

# SDD System Design Document

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## 1. Introduction

### 1.1 Date of Issue

December 8, 2022

### 1.2 Context

The Transiting Exoplanet Survey Satellite (TESS) is an Astrophysics Explorer-class mission that performs a survey to search for planets transiting nearby stars nearly in all-sky. TESS's goal is to discover planets with sizes smaller than Neptune that transit stars with a certain level of brightness allowing spectroscopic observations to determine the planet's mass and atmospheric compositions.

TESS is now operating in its extended mission with a science program that is heavily influenced by general investigators from around the world. These investigators search not only for exoplanets but also examine many other kinds of astrophysical phenomena. Hence the need for a tool to help users propose for time on the telescopes.

TESS has one such tool, WTV which helps users find where targets will be observed, and some basic information about the targets. However, would like a proposal tool “web app” that helps users propose for time, and helps users visualize what is observed when. Crucially this tool should work now (when we have ~50 sectors of data) and also in the future (when we have 100s of sectors). The design needs to be thought of carefully to ensure that the tool is not to “busy” but still presents the right information.

### 1.3 Scope

Business domain: <https://www.nasa.gov/>;

The Transiting Exoplanet Survey Satellite (TESS) is the next step in the search for planets outside of our solar system, including those that could support life. The mission will find exoplanets that periodically block part of the light from their host stars, events called transits. TESS will survey 200,000 of the brightest stars near the sun to search for transiting exoplanets.[1]

#### 1.3.1 Product Name

TPT (TESS Proposal Tool)

#### 1.3.2 Overview

TESS scientists expect the mission will catalog thousands of planet candidates and vastly increase the current number of known exoplanets. Of these, approximately 300 are expected to be Earth-sized and super-Earth-sized exoplanets, which are worlds no larger than twice the size of Earth. TESS will find the most promising exoplanets orbiting our nearest and brightest stars, giving future researchers a rich set of new targets for more comprehensive follow-up studies.[2]

#### 1.3.4 Authorship

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Patrick McCormick

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Charles Lowers

## 2. Software Architecture

### 2.1 Overview

TESS proposal tool (TPT) will be a web app that helps users propose for time to deeply look at targets, and helps users visualize what is observed when. Crucially this tool should work with 50 and 100s sectors of data.

### 2.2 Goals

- The (TESS Proposal Tool) TPT should look like a “dashboard” with adaptive plots and inputs. TPT should at minimum assist users with building a table of TESS targets to observe that will be in a set format and will have:

RA/Dec

TIC

Magnitude

- And will account for proper motion. Users will input targets as either TIC numbers, or RA/Dec pairs. The TPT should in some way interface with the TIC catalog, either on the server or (perhaps better) by querying and crossmatching TIC on Vizier.
- Sometimes these target lists will be single targets, sometimes they will be thousands, it's reasonable to limit this to some number (e.g. 1000) if necessary.
- The TPT will ideally have some visual interfaces to show users what targets they are selecting, with some ability to pan, and potentially have tool tips if that makes visual sense. It would be useful to have a “sky-map” with the points in the target list and the footprint of sectors highlighted. TPT should be able to have some way to select different TESS years and different TESS sectors to display the footprints of. Ideally this visualization will be on a sphere, so users can grab and rotate the sphere. This will mean the projection is always right, and we don't have all the targets at the pole squished together.
- TPT should be able to download the input targets to a CSV file with the corrected target list, accounting for proper motion (if necessary), applying TIC numbers, and calculating the approximate TESS magnitudes.

**Summary: a final project could have a way to take inputs and output csv files, much like WTV, but with a visualization that is responsive and fast.**

### Stretch Goal A:

If the above is easily achievable, the TPT visualization might have:

- A way to look at a detailed view of a target, e.g. maybe with a tool tip, containing all the known information about the target:
  - RA/Dec/TIC ID/TESS magnitude
  - Maybe photometry in multiple bands, queried from Vizier SED service
  - Which sectors it has been observed in, at which cadence
  - A link to archival data
  - A link to the TFOP page (if necessary)

### Stretch Goal B:

If both of the above goals are easily achievable, the TPT could have the following functionality to help users select a sample of targets from the TIC.

