

5. INTRODUCTION

5.1 NEWS RELEASE

June 13, 2005

Please join us for a historical review of Genesis, the first outpost on the moon.

The year is 2005. Today the United States in conjunction with its space partners Canada, Japan, the European Space Agency, and the Soviet Union has landed its first team of astronauts, scientists, architects, and engineers to build a permanently occupied habitat on the moon.

Called Genesis, this early, evolutionary Outpost will function as a long-term testbed for all materials, processes, and development strategies to be employed in a mature lunar colony to be undertaken in the next 20 years, and as a testbed for developmental technologies to be employed in the exploration and settlement of Mars.

Design and development of this lunar test facility was initiated in the year 1989 by NASA/USRA and its prime contractors in conjunction with the University of Wisconsin-Milwaukee's Center for Architecture and Urban Planning Research and Department of Architecture in cooperation with the College of Engineering and Applied Science. A dedicated, insightful, and resourceful group of eleven students — architects, interior designers, and engineers — developed three experimental scenarios for Genesis.

These three scenarios, each based on different assumptions, provided the basis for the Lunar Outpost, and for the further development of one of Earth's last frontiers.

The best of each of the three scenarios was subsequently combined into one integrated design solution for the Outpost, since known as NASA Project Genesis.

Following guidelines provided by NASA and its prime contractors, the UWM design team designed Genesis for a full-time crew of eight to twelve persons on rotations of six to nine months. Crew gender, nationality, and ethnicity varied as the consortium of world aerospace partners all became involved after the fall of the Iron Curtain and the subsequent fall of the Great Wall, opening the entire world to free flowing scientific, architectural, and engineering communication.

There were five purposes for Project Genesis: (1) lunar surface mining and production analysis for lunar oxygen (Lunox), helium 3 (H3), and other minerals; (2) lunar construction technology and materials testbed for testing high technology construction with inflatable, the use of lunar regolith for radiation shielding, lunar glass, lunar concrete, and sintering techniques using advanced telerobotic systems; (3) closed system ecological life support system (CELSS) test facility; (4) lunar far side observatory; and (5) human factors and environment-behavior research facility.

The first manned mission, which landed earlier today, June 13, 2005, will last only 14 days. The astronauts, architects, and engineers, will live inside their lunar landing vehicle (LLV) and spend much of each day performing extra vehicular activities (EVA) involved in the initial base construction. A pressurized construction module will be the first order of business, followed by the evolutionary development of phased construction of the rest of the Genesis. Once all systems, subsystems, and backups have been verified, and the initial operation configuration (IOC) has been put in place, crew change outs will occur every 9 months to a year as the astronauts and their partners perform research and manufacturing operations at the Lunar Outpost.

We recall the words of former Chancellor Clifford V. Smith, Jr. of the University of Wisconsin-Milwaukee, as quoted in the Milwaukee Journal and elsewhere, "With this sizable grant and the unique challenges it brings, the University of Wisconsin-Milwaukee and its students, faculty, and administrators have taken a giant stride toward the future." The world owes much to the brave beginnings of this hearty group of students, now successful architects and engineers at NASA and its prime contractors.

But let us step back, and look at the beginnings of Genesis. Let us take a historical look at the three scenarios as they were first presented in a design studio at UWM back in February, 1990, and at the final integrative design as it was presented at the 6th Annual NASA/USRA Summer Conference held at NASA/Lewis Research Center exactly 15 years ago to the day.

5.2 PROJECT GOALS

This project was part of a three-year effort to investigate, research, analyze, and design outposts on the moon, human settlements on Mars, and the habitation requirements of long-duration manned transportation systems such as will be used between the Earth, the moon, and Mars.

The overriding objective of the project is to enhance architectural and architectural/engineering education in space design through establishing an advanced space architecture program that integrates architecture, engineering, planning, human factors, environment-behavior studies, natural resource utilization, and advanced construction technology.

The project had three specific project goals:

1. **Design solutions.** To develop major, creative yet realistic architectural and architectural/engineering design solutions to space design issues involved in the "bridge between worlds," in particular, in response to lunar outpost evolution, human factors and environment-behavior issues, safety, energy, construction technology, and the utilization of natural resources.

