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THE CENTAURI PROJECT: MANNED INTERSTELLAR TRAVEL

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ABSTRACT

The development of antimatter engines for spacecraft propulsion will allow man to expand to our nearest stellar neighbors such as the Alpha Centauri system. Compared to chemically powered rockets like the Apollo mission class which would take 50,000 years to reach the Centauri system, antimatter propulsion would reduce one way trip time to 30 years or less.

The challenges encountered by manned interstellar travel will be formidable. The craft must be a combination sub-light speed transportation system and a traveling microplanet serving an expanding population. As the population expands from the initial 100 people to ~ 300, the terraformed asteroid, enclosed by a man-made shell will allow for expansion over its surface in the fashion of a small terrestrial town. All aspects of human life - birth, death, physical, emotional and educational needs, government and law must be met by the structure, systems and institutions on board.

INTRODUCTION

Interstellar space exploration is at once profoundly exciting and profoundly frightening. The isolation and vast distances along the paths of these starlines are beyond the understanding of today's civilizations. The Alpha Centauri star system, our Sun's closest stellar neighbor, lies 4.3 light years away from us. This is the equivalent of just over twenty-five trillion miles. A one way trip to Proxima Centauri, the closest member of this three star system, will require 30-50 years, depending on the minimum cruise velocity required (between 10 to 30% of the speed of light).[ref. 7]

If the exploration of the solar system is the Third Great Age of Discovery as suggested by Pyne [ref. 12], the exploration of star systems will herald the dawn of the Fourth Age of Discovery. Though each age ultimately deals with worlds beyond the terrestrial sphere, the discovery and exploration of stellar systems is fundamentally different from the discovery of abiotic planets within the solar system. The rift valleys, ice caps and red deserts of Mars, the volcanoes of Io and the great cliffs of Miranda are images that our civilization can understand through terrestrial counterparts. Images of stellar systems bear few if any physical, temporal or social symbols recognizable to our civilization.

It is necessary for the structure of a paper such as this to make assumptions. The time frame of this mission is placed in the latter part of the twenty first century - when we assume that man has explored and colonized the majority of Solar Systems. This colonization effort has established a network of manufacturing plants and O'neill type colonies amongst the Jovian planetary systems.[ref. 11] Construction in space is a mature technology, as is materials processing and the use of antimatter engines for propulsion. Finally, it is assumed that non-centrifugal artificial gravity has been developed and implemented in a number of vessels and orbiting colonies.

THE INTERSTELLAR VESSEL

The interstellar vessel for the Centauri Project will consist of an asteroid of the stony carbonaceous chondrite class, with a nominal diameter of approximately two miles. Surrounding this asteroid will be a man-made shell, best defined as a '2-manifold in 3 space' [ref. 8], which folds in on itself at each end along the primary axis. (See figures 1 & 2). This shell, approximately 60 feet thick and containing three graduated pressure levels, encloses an atmosphere that allows the crew to live on the surface of the asteroid.

