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Illustrative Science Mission

OVERALL MISSION CONCEPT

The primary goal of TPF is to detect and characterize planets orbiting nearby stars. This program will be carried out in three stages spread throughout TPF's five-year mission:

- Complete survey of ~150 stars, looking for planets (terrestrial and larger) around a large variety of stars.
- Spectroscopic follow-up of ~50 systems, looking for broad, strong spectral lines of species such as CO_2 and H_2O.
- Very sensitive spectroscopic observations of ~5 most favorable systems looking for O_3.

Interleaved with the observations of planetary systems will be imaging observations of general astrophysical sources. These might start in Year 2 of the TPF mission, rising to take ~40% of the observing time by the end of the mission. Table 9.1 indicates an illustrative breakdown of the observing time by program.

PLANET SURVEY

The goal of the initial survey for planets is to understand the incidence of planets around a broad variety of stars. As discussed in Chapter 7, the TPF target list will include about 150 stars of various spectral types, ages, metallicities, etc. The target list would be based in part on the results from the planet census obtained from the Keck Interferometer and SIM projects (Chapter 3). The sensitivity calculations of Table 6.1 and Appendix A indicate that the version of TPF using 3.5 m telescopes can detect an Earth-like planet in the habitable zone of a star 10 pc away in just 2 hours (*SNR*=5 at spectral resolution of 3) and 10 hours for a planet 15 pc away. If we assume that the overhead for an observation is six hours for constellation slewing and configuration, array rotation, etc., and add to that time an integration time of $2\times(\text{distance}/10\text{ pc})^4$ hours, then the wall clock time to survey the 141 objects listed in sample #2 of Table 7.1 is approximately 62 days taking into account the actual distance to each star. If we observe each star three times per year for a total of 186 days per year, then the planet sur-

Table 9.1. Illustrative Scientific Utilization Plan for TPF

	Year 1	Year 2	Year 3	Year 4	Year 5
In-orbit Checkout	0.2	0	0	0	0
Planet Survey	0.5	0.5	0.2	0.1	0.1
Medium-Depth Spectroscopy	0.1	0.2	0.4	0.4	0.3
Deep Spectroscopy	0.1	0.1	0.1	0.2	0.2
General Astrophysical Imaging	0.1	0.2	0.3	0.3	0.4

vey will require roughly 50% of the annual observing time as indicated in Table 9.1. After two years, we will have six sightings of each planetary system spread out over time so that we will see each planet sharing the proper motion and parallax of its parent star, as well as moving in orbit around its parent star. These observations will give definitive proof of the reality of the detected sources and of their association with the target star. All of these observations can be combined to improve the signal to noise to search for absorption lines from water and carbon dioxide as part of the more ambitious spectroscopic follow-up program described below.

From the survey observations, astronomers will derive the orbital parameters of all planets in a target system, particularly when the TPF data are combined with the astrometric and radial velocity measurements. Further, astronomers will derive basic physical information such as temperature, radius, and albedo for the detected planets.

SPECTROSCOPIC FOLLOW-UP PROGRAM

The spectroscopic program will be divided into two parts: modest sensitivity observations requiring 1-2 days to obtain spectra adequate to deduce the presence of CO_2 and H_2O (these data might be obtained as part of the initial survey); and high quality spectra to search for signs of life using species such as O_3 and CH_4. Using the sensitivity calculations given in Table 6.1, the lower resolution observations will take 2.3 days, or approximately 3 days per star including nominal overheads. As the results of the survey accumulate during the first two years of the mission, TPF could spend up to 150 days per year observing up to 50 stars. These observations would probably be repeated at least twice, given their importance. Finally, TPF could spend up to two weeks per star making observations to the ultimate depth to search for spectral lines of O_3 and CH_4. TPF might observe 5 stars per year with the higher level of sensitivity.

GENERAL ASTROPHYSICAL IMAGING

The time required to complete a particular astrophysical image will be a complex function of source brightness, source complexity, and propellant mass budgets. Some sources will demand the longest baselines and a large number of non-redundant *uv*-plane points. Others will demand very long integration times at a relatively small number of *uv*-

plane points. In the absence of a detailed data acquisition scenario, we can only estimate at this stage that the typical system will take about one half to one day to observe completely. Thus, with the nominal allocation of time given in Table 9.1, TPF might obtain milli-arcsecond images of 750-1,000 objects through the course of a five-year mission.

ALLOCATION OF TPF OBSERVING TIME

The allocation of observing time with TPF will depend on the results of the initial survey for planets and on the demonstrated performance of TPF for long (and very long) integration times. The relative proportion of time spent on surveying, making spectroscopic follow-up observations, and astrophysical imaging will be made by some appropriate combination of NASA officials, a TPF science team, and a community-based time allocation committee.