2. **Curriculum development and pedagogy.** To enhance, further develop, and maintain courses and studios in the area of space architecture in the School of Architecture and Urban Planning in conjunction with the College of Engineering and Applied Science at the University of Wisconsin-Milwaukee, and also to offer the design student the opportunity to become well versed in space and high technology.

3. **Useful information.** To produce information and design solutions useful to the aerospace community, NASA, its prime contractors and subcontractors, and NASA/USRA schools in the area of long-duration habitation design, and to publish this information and disseminate it in a manner that makes it accessible and timely to these communities.

5.3 LUNAR BASE OBJECTIVES

A lunar outpost had eight major objectives or performance requirements to satisfy:

1. Able to be constructed at an Earth-facing equatorial location.
2. Able to be constructed of light-weight, durable materials that require a minimum of EVA time.
3. Contained within the next generation of sophisticated Earth-lunar transport systems, expected to be comprised of four primary components:

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- a. the US Space Transport Shuttle system;
 - b. heavy-lift launch vehicle such as the Space Transport System unmanned Shuttle C with its cargo capacity of 69,000 K (150,000 lbs) and cargo bay accommodating payloads up to 25 m long by 4.5 m wide (82 x 15 ft) to low-Earth, space-station-inclination orbit (LEO);
 - c. the low-Earth orbit Space Station Freedom (SSF) and associated platforms, perhaps to include the more recently proposed Lawrence Livermore National Laboratory Earth Station; and
 - d. the planned Cis-lunar transport system, a dual-use system comprised of an orbital transfer vehicle (OTV) and a separated reusable lunar lander that transports construction components to the lunar surface along with crews and logistics.
4. Capable of housing 8-12 astronauts of different nationalities, genders, and specialties for periods of time up to 20 months though with a normal change-out time of 6-9 months.
 5. Provision for all necessary life-support systems and quality of life systems necessary for a safe and humane existence, including but not limited to:
 - a. anthropometrics and human factors;
 - b. health and safety issues;
 - c. environment-behavior issues including people, activities, isolation and interaction, privacy, personal space, and territoriality;
 - d. habitability and architectural issues;
 - e. environment-behavior issues in crew areas, crew support, operations of base, and design for productivity; and
 - f. space biospheres, Controlled Ecological Life-Support Systems (CELSS), and Environmentally Controlled Life-Support Systems (ECLSS).
 6. Integration of advanced technologies, including but not limited to the following:
 - a. space construction technology;
 - b. advanced systems of energy use and energy conservation; and
 - c. advanced mechanical systems including power, thermal, air movement, and hydraulic systems;
 7. Understanding and response to the natural environment of the moon, the physics, geology, and natural environmental qualities of the moon, lunar resource utilization, and
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appropriate “urban” design so as to retain the natural qualities of the moon: “Take only pictures, leave only footprints.”

8. Support for five main mission operations, all research functions:
 - a. lunar surface mining and production analysis for lunar oxygen (Lunox), helium 3 (H3), and other minerals;
 - b. lunar construction technology and materials testbed for testing high technology construction with inflatable, the use of lunar regolith for radiation shielding, lunar glass, lunar concrete, and sintering techniques using advanced telerobotic systems;
 - c. closed ecological life support system (CELSS) test facility;
 - d. lunar far side observatory; and
 - e. human factors and environment-behavior research facility including post-occupancy evaluations (POEs) of Genesis itself.

Each of these mission objectives and their associated performance requirements are examined in detail in the next major section, Section 6.

5.4 DESIGN METHODOLOGY

To achieve these goals and mission objectives, the project team proceeded in three main phases:

1. **Fall semester seminar.** The project began with a fall semester seminar of 12 students from architecture, interior design, mechanical and structural engineering, and liberal arts/pre-architecture. The seminar was under the leadership of Edwin Cordes, a recent graduate of the UWM M.Arch. program and of the International Space University in Strasbourg, France, and Dr. Gary Moore, a research architect and environmental psychologist who was the overall project director. The NASA/USRA teaching assistant was Mr. Timothy Hansmann, who had been a NASA/USRA intern at the Johnson Space Center. The product was a programming/requirements document (Baschiera et al., 1989).

