wide range of stellar types and orbital distances. No ground-based survey can achieve this feat.

TESS is expected to catalog more than 3,000 transiting exoplanet candidates, including a sample of approximately 500 Earth-sized and 'super- Earth' planets, with radii less than twice that of the Earth. TESS will detect small rock-and-ice planets orbiting a diverse range of stellar types and covering a wide span of orbital periods, including rocky worlds in the habitable zones of their host stars.

The principal goal of the TESS mission is to detect small planets with bright host stars in the solar neighborhood, so that detailed characterizations of the planets and their atmospheres can be performed.

TESS will monitor the full celestial sphere in a two-year mission. The observation strategy is "stare and step." The brightness of up to 25,000 stars in a 24 degree x 96 degree sector of the sky opposite the Sun is measured continuously for 27 days. The field-of-view of the cameras is then stepped 27 degrees east, and a new sector of sky is monitored. Overlap between successive observation sectors allows a subset of stars to be monitored for longer periods, up to six months near the ecliptic poles.

The TESS high Earth orbit (HEO) is in a 2:1 resonant orbit with the moon, meaning its orbital period is half of that of the moon, or 13.7 days. In HEO, TESS is afforded continuous viewing of the anti-solar sky for a period greater than 27 days per month. The HEO provides a very stable environment for exoplanet observations, allowing for sensitivities of less than 60 ppm for the brightest stars.



TESS stars will be 30-100 times brighter than those surveyed by the Kepler satellite; thus, planets observed by TESS should be far easier to characterize with follow-up observations. These follow-up observations will provide refined measurements of the planet masses, sizes, densities, and atmospheric properties.

TESS will provide prime targets for further, more detailed characterization with the James Webb Space Telescope, as well as other large ground-based and space-based telescopes of the future. TESS's legacy will be a catalog of the nearest and brightest stars hosting transiting exoplanets, which will comprise the most favorable targets for detailed investigations in the coming decades.

The TESS instrument consists of four Wide Field-Of-View Charge-Coupled Device Cameras. Each of the four cameras has:

- 24° × 24° Field-of-View
- 100 mm effective pupil diameter
- Lens assembly with 7 optical elements
- Athermal design
- 600nm - 1000nm band pass
- 16.8 Megapixel, low-noise, low-power, Massachusetts Institute of Technology (MIT) Lincoln Lab Chip Card Interface Device -80 detector

The TESS mission will be based on Orbital Science Corporation's (OSC) LEOStar-2 platform, a flexible, high-performance spacecraft for space and Earth science, remote sensing

and other applications. LEOStar-2 can accommodate various instrument interfaces, deliver up to 2 kilowatt orbit average payload power, and support payloads up to 500 kilograms. Performance options include redundancy, propulsion capability, high data rate communications, and high-agility/high-accuracy pointing. The heritage OSC LEOStar-2 spacecraft bus has:

- 3-axis stabilized pointing, with ≤3 arc-sec performance
- Two-headed star tracker; 4 wheel zero momentum system
- 400W single-axis articulating solar array
- Passive thermal control
- Mono-propellant propulsion system
- Ka-band 100 Mbps science downlink

TESS team partners include the MIT Kavli Institute for Astrophysics and Space Research and MIT Lincoln Laboratory; NASA's Goddard Space Flight Center; Orbital Sciences Corporation; NASA's Ames Research Center; the Harvard-Smithsonian Center for Astrophysics; the Aerospace Corporation; and the Space Telescope Science Institute.

3.0 NASA Routine Payload Determination

The components utilized in the TESS spacecraft are made of materials normally encountered in the space industry. Materials and operations to provide power, propulsion, and communications for the spacecraft and instruments will not pose substantial risks to human health and safety. TESS will not utilize radioactive sources or lasers, will not carry pathogenic organisms and will not return samples to Earth. No reentry is planned for TESS.

The TESS mission has been evaluated against NASA's Routine Payload EA, using the RPC (see enclosed Evaluation Recommendation Package.) The evaluation indicates that the mission meets the criteria for a routine payload and falls within the scope of the reference EA. The launch vehicle and launch site have yet to be selected; however, the candidate launch vehicle/launch site combinations all fall within the scope of the EA. The mission does not present any unique or unusual circumstances that could result in new or substantial environmental impacts. Based on the analyses set forth in the 2011 NRPEA, NASA has determined that the environmental impacts associated with the TESS mission will not individually or cumulatively have a significant impact on the quality of the human environment and that a routine payload classification for the TESS mission is applicable.

