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The Development of the Terrestrial Planet Finder Mission

DEFINING THE TPF MISSION AND CONFIGURATION

The requirements of the Terrestrial Planet Finder (TPF) are defined both by the long-term vision of NASA's Origins program to search for life beyond the solar system, and by our ability to achieve an appropriate subset of those goals in the next decade at an acceptable cost. NASA and the scientific community must judge when a mission that is sufficiently rich in its science and mature in its technology is ready for a new start.

The definition of TPF's configuration and capabilities is the result of a highly iterative process that will continue through the formulation phase up to the start of the construction phase of the project. An early output of this iterative process is the definition of the crucial technologies which in turn will lead to a better understanding of possible instrument and spacecraft configurations. The process leads to a better understanding of the science possible with TPF. In time, the technology development and the mission definition studies will converge on a powerful and feasible TPF ready for a new start. Until that moment arrives, one or more reference designs will guide the technology program and give insights into the feasibility and cost of TPF. The current reference mission is described in Chapter 11.

Goals of NASA's Origins Program

- ***To understand how galaxies formed in the early universe and to determine the role of galaxies in the appearance of stars, planetary system, and life.***
- ***To understand how stars and planetary systems form and to determine whether life-sustaining planets exist around other stars.***
- ***To understand how life originated on Earth and to determine if it began and may still exist elsewhere as well.***

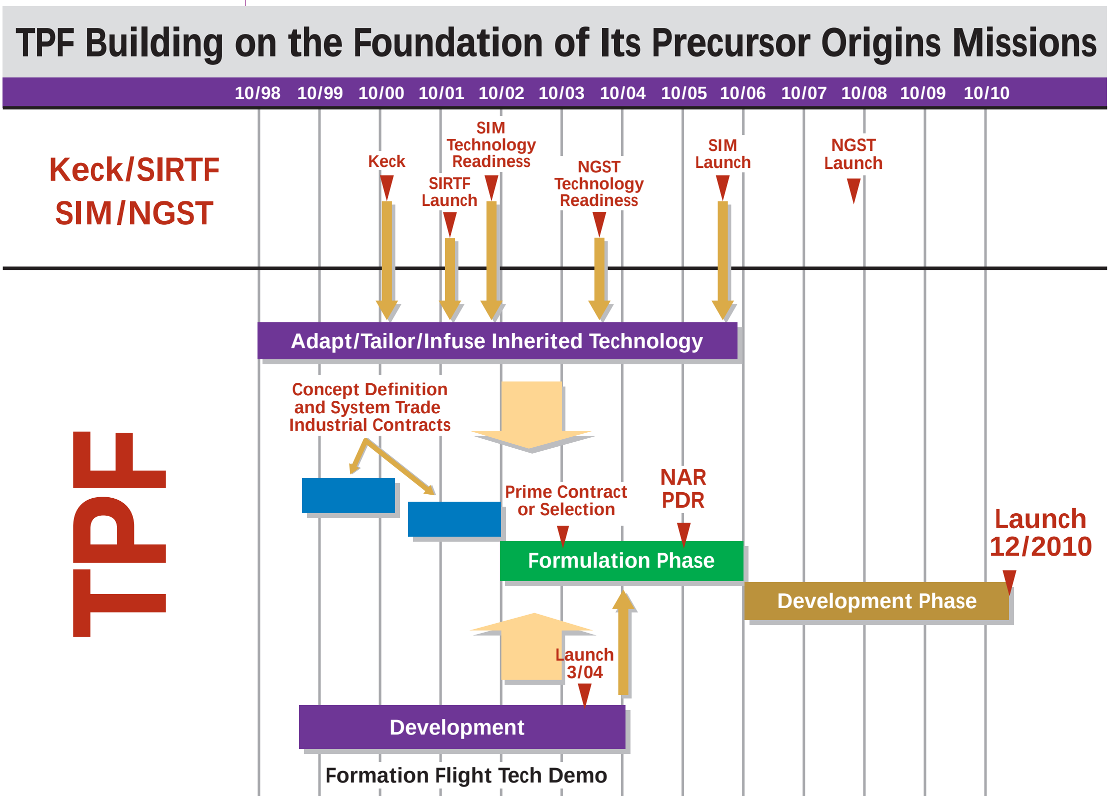

Figure 13.1 Technological precursors to TPF.

SCHEDULE AND COST

The Origins program master schedule is shown in Figure 13.1 and includes the Space Interferometry Mission (SIM), the Next Generation Space Telescope (NGST), Space Technology-3 mission (ST-3, formerly DS3), and TPF. It is a fundamental part of the philosophy of the Origins program that one project feeds scientific results and technological capabilities to the next project. As described in Chapter 12, TPF will benefit enormously from the earlier missions for developing and demonstrating key technologies.

The TPF technology development program will address the development of TPF-specific technologies as well as the adaptation of technologies inherited from the precursor missions to TPF needs. Broadband cryogenic IR nulling and multi-spacecraft precision formation flying, beyond that to be demonstrated by the ST-3, are two major TPF-specific technologies to be developed and validated. Cryogenic collector and instrument optics, sunshades and IR detectors are examples of technologies to be adapted, demonstrated and validated for TPF implementation. Finally, the TPF technology program will develop a series of subsystem- and system-level testbeds to validate system performance and integration and test methodology.

The implementation cost of TPF can best be estimated by leveraging the cost estimates of precursor missions such as SIM, NGST, ST-3, and the Keck Interferometer. As described in Chapters 11 and 12, these projects have many capabilities similar to those needed by TPF. And because these missions are now well along in their preparation for implementation, their cost estimates are fairly well defined. Therefore it can be argued that if: 1) the estimates for the precursor missions are accurate, and 2) the TPF cost estimates are tied to those estimates through the use of their detailed bottom-up analysis; then the TPF cost estimate will be fairly accurate.

The current reference mission described in Chapter 11 was used as a basis for three industrial estimates and one JPL estimate for the cost of TPF. The JPL team and the industrial contractors who supported this exercise were the same as those actively involved in the development of the precursor missions (SIM, NGST, etc.), to tie the quality of the TPF cost estimate directly to the quality of the estimates of these precursors. These estimates are consistent with an implementation cost (Phase C/D) for TPF of approximately 1 billion dollars (including launch) assuming that the precursor missions are implemented as planned.

NEAR-TERM PLANS

The past year has led to the design of a reference mission with the goal of focusing the technology development program as described in Chapter 12. Efforts over the next two years will address:

1) The detailed definition and implementation of a technology development plan with an emphasis on TPF technologies that will not be developed by one of the precursor missions. A major area of emphasis will be on the laboratory demonstration of starlight nulling in the infrared to the required level of 10^{-5}-10^{-6}.
2) Continued definition of reference missions to improve our understanding of TPF's technology requirements and scientific performance. In particular, the choice of array configuration, e.g. linear or two-dimensional, with chopping or without, needs careful attention (Table 6.2) The knowledge gained through this process will be fed back to the technology program.

POTENTIAL FOR INTERNATIONAL COLLABORATION

The challenge and broad public interest of TPF make this mission an excellent candidate for international collaboration. Like HST, NGST, and FIRST, the technical challenges and cost can be shared by identifying suitably ambitious contributions for countries interested in participating. Because the European Space Agency (ESA) is currently studying the Infrared Space Interferometer (IRSI), a mission with nearly identical goals to TPF's, ESA is a likely collaborator. Already IRSI and TPF scientists and engineers have developed harmonious relationships, sharing design concepts related to array configurations, telescope size, and orbital location. Prospects for collaborations should be assessed following milestones such as the selection of ESA's Horizon 2000+ Cornerstones, the development of NASA's next Strategic Plan, and the submittal of the U.S. National Research Council's Decennial report on astronomy.

COMMUNITY INVOLVEMENT

There will be numerous opportunities for involvement in TPF by the astronomical community through normal peer-reviewed channels, including: technology and instrument development, theoretical investigations of the possible signatures of habitable planets (through NASA's Astrobiology Institute), development of target star lists along with preparatory ground-based observations, execution and analysis of observing programs to search for and characterize planets using TPF, and General Observer programs for astrophysical imaging. The relative proportion of time TPF will spend on surveys of nearby stars, making spectroscopic follow-up observations of promising targets, and on astrophysical imaging will be made by a combination of NASA officals, a TPF science team selected by peer review around the start of the TPF implementation phase, and a community-based time allocation committee.