A brief study of the current habitation/laboratory modules for Space Station Freedom was conducted to acquaint the students with certain design constraints. Highlighted results appear in Figures 5.4-3, 5.4-4, 5.4-5, and 5.4-6. Additionally, the base was organized into four program categories, and a programming matrix addressing the base elements and their design issues was formulated.

2. **Spring design studio — three alternative design scenarios — preliminary design.** A design studio in the spring semester developed a lunar outpost initiated from that document. A group of 11 students, more than half of whom had been in the fall seminar, were drawn from architecture, interior design, and mechanical and structural engineering. Issues considered included anthropomet

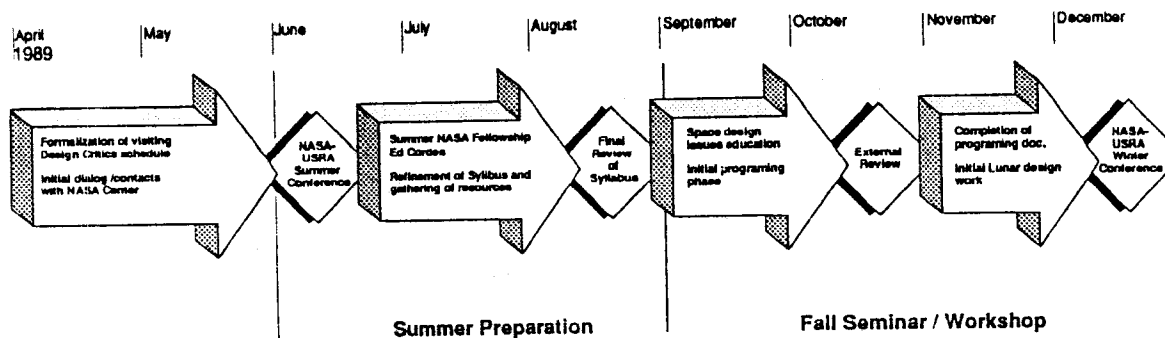


Figure 5.4-1. Fall semester objectives and milestones.

rics, human factors, health and safety, psychological and social issues, habitability, energy systems, construction technology, internal and external base operations, and base master planning and phasing.

For a short time, teams explored different sub-systems of the base (research module, manufacturing module, habitat module, transportation system, overall base planning and layout). Three alternative design scenarios were explored in detail, and preliminary design