No additional NEPA action or documentation is required.

George W. Morrow
Director of Flight Projects

7/24/14
Date

Christopher J. Scolese
Director

30 July 2014
Date

Enclosure

Reference
http://tess.gsfc.nasa.gov/index.html
http://space.mit.edu/TESS/TESS/TESS_Overview.html

EVALUATION RECOMMENDATION PACKAGE

Record of Environmental Consideration
Routine Payload Checklist
Flight Project Environmental Checklist

Enclosure

RECORD OF ENVIRONMENTAL CONSIDERATION

1. Project Name: Transiting Exoplanet Survey Satellite (TESS)

2. Description/location of proposed action: TESS will use an array of wide-field cameras to perform the first space-borne all-sky transit survey of a broad range of exoplanets, ranging from Earth-size to gas giants. The survey data will be used to further characterize the planets with follow up observations.

Date and/or Duration of project: Launch – August 2017

3. It has been determined that the above action:

☒ a. Is adequately covered in an existing EA or EIS.
Title: *Environmental Assessment for Launch of NASA Routine Payloads*
Date: November 2011

☐ b. Qualifies for Categorical Exclusion and has no extraordinary circumstances which would suggest a need for an Environmental Assessment.
Categorical Exclusion: _____

☐ c. Is exempt from NEPA requirements under the provisions of: _____

☐ d. Is covered under EO 12114, not NEPA.

☐ e. Has no significant environmental impacts as indicated by the results of an environmental checklist and/or detailed environmental analysis.
(Attach checklist or analysis as applicable)

☐ f. Will require the preparation of an Environmental Assessment.

☐ g. Will require the preparation of an Environmental Impact Statement.

☐ h. Is not federalized sufficiently to qualify as a major federal action.

Beth Montgomery — NEPA Program Manager, Code 250 — 6/18/14
Beth Montgomery — Date

Jeff Volosin — Project Manager, Code 460 — 6/18/14
Jeff Volosin — Date

NASA ROUTINE PAYLOAD EVALUATION AND DETERMINATION PROCESS AND CHECKLIST

After a proposed spacecraft mission is sufficiently well formulated (usually the Phase B design study), the Sponsoring Entity, in coordination with the local Environmental Management Office (EMO), will prepare an environmental evaluation. An environmental evaluation is a preliminary review that determines what aspects of the proposal are of potential environmental concern. The environmental evaluation also assists in determining the appropriate level of National Environmental Policy Act (NEPA) documentation (i.e., environmental assessment [EA], or environmental impact statement [EIS]) for the proposal. The local EMO uses a comprehensive checklist to provide a level of rigor to this early evaluation of the proposal, helping to ensure that pertinent considerations are not overlooked. Local EMO review of the Routine Payload Checklist (RPC, below) forms the basis for evaluating the applicability of a NASA Routine Payload (NRP) spacecraft classification for a proposed mission.

The local EMO uses the completed RPC (and required attachments) to evaluate the proposed mission against the NRP EA criteria. If the EMO evaluation of the RPC indicates that a NRP categorization may be appropriate, the Sponsoring Entity documents this in an Evaluation Recommendation Package (ERP). The ERP is then processed for review and approval in accordance with established National Aeronautics and Space Administration (NASA) procedures and guidelines. If approved, the ERP would be attached to a Record of Environmental Consideration (REC).

The Sponsoring Entity can then proceed with the proposal while monitoring the project activities, for changes or circumstances during implementation that could affect classification of the proposed mission as a NRP spacecraft. If a NRP spacecraft categorization is determined to be inappropriate, the local EMO will initiate plans for preparation of additional NEPA documentation.

NASA ROUTINE PAYLOAD CHECKLIST

Project Name: Transiting Exoplanet Survey Satellite (TESS)		Date of Launch: August 2017
Project Contact: Jeff Volosin	Phone Number: (301) 286-9924	Mailstop: 460.0
Project Start Date: May 2014	Project Location: GSFC Code 460, B22/282	

