SAMPLE

Great Observatories: TESS

The Transiting Exoplanet Survey Satellite

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Conclusion

This free sample contains the Introduction and Chapter 1. The complete book contains the full contents above.

Introduction

The subject of this book is a satellite, not a novel, a film, a television presenter, or a person: the Transiting Exoplanet Survey Satellite, TESS, NASA's all-sky hunter of planets that cross their stars. The namesakes have crowded the word, and a reader who searches for "Tess" will meet a tragic heroine of Victorian fiction, a presenter of Saturday-night television, and more besides; none of them is treated here beyond this note. The book's business is the machine that stares at two hundred thousand of the Sun's brightest neighbors, night after night, watching for the flicker of a planet.

The flicker is the method. When a distant planet happens to orbit edge-on to our line of sight, it crosses the face of its star and dims it by a fraction of a percent, once per orbit, with clocklike regularity; the transit method that reads this signal has, in a generation, turned planet-hunting from an art of rare triumphs into an industrial catalog of thousands of worlds. TESS was built to finish the job the method made possible: the first space telescope to survey nearly the entire sky for transits, not a single crowded patch of it, and to do so among stars bright enough, and close enough, that every candidate it found could be checked, weighed, and studied by the telescopes already on the ground and the great observatories that followed it into space.

This book tells that machine's story in order: the discovery chapter follows the idea from the first transiting planets to the design that made an all-sky survey possible; the understanding and characteristics chapters describe the spacecraft, its cameras, and its improbable orbit; the observation chapters follow a sector of data from the CCDs to the community; the discovery chapters gather the worlds TESS found, from Earth-sized temperate candidates to planets orbiting three suns; and the closing chapters take up the mission's challenges, its future, and its place in the longer project of finding, among the thousands, the one planet that matters most. The reader needs no mathematics beyond the patience to picture a small dip repeating, and every number that matters is given plainly, because the subject rewards plain telling: a camera the size of a suitcase, an orbit tuned to the Moon, and a catalog of new worlds that grows to this day.

Chapter 1: The Discovery of TESS

The idea behind TESS begins with the strangest fact of the exoplanet era: planets announce themselves by accident, if the geometry is kind. A planet does not glow visibly against its star; it reveals itself only when its orbit carries it across the stellar disk, blocking a sliver of the starlight for the few hours of a transit. The chance that a given orbit is aligned so nearly edge-on that transits occur at all is small, roughly one in ten for planets hugging their stars, and vanishingly small for planets at Earth-like distances. The method therefore demands volume: watch enough stars, for long enough, and the lucky alignments reveal themselves as repeating dips. The first transiting planet, a hot Jupiter crossing a Sun-like star in the late 1990s, proved the geometry could be caught from the ground; the first spaceborne surveys turned the accident into a census.

The census that changed the field was Kepler's. Launched in 2009, the Kepler telescope stared for four unblinking years at a single patch of sky between Cygnus and Lyra, monitoring a hundred and fifty thousand stars at once, and it returned the modern field's founding statistics: small planets are common, most stars have them, and Earth-sized worlds around Sun-like stars, while not absent, are hard to confirm because the stars are far and faint. That last clause became the seed of everything that followed. Kepler's field of view was rich but deep: its stars are hundreds to thousands of light-years away, too dim for most follow-up instruments, so that thousands of candidate planets sat in catalogs waiting for confirmation that the world's telescopes could not practically deliver. The lesson the community drew was architectural rather than astronomical: the next survey should sacrifice depth for breadth, and find planets around the brightest, nearest stars, where a candidate could be confirmed, weighed, and studied in detail.

The design that answered this lesson began, unusually, outside the government: a small group at MIT, seeded by private funding from individuals, Google, and the Kavli Foundation, developed a concept for a small array of wide-angle cameras that could tile the whole sky, sector by sector, monitoring the brightest stars for transits. The concept matured into a NASA proposal cycle that ran for nearly a decade: submitted as a Small Explorer, deferred, resubmitted, and finally approved in 2013 as a Medium Explorer mission at a fraction of flagship cost. The approved mission inherited the Kepler heritage directly: the same CCD detector technology, developed at MIT's Lincoln Laboratory, and the same data philosophy, a public archive that any astronomer could mine, but pointed at a sky chosen so that its discoveries could be followed up by everyone else's telescopes rather than buried in

dimness.

The discovery this chapter records is thus a discovery about strategy. TESS did not find the first exoplanets, did not break Kepler's records for sheer numbers, and was not built to; it was built to invert Kepler's trade, watching nearly the whole sky at moderate depth instead of one deep field, and choosing bright, nearby, well-characterized stars as its quarry. The wager was that a survey of the solar neighborhood would produce the most useful planets rather than the most planets: worlds whose stars could be weighed spectroscopically, whose atmospheres could be probed by the coming generation of great telescopes, and whose transits could be confirmed by graduate students with meter-class instruments rather than billion-dollar missions. The chapters that follow are, in effect, the audit of that wager: the machine, the method, the discoveries, and the verdict, still accumulating, that the all-sky, bright-star strategy gave the field exactly what it needed next.

The decade between the concept and the launch also taught the field a lesson about how such missions actually get built, and the lesson is part of the discovery story. The TESS concept survived proposal rounds in which it was declined, reworked, and submitted again, and its development years coincided with an era in which the American decadal reviews were asking hard questions about the balance between flagship observatories and the small missions that fill the gaps between them. The mission that emerged from that gauntlet was leaner and more sharply focused for it: one instrument, one orbit, one survey, and a management structure in which a university laboratory led the science while an industrial partner built the bus.

The reader will meet that structure repeatedly in the operations chapters, because the mission's unusual organization, a university-led science team distributing data to the whole world, was not an afterthought but the plan itself, and the discovery chapter's last word should be that TESS was discovered twice: once as an idea, in the trade of depth for brightness, and once as an institution, in the ten years of advocacy and redesign that turned the idea into a spacecraft on a launch pad.

The idea also had a ground-level rehearsal the spaceborne chapters should credit, because the all-sky wager was tested on Earth first. In the years before TESS flew, the wide-field ground surveys, the small-telescope networks with names like alphabet soup, had already found hot Jupiters by the hundreds: the transit method worked on bright stars with ordinary optics, and the follow-up spectrographs could weigh the giants because the hosts were near and luminous. What the ground could not do was find small planets, its scintillating atmosphere drowning the hundredth-of-a-percent dips that Earth-sized worlds

imprint, and the gap defined the strategy exactly: keep the ground networks' brightness, move the small-planet hunt above the atmosphere. TESS's designers liked to say the mission inherited its geometry from the ground surveys and its sensitivity from Kepler, and the sentence is the discovery chapter's cleanest summary of what the machine actually is, a hybrid deliberately bred from the two proven successes.

The human thread of the discovery deserves its paragraph too, because missions are arguments won by people. The concept's principal investigator, a veteran of space instrumentation whose laboratory had built detectors for high-energy missions since the era of early orbiting observatories, spent the proposal decade the way founders spend start-up years, reworking the concept after each rejection, shrinking the cost, sharpening the science case, and assembling the coalition of universities, a government laboratory, an industrial partner, and foreign contributors that eventually stood behind the approved mission. The reader should notice what the decade made: not merely a cheaper spacecraft but a new template, the Medium Explorer mission as a serious science engine, a class of mission small enough to be approved quickly and powerful enough, in this case, to redraw the exoplanet map, a template the field has been copying ever since.

End of free sample. The full book is available at putrabooks.github.io

ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.