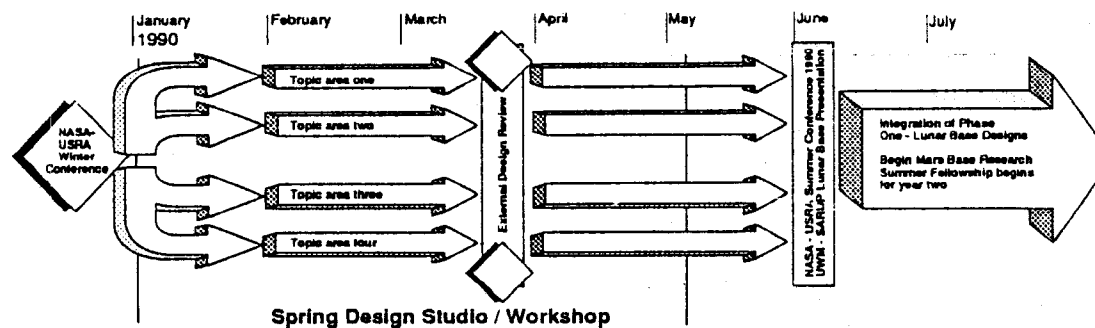
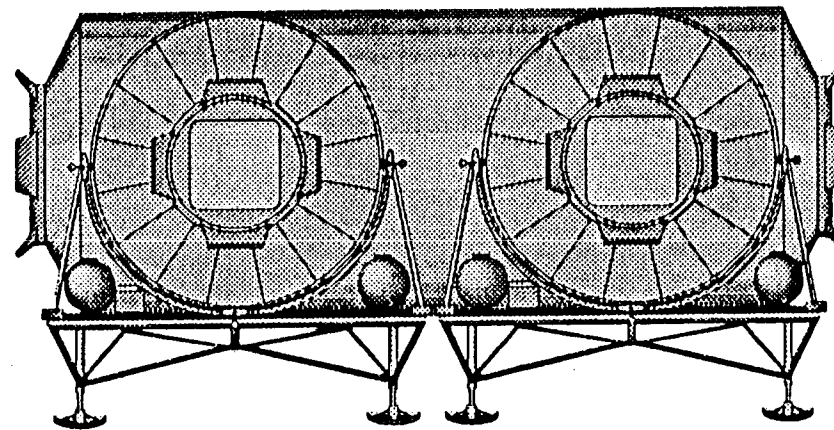
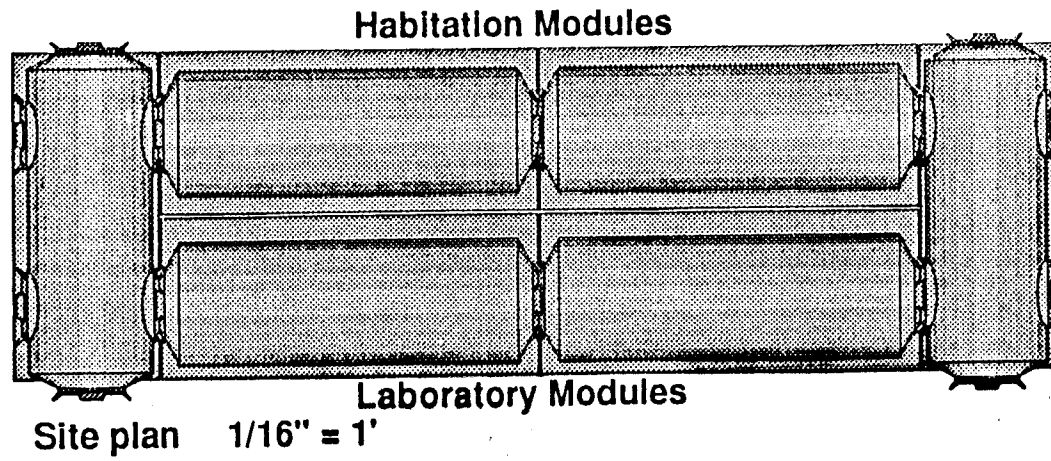


Figure 5.4-2. Spring studio objectives and milestones.



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Figure 5.4-3. Module design.

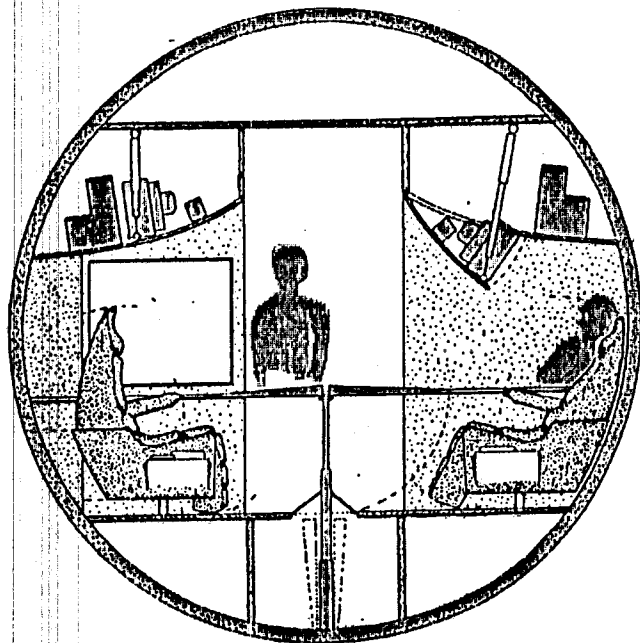


Figure 5.4-4. Example: teleconference area.