Project Description:
Survey mission to identify planets orbiting other stars

	Yes	No
A. Sample Return:		
1. Would the candidate mission return a sample from an extraterrestrial body?	☐	☑
B. Radioactive Materials:	Yes	No
1. Would the candidate spacecraft carry radioactive materials in quantities that produce an A2 mission multiple value of 10 or more?	☐	☑
Provide a copy of the Radioactive Materials On Board Report as per NPR 8715.3 with the ERP submittal.		
C. Launch and Launch Vehicles:	Yes	No
1. Would the candidate spacecraft be launched on a vehicle and launch site combination other than those listed in Table C-1 below?	☐	☑
2. Would the proposed mission exceed the approved or permitted annual launch rate for the particular launch vehicle or launch site?	☐	☑
Comments:		
D. Facilities:	Yes	No
1. Would the candidate mission require the construction of any new facilities or substantial modification of existing facilities?	☐	☑
Provide a brief description of the construction or modification required, including whether ground disturbance and/or excavation would occur.		
E. Health and Safety:	Yes	No
1. Would the candidate spacecraft utilize batteries, ordnance, hazardous propellant, radiofrequency transmitter power, or other subsystem components in quantities or levels exceeding the EPC's in Table C-2 below?	☐	☑
2. Would the expected risk of human casualty from spacecraft planned orbital reentry exceed the criteria specified by NASA Standard 8719.14?	☐	☑
3. Would the candidate spacecraft utilize any potentially hazardous material as part of a flight system whose type or amount precludes acquisition of the necessary permits prior to its use or is not included within the definition of the Envelope Payload Characteristics?	☐	☑
4. Would the candidate mission, under nominal conditions, release material other than propulsion system exhaust or inert gases into the Earth's atmosphere or space?	☐	☑
5. Are there changes in the preparation, launch or operation of the candidate spacecraft from the standard practices described in Chapter 3 of this EA?	☐	☑
6. Would the candidate spacecraft utilize an Earth-pointing laser system that does not meet the requirements for safe operation (ANSI Z136.1-2007 and ANSI Z136.6-2005)?	☐	☑
7. Would the candidate spacecraft contain, by design (e.g., a scientific payload) pathogenic microorganisms (including bacteria, protozoa, and viruses) which can produce disease or toxins hazardous to human health or the environment beyond Biosafety Level 1 (BSL 1)[1]?	☐	☑
Comments:		

Continued on next page

[1] The use of biological agents on payloads is limited to materials with a safety rating of "Biosafety Level 1." This classification includes defined and characterized strains of viable microorganisms not known to consistently cause disease in healthy human adults. Personnel working with Biosafety Level 1 agents follow standard microbiological practices including the use of mechanical pipetting devices, no eating, drinking, or smoking in the laboratory, and required hand-washing after working with agents or leaving a lab where agents are stored. Personal protective equipment such as gloves and eye protection is also recommended when working with biological agents.

NASA ROUTINE PAYLOAD CHECKLIST

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Project Start Date: May 2014	Project Location: GSFC Code 460, B22/282	
Project Description: Survey mission to identify planets orbiting other stars		

F. Other Environmental Issues:	Yes	No
1. Would the candidate spacecraft have the potential for substantial effects on the environment outside the United States?	☐	☑
2. Would launch and operation of the candidate spacecraft have the potential to create substantial public controversy related to environmental issues?	☐	☑
3. Would any aspect of the candidate spacecraft that is not addressed by the EPCs have the potential for substantial effects on the environment (i.e., previously unused materials, configurations or material not included in the checklist)?	☐	☑

Comments:

Table C-1. Launch Vehicles and Launch Sites

Launch Vehicle and Launch Vehicle Family	Space Launch Complexes and Pads				
	Eastern Range (CCAFS)	Western Range (VAFB)	USAKA/RTS	WFF	KLC
Athena I, IIc, III[a]	LC-46	CA Spaceport (SLC-8)	NA	Pad 0	LP-1[a]
Atlas V Family	LC-41	SLC-3	NA	NA	NA
Delta II Family	LC-17	SLC-2	NA	NA	NA
Delta IV Family	LC-37	SLC-6	NA	NA	NA
Falcon I/Ie	LC-36	SLC-4W	Omelek Island	Pad 0	LP-3[b]
Falcon 9	LC-40	SLC-4E	Omelek	Pad 0	LP-1
Minotaur I	LC-20 and/or LC-46	SLC-8	NA	Pad 0	LP-1
Minotaur II-III	LC-20 and/or LC-46	SLC-8	NA	Pad 0	LP-1
Minotaur IV[c]	LC-20 and/or LC-46	SLC-8	NA	Pad 0	LP-1
Minotaur V	LC-20 and/or LC-46	SLC-8	NA	Pad 0	NA
Pegasus XL	CCAFS skidstrip KSC SLF	VAFB Airfield	Kwajalein Island	WFF Airfield	NA
Taurus	LC-20 and/or LC-46	SLC-576E	NA	Pad 0	LP-1
Taurus II	NA	NA	NA	Pad 0	LP-3[b]
Any other launch vehicle/launch site combination for which NASA has completed or cooperated on the NEPA compliance.					