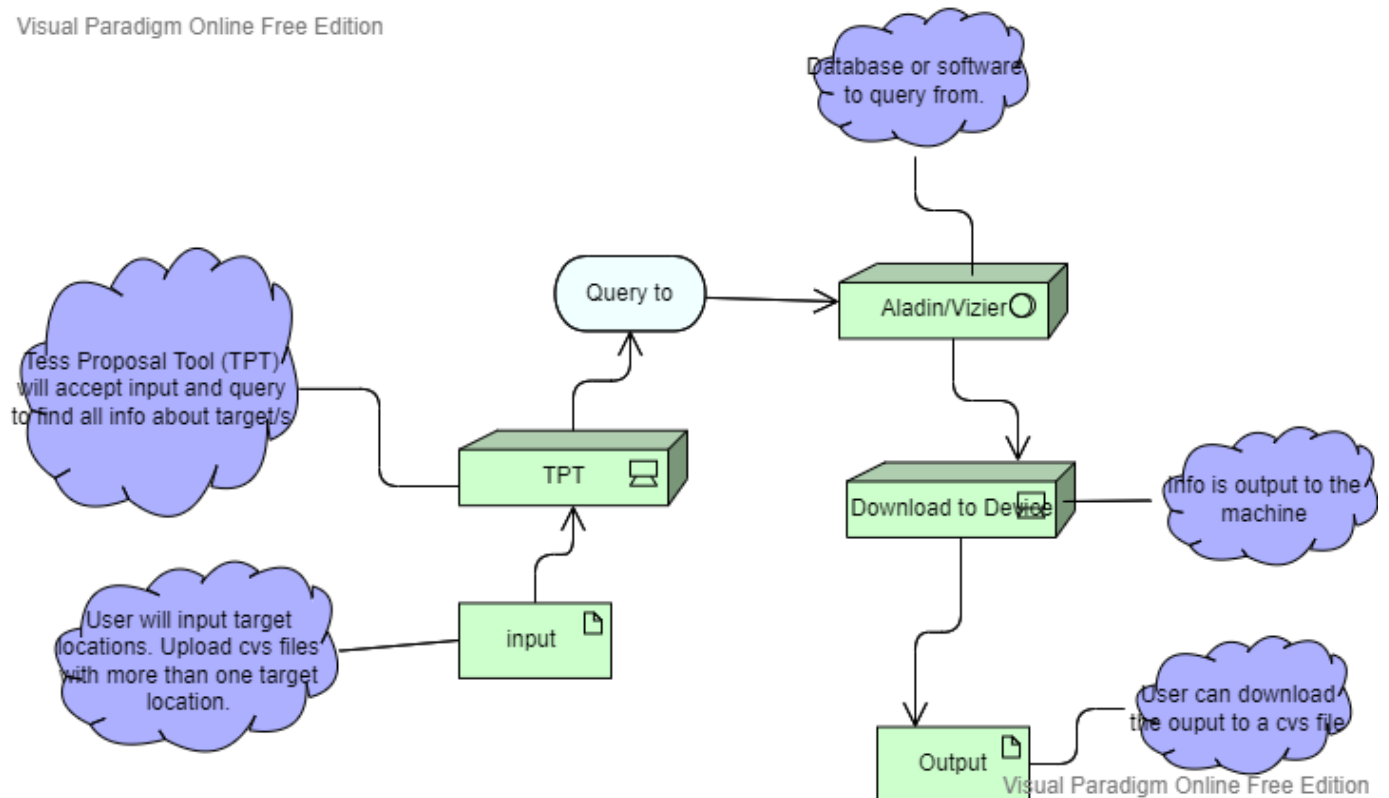
- Have the TIC on the server
- Present different, dynamically linked plots including e.g. the HR diagram, magnitude histograms, histograms of number of “observable” sectors etc, maybe allowing some selections for known planets
- Allow users to use a lasso tool to select subsamples of the data, display them on the “sky view” and select their cuts, then download the target table to observe.
- There may be other diagrams we’d want to use to cut down a sample but having these dynamically linked plots would be fantastic to achieve this. This should really lower the barrier for users who struggle to do crossmatching and work with the giant catalog. (It could start with just a few plots and expand it.)

### Super Stretch Goal C:

- If all of this is achievable, for a super stretch goal, the visualization would include TESS FFIs, so that when users zoom in, they can see the true TESS data from previous cycles. This will help users understand whether e.g. two neighboring stars are separable.