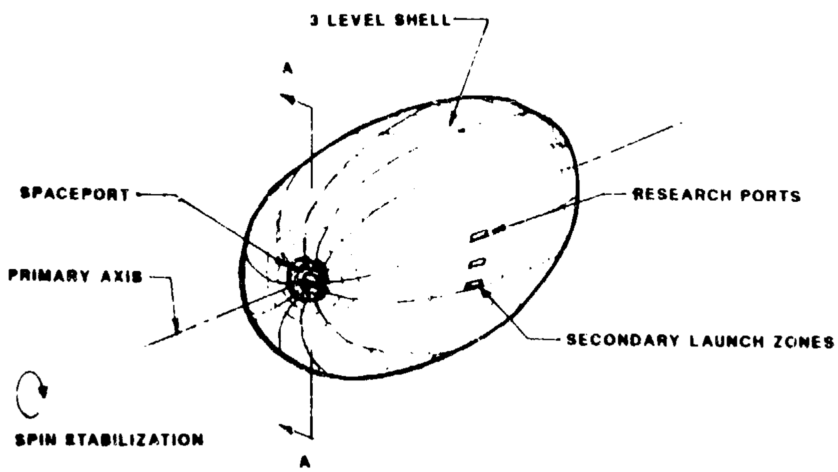

FIGURE 1: EXTERIOR VIEW OF INTERSTELLAR VEHICLE

Upon enclosure, the surface of the asteroid will be terraformed to contain a variety of Earth ecosystems: forests, farmlands, small lakes, etc. Highly automated food production techniques will be incorporated to control highly automated agriculture, fish farming, husbandry and hydroponics. An asteroid measuring slightly less than four kilometers across has a surface area of roughly 9,000 acres, satisfying Nasa's guidelines for area requirements of habitation, and food production. [ref. 2,9]

Livability Requirements

The habitable surface of an asteroid serving as a microplanet creates an environment which will appear quite Earth-like. The importance of Earth-like living conditions becomes evident through positive effects of privacy, mobility and the reduction of the closed environment feeling. Provisions for long lines of sight, views of a horizon and large overhead clearances - all possible with this vessel style - offer enormous benefits to intellectual and emotional well being of crews on long duration missions. [ref. 6] Combining these provisions

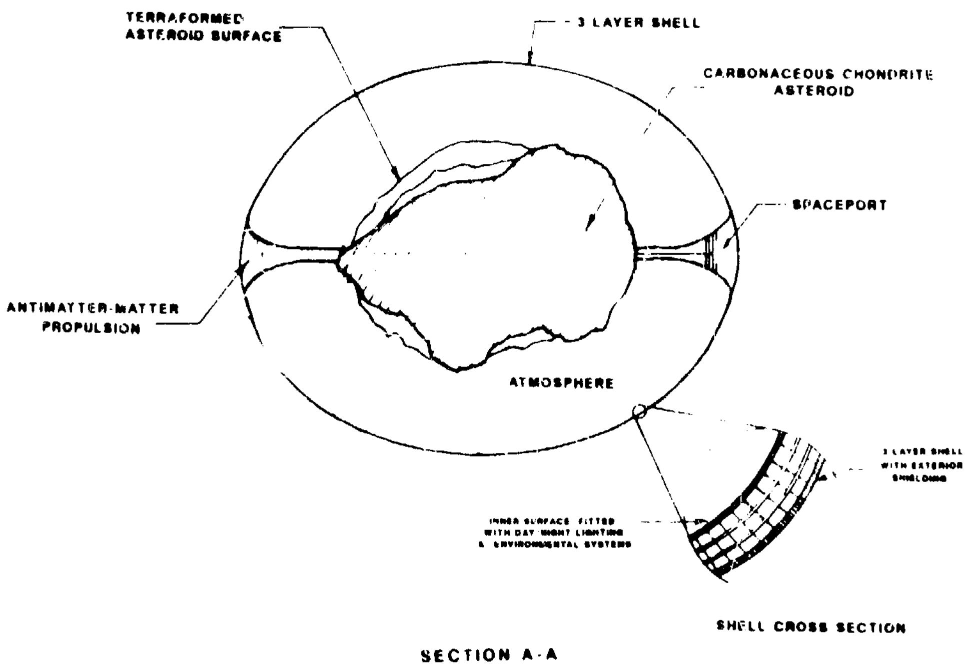

FIGURE 2: CROSS SECTION THRU INTERSTELLAR VEHICLE

with a variability factor in the environment will provide the stimulation necessary to suppress the symptoms of Solipsism. Solipsism is a state in which a person feels that everything is a dream and nothing is real. This state of mind often occurs in the Arctic winter when darkness lasts 24 hours a day. A person feels lonely and detached, eventually becoming apathetic and indifferent. Variability will be enhanced by proper asteroid selection which will provide varied topography allowing for views of natural objects such as hills and valleys on the terraformed surface.