[a] Athena III is currently under design.

[b] LP-3 is currently under design.

[c] While not explicitly listed in this table, the Minotaur IV includes all configurations of this launch vehicle, including the Minotaur IV+, which is a Minotaur IV with a Star 48V 4th stage.

Key: CA = California; CCAFS = Cape Canaveral Air Force Station; KSC = Kennedy Space Center; LC = Launch Complex; LP = Launch Pad; MARS = Mid-Atlantic Regional Spaceport; SLC = Space Launch Complex; SLF = Shuttle Landing Facility; USAKA/RTS = United States Army Kwajalein Atoll/Reagan Test Site; VAFB = Vandenberg Air Force Base; WFF = Wallops Flight Facility.

Table C-2. Summary of Envelope Payload Characteristics by Spacecraft Subsystems

Structure	• Unlimited: aluminum, beryllium, carbon resin composites, magnesium, titanium, and other materials unless specified as limited.
Propulsion[a]	• Liquid propellant(s); 3,200 kg (7,055 lb) combined hydrazine, monomethyhydrazine and/or nitrogen tetroxide. • Solid Rocket Motor (SRM) propellant; 3,000 kg (6,614 lb) Ammonium Perchlorate (AP)-based solid propellant (examples of SRM propellant that might be on a spacecraft are a Star-48 kick stage, descent engines, an extra-terrestrial ascent vehicle, etc.)
Communications	• Various 10-100 Watt (RF) transmitters
Power	• Unlimited Solar cells; 5 kilowatt-Hour (kW-hr) Nickel-Hydrogen (NiH_2) or Lithium ion (Li-ion) battery, 300 Ampere-hour (A-hr) Lithium-Thionyl Chloride (LiSOCl), or 150 A-hr Hydrogen, Nickel-Cadmium (NiCd), or Nickel-hydrogen (Ni-H_2) battery.
Science Instruments	• 10 kilowatt radar • American National Standards Institute safe lasers (see Section 4.1.2.1)
Other	• U. S. Department of Transportation (DoT) Class 1.4 Electro-Explosive Devices (EEDs) for mechanical systems deployment • Radioactive materials in quantities that produce an A2 mission multiple value of less than 10 • Propulsion system exhaust and inert gas venting • Sample returns are considered outside of the scope of this environmental assessment

[a] Propellant limits are subject to range safety requirements.

Key: kg=kilograms; lb=pounds.

Goddard Space Flight Center
FLIGHT PROJECT ENVIRONMENTAL CHECKLIST

1. PROJECT/PROGRAM	Date:
Transiting Exoplanet Survey Satellite (TESS)	3/28/14

2. SCHEDULE

PDR/CDR:	Launch Date:
PDR: 9/14, CDR: 4/15	August 2017

3. CURRENT STATUS

Phase-B, SRR Completed 2/14. Confirmation 10/14, LV Selection 11/14

4. PROJECT DESCRIPTION

a. Purpose:

2 year Exoplanet All-Sky Survey Mission

b. Spacecraft:

Orbital Sciences LEOStar-2

c. Instruments:

4 CCD cameras and a Data Handling Unit computer system

d. Launch Vehicle:

Not selected until late in 2014 (Launch Vehicle selection will be through the KSC/Launch Services Program contract)

e. Launch Site:

Not selected until late in 2014 (Wallops (Antares, Minotaur-C) and KSC (Falcon-9 1.1, Atlas-V) are candidates depending on LV selection)

f. NASAs Involvement/Responsibility:

Project Management and Systems Engineering leadership.

g. Participants/Locations:

Orbital Sciences Corp./Dulles VA: Responsible for spacecraft bus development, observatory integration/test, Mission Operations
MIT Kavli Institute/Cambridge MA: Responsible for sky survey camera integration/test, science Data Handling subsystem development, Science Operations
MIT Lincoln Laboratory/Lexington MA: Responsible for survey camera optical system and CCD development
Ames Research Center/Mountain View CA: Responsible for science data processing
Space Telescope Science Institute/Baltimore MD: Responsible for science data archiving

h. End-of-Mission Plan: Planned Re-entry (controlled/uncontrolled?)