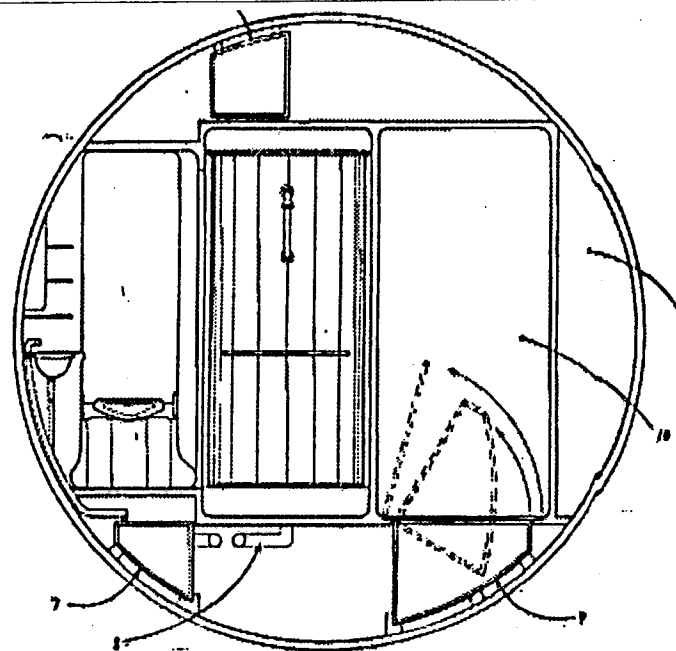


Figure 5.4-5. Example: hygiene facility.

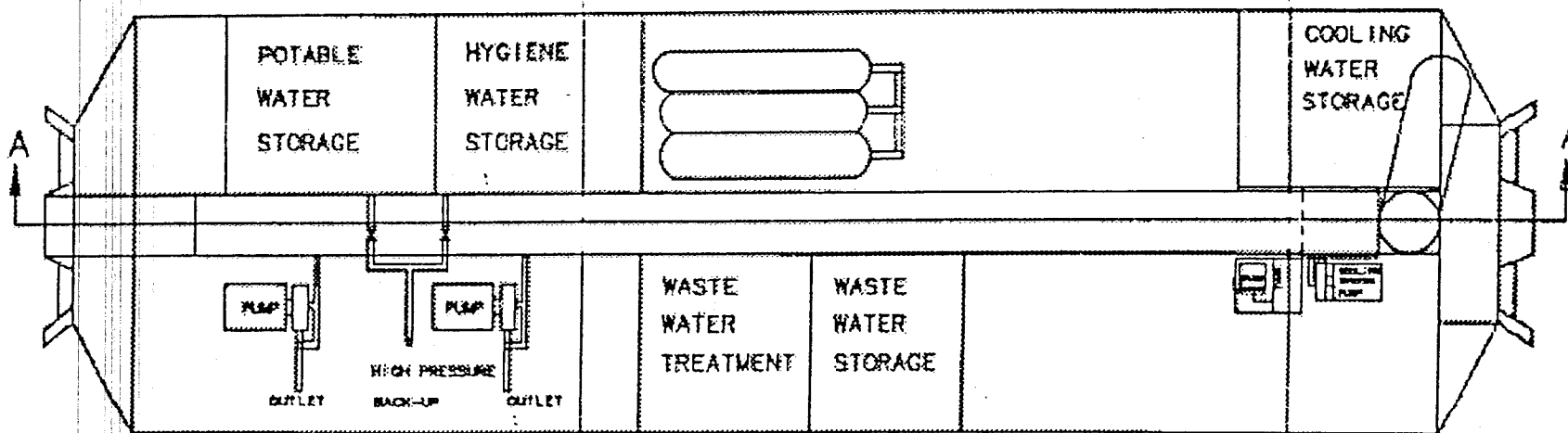


Figure 5.4-6. Preliminary water subsystem.