The ability to invoke randomized environmental patterns is crucial to the goal of allowing this vessel to simulate a microplanet. To achieve randomized patterns, a 'unpredictability factor' is included in the systems programming. The program then controls day/night illumination cycles, temperature variations and even the creation of breezy conditions. Of the randomized systems discussed, the day/night cycle - serving as a zeitgeber - is perhaps the most important. Zeitgebers are physical, temporal and social cues that help to establish rhythmicity in the sleep/wake cycle. Social cues such as daily meals, work/rest schedules and evening leisure time also reinforces the circadian rhythm, which enhances performance.

The Shell

The shell of our vessel bears a resemblance in appearance and function to the shell of an egg. Attached to the asteroid at only two points - where the manifold folds in on itself - the shell rotates with the asteroid for spin stabilization around the primary axis. As an extension of the asteroid's terraformed surface, the shell provides livable spaces throughout selected zones of the triple level structure. These three levels, having the potential of providing habitable space will serve as laboratory, communications and scientific research spaces, as well as distribution corridors for various environmental and recycling systems.

The involuted areas at each end of the shell provide specialized areas for propulsion systems on one end and space port facilities on the other . The inward folds of this shell which reach the surface of the asteroid will serve as main traffic and systems corridors between the surface and the shell. Elevator systems within the involutions and in the shell proper will provide access to habitable shell zones as well as the activities zones housed within the involutions.

The spaceport (see Fig. 3), will provide the crew with the ability to launch a variety of shuttles, space probes and experiment packages, as well as accept incoming personnel and cargo vessels. As the leading edge of the vessel, a concentration of navigation and scientific decks will also be located here.

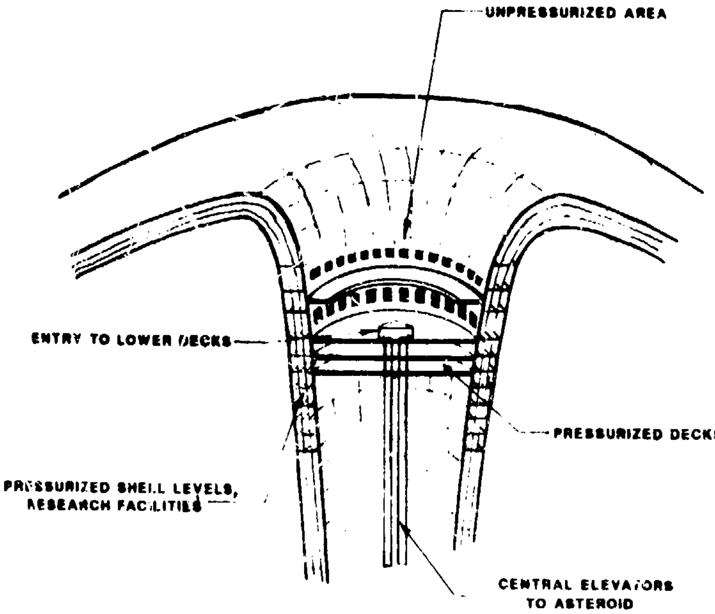

FIGURE 3: DETAIL OF SPACEPORT

Antimatter Propulsion & Power Systems

It is highly probable that first generation interstellar vessels will use multiple energy sources to fulfill the needs of a vessel of such magnitude. Antimatter engines for propulsion will be required during the boost phase for between one to two years of constant acceleration. During this boost phase and through the mission, power requirements for light, heat and life support systems will be large, given the vessels volume. The antimatter engines may not be the best source of energy for daily power demands. Multiple fusion reactors distributed within the shell and below the surface of the asteroid may be a practical configuration.

The viability of antimatter as a propulsion source has been under investigation by many [ref.'s 5,14,15]. When a particle and its antiparticle collide at a sufficiently low energy level, annihilation results in a high conversion of their mass into kinetic energy of other particles, photons and neutrinos. To harness and control this energy only kinetic energy and photons may be utilized. Therefore a matter - antimatter annihilation propulsion system is a device which would use these to produce thrust.

Since stable, long lived particle-antiparticles should be considered for propulsion - only electron-positron and nucleon-antinucleon annihilation reactions have potential for space propulsion. The advantage of the latter pair is the larger amount of energy released by these collisions. For this discussion, we will therefore assume that an antiproton-proton or antiproton-neutron annihilation will be used for the propulsion system, stored perhaps as magnetically levitated diamagnetic balls of antihydrogen, or a levitated ball of hydrogen with molecules of antihydrogen embedded in the crystal lattice of the ball.[ref. 12]

In general, matter-antimatter engines utilize the mixing of antimatter(antihydrogen) and matter(hydrogen) together in an annihilation chamber to interact, annihilate and exhaust a high velocity energetic plasma. Figure 4 shows one such concept of a matter-antimatter engine design.

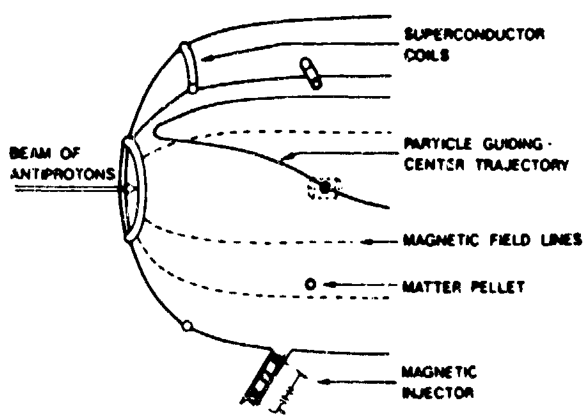

FIGURE 4: CONCEPT FOR ANTIMATTER ENGINE
(REF. 14)

THE CREW

We will assume that this interstellar vessel is equipped with highly automated systems. Though not attaining the sophistication of a 'von Neuman probe'*[ref. 1], these systems will nonetheless be capable of self monitoring and autonomous repair. With this level of automation in power, life support, food production and other critical functions, smaller crew sizes become practical. One benefit of this automation is the time available for research and experimentation during the mission.

Crew Size

The social dynamics of small groups, staffing requirements, and long term population growth must be considered before establishing initial crew size. Too small a group may create understaffing during a crisis situation. Social variety, necessary for individual fulfillment, is dependent on the number of available social contacts. A crew of thirty or less may be incapable of providing this social variety. On the other hand too large of a group may create control problems for the leadership and may contribute to runaway birth rates.

For this discussion, our crew size will total one hundred people: forty men, forty women and 20 children. Because we will need a young healthy crew for the start of this mission, the adults will be between 21 and 26 years old. The children will range from five to ten years old. There are positive and negative aspects regarding the inclusion of children at the beginning of this mission. On the negative side, children require a great deal of time and attention, something that may be scarce early in the mission. They must also be educated, requiring the dedication of crew members to this task.

On the positive side, these children represent the first of the next generation of adult crew members. This reduces the need for females to produce offspring almost immediately after the mission begins. It could be argued that the stresses involved in pregnancy and childbirth would outweigh those associated with raising children. The inclusion of children will also create a social structure closer to the mix of peoples on Earth. It has been speculated that this inclusion of the family structure early in this mission will provide social stability to the crew. [ref. 4]

*. The 'von Nueman probe' is a self-reproducing universal constructor, capable of making any device, given the materials and construction programs.

THE SOCIAL ENVIRONMENT

The crew of an interstellar vessel embarking on a long duration mission will enter a microsociety which will have its own rules, benefits and hardships. Analogous to air-born seed pods of terrestrial plants, this social pod will take the elements of humanity into the galaxy. The remoteness of an interstellar crew possess special problems for mission planners, particularly in the area of organizational and management structure.

Leadership

Almost all of the space efforts by the USA and the USSR have used military personnel to staff the missions. The use of a military organizational and management structure has proved successful in almost 100% of these missions, especially in those missions where crises has occurred. This military authority structure may not work however, for a crew made up of non military personnel.

It is probable that on a multi-decade mission, the authority structure in place at the outset of the mission may have been completely abandoned for an alternate style later. The isolation, confinement and risk of long duration missions may prove to undermine authority structures and increase demands on the leaders. In addition there is the issue of a multi-generational crew coming of age on an interstellar vessel. The challenge will be to instill a commitment to the mission.

The point is that whether a military based model or a community democracy model is used, each has advantages and disadvantages of its own. No one model will work the best for all situations. As mankind populates the Solar System, novel alternatives may evolve which may be better adaptable to interstellar travel.

The Life Cycle

Unlike most space efforts today, the drama of the life cycle will be a predominant part of the Centauri project. Birth, aging and death will be present as will the many anomalies associated with the process. As the population expands, crime will likely exist, perhaps even murder; requiring social systems to be in place to deal with events which could effect the performance of the crew. The existence of marriage and the family unit also presupposes the existence of divorce. The practicality of divorcing a spouse in such a closed society is an unknown factor, but it will certainly require contingency planning.

Unique to this type of mission is the simple act of living out a life in space. The day to day activities and demands of mental, physical and social maturation must be dealt with in addition to responsibilities of a crew member on the mission. An aside to this life cycle is the unprecedented fact that humans will be born with lives totally disassociated from the planet Earth. For those crew members born as part of the first Centauri generation, the microplanet serving as their starship may well be all they will know of life.

Space travel, particularly long duration missions, involves the sacrifice of personal freedoms. For those individuals born aboard the Centauri vessel another basic freedom will be lost - free choice of a profession. Because the vessel and systems must be maintained, many positions must be manned for the entire length of the mission. This means that replacements must be trained for the original crew, requiring a portion of the descendants to be selected for a specific function. The process and timing of this selection may best be left to social norms developed within the society.

SUMMARY OF VESSEL PARAMETERS

PROJECTED SURFACE AREA OF ASTEROID:	9000 Acres	
PROJECTED EXTERNAL SURFACE AREA OF SHELL:	9×10^7 m^2	
MAXIMUM HABITABLE SURFACE AREA WITHIN SHELL STRUCTURE:	2.25×10^8 m^2	
ATMOSPHERIC COMPONENTS: (1 standard atmosphere=101kPa)	(kPa)	(mmHg)
O_2:	22.7 (±9)	170
N_2:	26.6	200
CO_2:	< .4	<3
TOTAL PRESSURE:	50.8	380
WATER VAPOR:	1.0 (± .33)	7.5 (± 2.5)
TEMPERATURE:	23° 8°C	
RELATIVE HUMIDITY:	50 ± 10 percent	
PSEUDOGRAVITY:	.95 ± .[illegible]g	
AVERAGE OVERHEAD CLEARANCE:	914 m	
LONGEST LINE OF SIGHT:	2414 m.	
PORTION OF HABITAT HIDDEN FROM VIEW:	90%	
ILLUMINATION CYCLE:	STANDARD TERRESTRIAL DAY (Variable)	

TABLE 1:
SUMMARY OF VESSEL PARAMETERS

SUMMARY OF DESIGN CONSIDERATIONS

LONG LINES OF SIGHT
LARGE OVERHEAD CLEARANCE
VIEWS OF LARGE NATURAL OBJECTS
PORTION OF HABITAT HIDDEN FROM VIEW
WATER VISTAS: SMALL LAKES
ACOUSTICS OF CHAMBER CREATED BY SHELL
AVAILABILITY OF PRIVACY
PLACEMENT OF MANUFACTURING FACILITIES UNDERGROUND
UNPREDICTABILITY FACTOR OF THE ENVIRONMENT

TABLE 2:
SUMMARY OF DESIGN CONSIDERATIONS

THE MISSION

Following the enclosure of the asteroid and the establishment of an atmosphere and a terraformed surface, a pre-flight shakedown will likely be undertaken in our Solar System. Navigating the planets at low speeds for twelve months, the shakedown will allow hardware, software and crew to be checked before leaving the Solar System. Minor problems in any systems hardware could quickly be repaired and serve as hands on experience for the crew. This twelve month period will also allow crew members to become acquainted with one another and discuss social norms and mission guidelines.

Boost and Coast Phase

Once vessel and crew have passed the shakedown portion of the mission, the antimatter engines will accelerate them to approximately thirty percent of the speed of light. Once this velocity is attained the engines will be shut down as the vessel enters the coast phase of the mission, traveling at sub-relativistic speeds for approximately three decades. After a decade of travel, one way communication time will exceed a year, limiting communication to the transfer of data on recent events or discoveries. As the vessel nears the Centauri system, one way message times will be roughly four years.