Orbit remains outside of GEO belt for 100+ years

5. Is there anything controversial or unique about the mission, spacecraft or instruments? If yes, Explain. Yes ☐ No ☑

6. Is the mission compliant with NASA requirements for limiting orbital debris (NPR 8715.6, and NASA Standard 8719.14? Explain non-compliances. Yes ☑ No ☐

7. During any phase, does the mission/project include or involve: Check yes for all that apply. If uncertain, check the corresponding box. For all that apply, provide an explanation. Use the additional space below if needed.	Yes	No	Uncertain
A. Fuels	☑	☐	☐
B. Ionizing Radiation Devices/Sources	☐	☑	☐
C. Explosives	☐	☑	☐
D. Hazardous Materials/Substances/Chemicals	☐	☑	☐
E. Lasers (Class, Earth Pointing)	☐	☑	☐
F. Disease Producing Pathogenic Microorganisms/Biological Agents	☐	☑	☐
G. Discharges/Venting of any Substances into Air, Water, or Soil	☐	☑	☐
H. Hazardous Waste Generation	☐	☑	☐
I. High Noise Levels	☐	☑	☐
J. Sample Return to Earth	☐	☑	☐
K. Radio Frequency Communications	☑	☐	☐
L. Construction/Modification/Demolition of a Facility/Lab (onsite - offsite)	☐	☑	☐
M. Land Disturbance, Tree Clearing, Removal of Vegetation	☐	☑	☐
N. Impact on Threatened or Endangered Species	☐	☑	☐
O. Impact/Destruction of Sensitive Wildlife Habitat	☐	☑	☐
P. Impact on/near Areas of Cultural Significance	☐	☑	☐
Q. Impact on Local Social or Economic Conditions (Increase in Traffic, Employment, etc.)	☐	☑	☐
R. Impact on Minority or Low Income Populations	☐	☑	☐
S. New or Foreign Launch Vehicle	☐	☑	☐
T. Other Issues of Potential Environmental Impact	☐	☑	☐
U. Environmental Permits	☐	☑	☐

Additional Information

A: Anhydrous Hydrazine
K: S-Band (2GHz) and Ka-Band (26GHz) transmitters, S-Band (2GHz) receiver

8. What Safety hazards are associated with the mission?

9. Summary of Subsystem Components

Propulsion (Include fuel type, amount, tank size, materials, dimensions	Blow-down, mono-propellant hydrazine; all-welded, radiographically inspected, aluminum tank (AFSPCMAN 91-710 compliant with a minimum of two mechanical inhibits to bulk propellant leakage and three electrical inhibits to actuate any valves); 19 inch diameter propellant tank contains 45.3 kg of propellant/pressurant at launch.
Communications	S-Band: DSN/SN compatible transponder and two hemispherical quadrifilar antennas. Receiver is powered at all times, transmitter is commanded on/off as required. EIRP: +3.2 dBW (DSN), +2.0 dBW (SN) Ka-Band: 26 GHz, DSN compatible transmitter with a single high gain antenna. EIRP: +41.1 dBW. Transmitter commanded on/off by command.
Structural Materials	The TESS structure consists of equipment panels of aluminum face-sheets and an aluminum honeycomb core. The Camera Accommodation Structure mounting plate for the four survey cameras will be a composite structure.
Power	28V primary bus, shunt regulated direct energy transfer system. Primary power provided by 2 solar array wings with GaAs cells generating 403 W (EOL). A 96 A-Hr Lithium-Ion battery is sized to accommodate expected infrequent eclipse periods of up to 6 hours. Battery charge is software controlled with hardware back-up.
Science Instruments	Four sky survey CCD cameras. Each camera is composed of a focal plane array and lens assembly. Lens assemblies each consists of 7 lenses RTV mounted with a fixed focal length in an aluminum lens barrel. Focal plan assemblies each include four CCD-80s (developed at MIT Lincoln Laboratory) mounted on silicon carbide pedestals with associated CCD readout electronics.
Hazardous Components (radioactive materials, lasers, chemicals, etc.)	None
Other (include dimensions and weight of s/c)	Dry Mass: 385 kg, Dimensions: Height: 1.5m, Diameter: 1.2m (primary bus without solar arrays), 3.7m (with solar arrays deployed)

Goddard Space Flight Center
FLIGHT PROJECT ENVIRONMENTAL CHECKLIST

Project Manager Printed Name:	Project Manager Signature:		
Jeff Volosin			
Project Name:	**Date:**	**Phone Number:**	**Org. Code:**
Transiting Exoplanet Survey Satellite (TESS)	3/28/14	(301) 286-9924	460.0

Comments: