SPACE RESOURCES FOR SPACE TOURISM. G. E. Maryniak, X PRIZE Foundation, 5050 Oakland Avenue, St. Louis MO 63110, USA (gmaryniak@xprize.org).

Introduction: Markets have replaced governments as the engines of technological change throughout the world. Unfortunately, world space programs, particularly those involving human spaceflight, are still running on inertia and mythology from the Apollo era and often concern themselves with “flags and footprints” activities which, if supportable at all, could only be funded by large governments.¹

Alternative space activities with a sustainable economic basis have been suggested. The provision of baseload electrical power from high orbit has been one of the most interesting of these as it is based upon the fundamental need for energy. After an initial favorable review of the concept by NASA and the US Department of Energy in the 1970’s and early 1980’s and an 18 year period of dormancy, the concept is once again under study by NASA. O’Neill proposed that solar power satellites could greatly benefit from the utilization of lunar resources. Subsequent studies by MIT, the Convair Division of General Dynamics and the Space Studies Institute indicated that between 90 and 99% of the mass of such large scale power systems could be lunar in origin.²

But the sheer size and cost of such projects have proved a serious barrier to their implementation. A large portion of the problem has been a lack of confidence in our ability to significantly reduce launch costs. Furthermore, the uncertainties associated with the use of nonterrestrial materials have discouraged NASA from considering their use in recent space solar power investigations. And at the end of the day, the perceived abundance of present low-cost energy sources requires space solar power advocates to rely upon ecological arguments for the implementation of such systems. In short, there is not a near-term provable market for space solar power.

Space Tourism: There is a growing realization that providing the experience of spaceflight to the public is a market which will dwarf present projections for conventional commercial launches of telecommunications and remote sensing satellites. The early history of aviation provides an existence proof for this concept. Market studies throughout the developed world have proven surprisingly consistent in showing that about 7 out of 10 persons contacted profess an interest in taking a ride in space.

Initially the bulk of early space tourism is likely to be suborbital in nature. Orbital tourism in its earliest forms might well consist of missions of less than one day duration. Although these first forms of tourism will be essential in creating a foundation for more ambitious business plans, they will not, at first be in a position to benefit from space resource utilization. However, the Japan Rocket Society’s survey research indicates that people may be willing to pay as much for about one week in a space hotel as for they paid for the lift to orbit. If this is true then habitable volume, shielding mass, life support consumables and makeup materials will be needed in low earth orbit.

The history of human exploration and settlement suggests that the characteristics of the first local resources utilized will include:

- Proximity to the market
- Little or no processing required
- No uncertainty as to the availability of the materials

Fortunately, there is one class of nonterrestrial resource which has precisely these characteristics. The resource is the Space Transportation System External Tank.

Proximity to the market: In the normal Space Shuttle mission profile the Shuttle’s main engines are purposely shut down before the liquid propellants contained in the tank are exhausted. The tank is then jettisoned and the Shuttle is given an additional velocity increment with the Orbital Maneuvering System engines. The main engines could be operated longer and doing so would actually increase the payload which the Shuttle takes to orbit. However, the low density and large area of the tank would cause it to be de-orbited by atmospheric drag. Absent a user willing to take responsibility for maintaining the orbit of the External Tank, NASA is naturally unwilling to deposit these structures in orbit. In terms of delta v, the External Tanks are the most accessible form of materials available. Basically, the delta v requirement is zero for delivery of the tanks although stationkeeping is necessary during the life of the asset.

Processing Requirements: External tanks are useful as structural elements with little or no processing. Many including Spencer, Taylor and Gimarc have considered the use of External Tanks in creating habitable volume.³ Although there has been some resistance to the notion of converting fuel tanks into habitats, the Skylab example (a pretty good station built from upper
stage tankage) tends to diffuse critics. In addition to considering the use of External Tanks as potential habitable volume, the Space Studies Institute has examined the use of tank materials as reaction mass and as potential feedstocks for space construction. Under SSI auspices, graduate students at the Air Force Institute of Technology developed systems designed to harvest the materials contained in External Tanks.\textsuperscript{4} Figure 1 depicts such a system in operation.

![Fig. 1. External Tank Harvesting System (photography and model by Ron Jones)](image-url)

**Knowledge of the Materials:** In this regard, Shuttle External Tanks are the ideal resource. Since we built them we have specific knowledge of their composition.

**Long-term implications of space resources and space tourism:** Once the demand for space tourism is established, a variety of destinations exist which could benefit from utilization of space resources. The use of lunar resources to support Low Earth Orbit (LEO) operations and trans-LEO flight has been well researched. Using electromagnetic launch, material can be supplied to free space on an economical basis.\textsuperscript{5} It is interesting to note that both lunar orbiting and lunar surface tourism are under study at this time.

Tourism could provide the rationale and the means to answer some of the most critical and questions which remain regarding human settlement of space. For example, late in his life Professor Gerard O’Neill considered the minimum size for self sustaining space colonies. The most critical parameter for these designs is the human pseudogravity requirements for indefinite stays.\textsuperscript{6} No present or proposed government space projects are planned which would provide an answer to the question of human gravity needs. The long-term staff of the first partial gravity space hotels may provide the clues which answer this question. Similarly, if the demand for propellant and other consumables is sufficiently large, tourism could provide the impetus for our species learning how to “live off the land” in the solar system.

**Getting started in space tourism - The X PRIZE:**

It will be necessary to prove the existence of the latent demand for personal spaceflight before large investments on the scale required for the use of space resources will be made. Initially, suborbital spaceflight is likely to demonstrate the existence of the space tourism market. Suborbital flight is roughly 25 times easier than orbital flight due to the relatively low energies required. The early history of commercial aviation suggests that large numbers of people will be willing to purchase tickets for spaceflights which simply permit them to directly experience spaceflight. This is likely to be true even though the flights are of relatively short duration and to not include a stopover at a space destination. Unlike the post World War I era, where there was a strong supply of surplus aircraft, we do not have a livery of ships available to meet the potential demand. To create an incentive for the development of the first spaceships which can fulfill the demand for the most rudimentary form of space tourism, the X PRIZE was announced by Diamandis, Lichtenberg et al in 1996. As of this writing, 19 teams in 5 nations including Argentina, Canada, Russia the United Kingdom and the United States have registered to compete for this $10 Million prize. To monitor developments in this area the reader is encouraged to visit the X PRIZE Foundation’s web site at www.xprize.org