2. PROCEDURE

The Synthesis Report presented two mission durations for Mars exploration: long-duration missions on the order of 1,000 days with a typical stay time on Mars of approximately 500 days (1-1/3rd years, 16-17 months), and short-duration missions on the order of 500 days with a 30 to 100 day stay on Mars (1-3 months). Our thinking lead us to believe that there were significant architectural, habitation, and environment-behavior issues to be explored and resolved in a long-duration permanent Martian habitat that would contain research work stations and crew living quarters. Reviewing other published mission scenarios (Stafford, 1991; Weaver, 1992; Zubrin, Baker & Gwynne, 1991) also lead us to believe that an initial short-duration outpost will quickly be followed by one or more exploratory long-duration outposts, which in turn will be followed by a permanent long-term base. The focus of our work for 1992, therefore, was on a long-duration permanent base.

Our work built off what the Synthesis Report referred to as the Mars "Waypoint" (by which is meant Mars planetary activities for human exploration of Mars, i.e., as a waypoint to later exploration into the Solar System). Phasing the development of a permanent base, we accepted the Synthesis Report recommendations of a crew size of 6 crew members for an initial human-tended outpost for change-out durations of 500 to 600 days on the Martian surface. The first permanent base, termed *initial operational configuration* (IOC), would be accomplished by repeating the mission via a revisit of a previously explored site, emplacement of one additional 6-person outpost, and then development of a permanent base for long-duration missions with stays on the order of 500 to 600 days or longer, and this time for multiples of 6 crew members, likely a full crew of 18 crew members.

The Mars waypoint assumes significant transfer of learning from orbital and lunar facilities including utilization of lunar in-situ resources and evaluation of lunar habitats. Our work in Years 1 and 2 of the USRA Advanced Design Program is thus very instructive. An early phase of our Martian work was an analysis and critique of the five former lunar habitats-- especially the two alternatives taken into detailed schematic design--for positive and negative lessons to be transferred to the design of a Martian habitat. The Synthesis Report recommended that the Mars habitat would be tested as a prototype on the Moon. As our previous work started with the Moon (see the four previous monographs in this series, listed in Appendix B), we expanded from our lunar knowledge base and lunar habitat design experience to generate alternatives for Martian habitation.

Thus, in the spring of 1992, the Space Architecture Design Studio designed a permanent, long-duration base for the surface of Mars. Subsequently named *Pax* (for the international Peace Settlement, opposite of the Latin name of the planet, *Mars*, the God of War), this first Martian permanent base will be capable of providing housing, research space, mission control space, and all amenities for 18 astronauts to live on Mars for durations up to two years.

The work was accomplished in an overlapping sequence of eight principle phases, as shown in the time line of Figure 2-1.

2.1 ORGANIZATION/MISSION SCENARIO

Analysis of alternative mission scenarios. As there are significant differences in the literature (Stafford, 1991; Weaver, 1992; Zubrin, et al., 1991), we elected to develop an integration of the commonalties between the three most prominently discussed mission scenarios (2 weeks-- January 6-21, 1992).

2.2 BASE DESIGN RESEARCH

Detailed scenario presentation followed by background research and development of design requirements on overall base design. A range of base design issues were explored (e.g., implications of the Mars environment) relevant to site selection, size and character of the site, site design, master plan, and sequencing of phases to IOC and NOC. Other issues were explored relevant to overall configuration of the site plan (siting of the habitat, solar array field, methane production facility, wind power facility, launch and landing facility, vehicle storage and maintenance facility, nuclear power plan, and transportation infrastructure; 3 weeks--January 23-February 11).

2.3 CONCEPT DESIGN EXPLORATION

Schematic design studies to develop and explore different base layout master and site planning concepts. The implications of four alternative concept designs for the base as a whole were explored, analyzed, and then compared at an internal preliminary design review (PDR–January 30):

- hard module habitat, partially buried and partially in the edge of a Martian crater
- inflatable habitat, partially buried and partially in the edge of a Martian crater
- Earth-like technology for Martian surface application
- space-frame construction spanning between crater edges

From the late-January PDR, considerable advantages were found for surface construction with a combination of hard module and inflatable structures (2-1/2 weeks-- January 24-February 11).

2.4 HABITAT DESIGN RESEARCH AND REQUIREMENTS

Accomplished in two parts:

- literature research on the full range of human factors and environment- behavior considerations in habitat design, including but not limited to crew quarters, crew support facility, mission operations, research workstations, biosphere, wardroom, recreation spaces, hygiene facility, and research laboratories;
- development of design requirements based on accumulated research (3 weeks-- February 4-20).

2.5 HABITAT SCHEMATIC DESIGN

Schematic designs developed for each space (laboratories, crew quarters, etc.) in response to the design requirements. Design directions and objectives were established for the complete schematic design of each activity space, the habitat as a whole, and the base site and master plan. Design attention was paid, however, to the habitat interior design in order to respond most directly to the human factors and environment-behavior requirements. Following an internal PDR (March 3), a formal intermediate design review (IDR) was conducted (April 3) to review the results of individual schematic designs and set priorities for the continuing work. Special guest reviewers from the UW-Milwaukee Department of Architecture, from the local profession, and from NASA- Johnson Space Center offered critical comments and recommendations for continued design development (7 weeks--February 13-April 3).