Design Issues

Base Elements	Design Issues																
	Privacy	Anthropometrics	Coding	Color / Decor	Gender Issues	Materials	Thermal / Light Req.	Health / Safety	Social Interaction	Sound Transmission	Personalization	Wayfinding	Productivity	Atmosphere Control	Redundancy	Ergonomics	Proximity
	+ Very Important - Somewhat Important 0 Not Important																
Personal Quarters	+	+	0	+	0		+	0	0	+	+	0	+	+	+		
Meal / Meal Prep.	0	+	+	0	0	-	+	+	+	0	0	-	+	+	+		
Sleeping	+	+	0	-	0	+	+	0	0	+	+	0	0	+	0		
Hygiene	+	+	-	0	+	-	+	+	0	-	-	0	0	+	+		
Exercise	0	+	-	+	0	-	+	-	-	0	0	0	+	+	+		
Group Recreation	0	+	+	+	0	-	+	-	+	0	0	0	0	-	+		
Materials Storage	0	0	+	0	0	0	-	+	0	0	0	0	0	+	+		
Workstations / Lab	-	+	+	+	0	-	+	+	-	+	-	-	+	+	+		
Biosphere	0	0	-	0	0	0	+	+	0	0	0	0	+	+	+		
Medical Facility	+	+	+	-	-	+	+	+	0	+	0	-	+	+	+		
Safehaven / Emergency		+															
Communications	0	+	+	-	0	-	-	-	-	+	0	-	-	-	-		
Teleconf. / Meetings	-	+	-	+	0	-	-	-	+	-	-	0	+	-	-		
Command Center	0	+	+	+	0	-	+	-	-	+	0	-	+	-	-		
EVA / IVA & Monitor	0	+	+	-	0	+	-	+	-	0	-	-	+	+	+		
Power	0	0	0	0	0	0	0	+	0	0	0	0	0	0	0		
Transportation	0	-	-	0	0	0	0	-	0	0	0	0	-	0	0		
Remote Operations	0	0	-	0	0	0	0	-	0	0	0	0	-	0	0		
ECLSS																	
Waste Storage	0	0	-	0	0	+	0	+	0	0	0	0	-	+	-		
Base Layout																	
Circulation / Translation	0	-	-	+	0	-	+	-	-	0	0	+	-	-	+		
Lighting	0	-	0	-	0	0	+	-	0	0	+	-	-	0	-		
Image	+	0	0	+	0	+	-	0	-	0	+	-	+	-	-		
Storage Systems	0	-	+	0	0	0	0	0	0	0	0	0	0	-	-		

Figure 5.4-7. Programming matrix.

solutions were presented at a Preliminary Design Review (PDR) on February 17, 1990. The three scenarios, each pursued by a different team, were as follows:

- a. prefabricated rigid space structures using clusters of space station-sized pressure vessels, aluminum alloy domes, and interconnect nodes;
- b. underground architecture using the natural lunar craters and lava tubes; and
- c. inflatables using a laminated Kevlar bladder with a space frame structure.

Separate modules were designed for laboratory and habitation functions. The entire facility was designed to be buried under a sufficient amount of lunar regolith (approximately 1.5 m) for proper radiation protection and thermal control.

Each team was comprised of architects and engineers with different specialties: environment-behavior systems, human factors, interior design, structural or mechanical engineering, and construction technology. This division — vertically by sub-system and horizontally by specialty — insured that each sub-system responded to all design factors and that all sub-systems would later contribute to an integrated solution.

The most promising design concepts and ideas were selected at a mid-semester PDR led by guest critics from NASA/JSC and McDonnell Douglas Space Systems Company and visiting faculty from the UWM Departments of Architecture, Mechanical Engineering, and

Civil Engineering.

The product was a set of design drawings and presentation boards, together with an associate slide presentation, that was presented at several regional and national meetings and received a special student design commendation award from the Environmental Design Research Association at its 21st annual conference held at the University of Illinois, Urbana-Champaign, Illinois.

3. Spring design studio - final integrated design solution - design development. The design concepts and ideas selected from the PDR were further developed by the entire project team.

First, a number of critical technical issues needed further research, analysis, and design exploration — materials, joining systems, hatches and gaskets, structural system, deployment and erection systems, and regolith containment systems. Each was explored in depth by one or two members of the team with critical input from our NASA/JSC consultants and industry representatives.

Second, the project team was subdivided into teams for the further exploration and design development of parts of the overall Genesis Lunar Outpost. The three critical teams were:

- a. site and master planning (see Sections 6.6 and 7.2.2 below);
- b. interior configuration (see Sections 6.7 and 7.2.3 below); and
- c. construction technology (see Sections 6.4 and 7.2.4 below).

Each team was again comprised, as best we could, of architects and engineers and of team members with backgrounds and expertise in design, environment-behavior issues, and technology.

The product was a final set of design development drawings, together with a comprehensive slide presentation, that was presented at the NASA/USRA 6th Annual Summer Advanced Design Program Conference, NASA/Lewis Research Center, and elsewhere in this country and overseas. The details of this design are given below in Section 7.