## 2.3 Data Flow / Software Context Model

Visual Paradigm Online Free Edition



## 2.4 Stakeholders

### Users:

Nasa Scientifics

volunteers

### Customers:

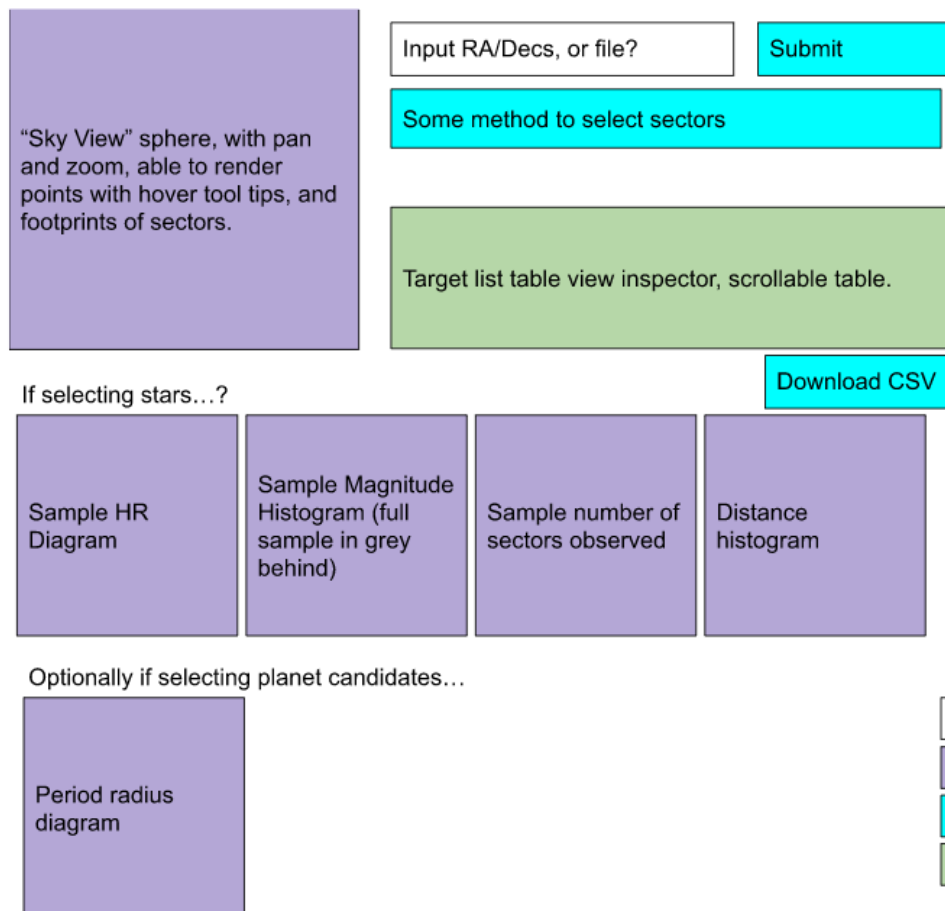
<https://www.nasa.gov/>

## 2.5 System Design Concerns

Need a fast backend language to take care of the queries to other systems.

TPT should adapt to work with different sectors of data.

## 2.6 Architectural Viewpoint



## 3. Detailed Design

### 3.1 Overview

### 3.2 Component Design Viewpoint

## 4 Glossary

### 4.1 Glossary of Terms

Term	Meaning
TESS	Transiting Exoplanet Survey Satellite
TIC	<p>TESS Input Catalog, available here:</p> <p><a href="https://vizier.cfa.harvard.edu/viz-bin/VizieR-3?-source=IV/39/tic82&amp;-out.max=50&amp;-out.form=HTML%20Table&amp;-out.add=_r&amp;-out.add=_RAJ,_DEJ&amp;-sort=_r&amp;-oc.form=sexa">https://vizier.cfa.harvard.edu/viz-bin/VizieR-3?-source=IV/39/tic82&amp;-out.max=50&amp;-out.form=HTML%20Table&amp;-out.add=_r&amp;-out.add=_RAJ,_DEJ&amp;-sort=_r&amp;-oc.form=sexa</a></p> <p>This is a catalog of star sources. To submit a target for observation by TESS it would usually require a TIC number. For unusual cases (e.g. if a target doesn't have a TIC number) we'd like that highlighted</p>
FFI	Full Frame Image. TESS observes "Full Frame Images" of each camera and downlinks them at cadences of 200 seconds.
TPF	Target Pixel File. TESS observes a subset of targets at a faster cadence, usually in 11x11 pixel cut outs. These products are additionally processed by the TESS team to remove noise.
TESS GI Office	TESS General Investigator Office, tasked with helping the community use the data
Proposal	Scientists propose to TESS for funding to complete science investigations with the data and request a number of targets be observed by TESS as TPFs.
Target	A star, galaxy, or other astronomical object selected by scientists for observation.
Target list	A list of targets proposed by scientists for TESS to observe with a higher cadence

## 5. References

### 5.1 Reference list

1. <https://www.nasa.gov/content/about-tess>
2. <https://heasarc.gsfc.nasa.gov/cgi-bin/tess/webtess/wtv.py>