During this coast phase, the crew will have the freedom to define social norms, establish routines for government and education of the children, and refine the physical aspects of their environment. As the colony settles down to living normal lives on this microplanet early planning can begin for the eventual need to expand habitats as the population grows. In conjunction with the sociological tasks of the crew, an itinerary of specific research goals and programs will have been established by mission planners. It is assumed however, that the crew will be allowed the flexibility to develop schedules, pursue new lines of research, launch space probes and develop new mission goals and hardware as needed.

The forced autonomy of this vessel after leaving the Solar system makes freedom of schedule planning an absolute necessity. Cognitive conflicts between Earth based planners and the vessel would quickly develop, should any group based in our Solar system attempt to dictate behavior patterns to an interstellar crew. Cognitive conflicts are caused by differences in information and rules regarding situations having no single concrete solution. This will

This will be particularly true with interstellar travel where the information and experiences of the people living on this micro - planet will be vastly different from mission control back in near solar space. Indeed, it may be the case that the need for a 'mission control' as we now define it will no longer exist. Other than serving as a rational voice from a distance, there is little else that we here in the Solar System could do to influence or assist this crew once they are on their way.

Major activities of this phase of the mission will likely center around long term research efforts in astronomy, astrophysics, human sociology, particle physics, and constant analysis and refinement of the star vessel and systems. In addition to looking back at our Sun and planetary system, the research teams will also be looking ahead to probe the Centauri system to better define its structure and formalize a plan of action upon arrival. Much of this phase of the mission planning must be done by the crew itself, for they will have access to the best data as they close in on the system.

Deceleration and Exploration Phase

As the interstellar vessel nears the appropriate distance from the Centauri star system, computers programmed by the crew will automatically begin to slow the vessel at a deceleration rate no greater than 1g. Based on years of observations during the cruise phase of the mission, an exploration plan will have been developed to best utilize the peculiarities of this three star system.

Arriving at this star system will be a crew in transition as the second generation prepares to takeover an increasing responsibility for the mission. The population of this microworld having at least doubled by arrival time, will be influencing social and leadership dynamics as well as the physical environment.

The exploration phase will afford a level of excitement for the crew after a long period of quiet research and social development. Travel within the Centauri system will allow the vessel to utilize solar energy to power various on-board systems, and perhaps even distribute natural light throughout the vessel during the daylight phase. Spaceport activity will likely increase as shuttles and experimental pods are orbited around the individual stars. If planetary bodies or asteroids are found, landers may well be deployed to explore their surfaces and collect samples.

The five to ten year stay within the Centauri system will allow the crew to draw on the natural resources there to replenish stocks of raw materials. The presence of solid bodies in the system would allow mining operations to provide elements facing exhaustion from the vessels asteroid or stores.

CONCLUSION

Given the proper assumptions, interstellar flight appears feasible. At least it is no less feasible than any of the thousands of explorational sorties undertaken by mankind over the centuries. What is unique and somewhat astounding is the level of complexity and the vastness of the distances.

While most of us want interstellar flight to be successful, we realize that even with quantum technological advances, travel to the stars will never be easy. Risks will abound within technology and within man himself. Structural decay of the vessel, fire, epidemic diseases and collisions with uncharted members of interstellar space would put the mission at risk. [ref. 13] Equally threatening is the prospect of this isolated microsociety developing along a perverse social path.

The exploration efforts of these missions into areas previously uninhabited or visited by mankind is part of the continuing moral drama of discovery. Mankind places himself in a vulnerable position as he takes with him news of his own existence to places that are likely to be abiotic and insentient. Undeniably, part of the risk of this moral drama is the chance of mankind losing its anthropocentricity with the discovery of other civilizations amongst the stars. Should intelligent life be found - though it is inconceivable that it will be in the Centauri system - assimilation of that information into our cultures could have devastating effects on the status quo of institutions and the collective intelligence of mankind.

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