2.6 INTERIOR DESIGN DEVELOPMENT

Design development of all interior spaces, refinement of design details, response to raised criticisms, and beginning of integration across the habitat as a whole. The layout of the base site and master plan were refined and solidified during this time. The overall conceptual design for the habitat as a whole, in response to a set of environment-behavior derived design principles, was integrated at this time. The final designs for each module and their subspaces was refined and consolidated. A not-quite-final design review (NQFDR, April 16) was conducted of the design development to identify areas needing fine-tuning (e.g., materials handling within the laboratories) and issues of integration across the habitat or base as a whole (e.g., lighting, color and material selection and coordination; 6 weeks--March 5-April 16).

2.7 DESIGN INTEGRATION AND PRESENTATION

In response to this final, internal self-evaluation, final design development and design integration occurred. The presentation of the results of the project–in mid-fidelity models for each floor of each module with lighting, colors, and textures, a mid-fidelity model of the habitat and regolith-containment space- frame structure, and drawings of site selection, site plan, and construction sequence to IOC and NOC--was developed. Slides were taken of all models and drawings, and of diagrams to explain the environment-behavior bases of habitat and base design (3 weeks--April 16- May 7).

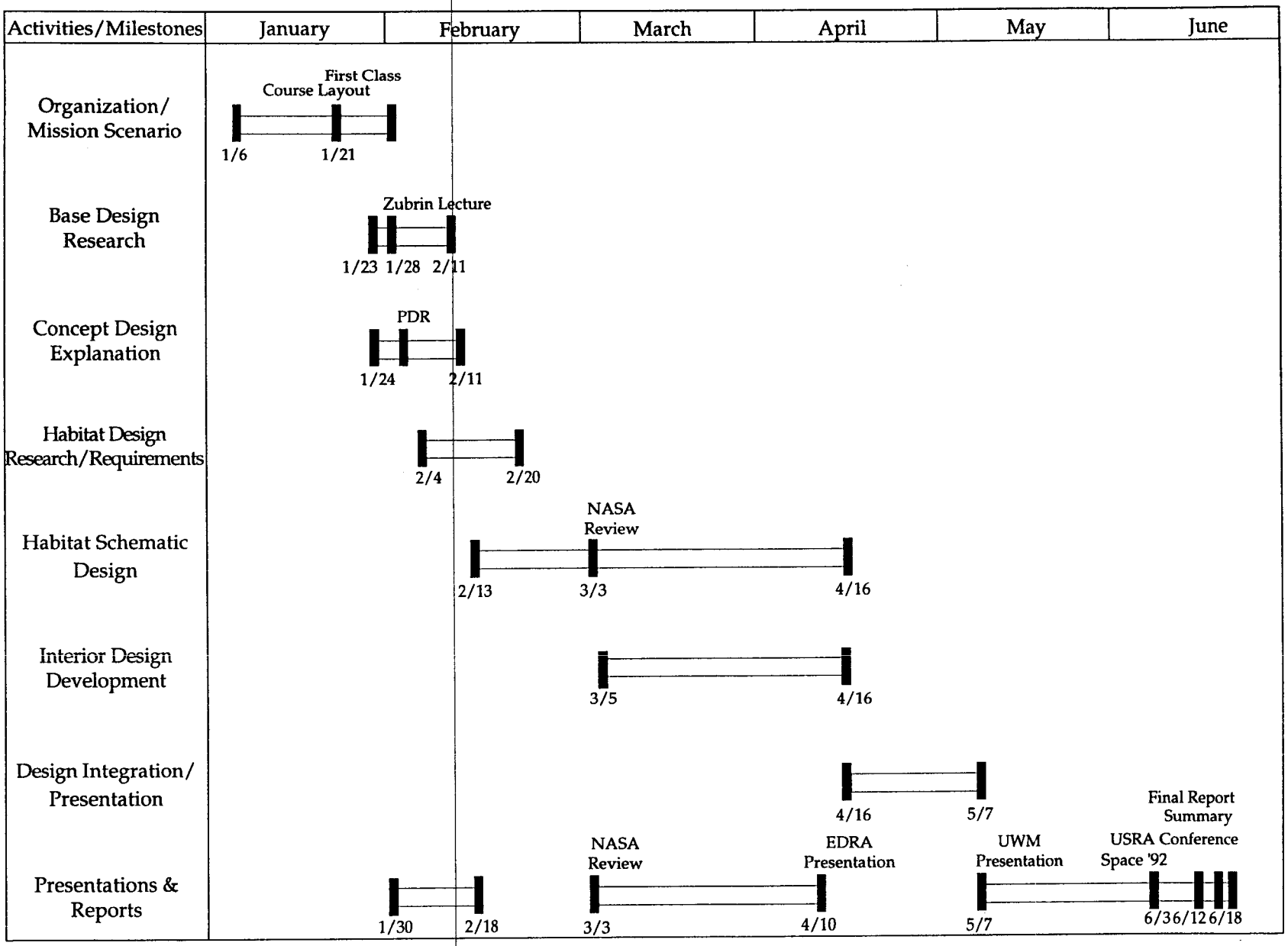

Figure 2-1. The 1992 timeline.

2.8 PRESENTATIONS AND REPORTS

Preliminary reports were written during the project and were reviewed at the NASA PDR and other times. The final product is a slide presentation based on photographs of large take-apart models, together with this final report. The project was and will be reviewed on several occasions in different forums: final internal design review at UW-Milwaukee School of Architecture and Urban Planning, invited presentation at the American Society of Civil Engineers Space 92 Conference in Denver and at the Annual NASA/USRA Summer Conference in Washington, D.C., and exhibition at the Wisconsin Space Conference.