

DUAL-USE TECHNOLOGIES FOR THE MINING, PROCESSING, AND ENERGY INDUSTRIES

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by

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ABSTRACT

Over the years, NASA has utilized several approaches towards transferring space technologies into the private sectors. Some of these approaches have been successful, others have had mixed results. The conventional approach usually involves identifying advanced NASA technologies and then searching for applications. Some approaches involve joint sponsorship, but mostly focus on technologies for space. The greatest success has occurred when market forces are used to determine technology initiatives. (See Reference 1).

This paper describes an unconventional approach that was structured to drive out customer requirements for advanced technologies where NASA is also a customer on par with others. Using the models defined in reference 1., the approach used herein is best described as entrepreneurial deal-making. This approach is new and is working very well so far, but it is still too early, and the process is too immature, for quantitative evaluation of success. However, it is appropriate to share these experiences at this time in order to obtain feedback and improve our chances for success.

One of the distinguishing factors of this approach is that NASA is not the "sole customer" nor the "sugar daddy". In the needs identification stage, NASA is one of many users (customers), and in the subsequent development stage, NASA is one of many suppliers along with industry, academia, and other government organizations. This specific characteristic of the approach was a primary goal that was incorporated from inception. It was the viewpoint of the instigators (the authors) that if the activity was customer focused, it would:

1. Have a higher probability for success since it will be driven by those who will reap the benefits.

2. Be able to advocate and promote action if necessary, since it would be founded outside the federal government.
3. Not be self-perpetuating; that is, if no common need could be found that had a reasonable return on investment, it would self-destruct.
4. Have increased stability from a broader base of support and not be dependent on NASA being the principal funding source.

To date, the workshop activities have identified a collection of potential customers in NASA, other federal government, private industry, and academia who have common needs for advanced technologies. These potential customers are beginning to collect around the following application categories:

1. Mining technologies
2. Materials processing technologies
3. Energy technologies

It must be noted here that not all benefits are derivable from the utilization of a "new technology" per se'. For example, Universities need to *educate* and the *focus* of the research is a lower priority; the mining industry is required to invest in returning mined areas into useful areas, such as a test bed for surface or subsurface robotic vehicles; and etc. As these "strange bedfellows" have shared ideas in the workshops, some dual use technologies have been identified and some lessons have been learned on how to encourage and nurture this process.

INTRODUCTION

The NASA Space Exploration Initiative began in the early 1980s albeit under different names. That was not the first time that the Space Exploration Initiative was proposed. The first time was in the 50s with studies by Werner

VonBraun and revisited again in the late 60s by the Space Task Group in a study for Vice president Agnew. Each time the human exploration of space was revived, new technologies changed the configuration or the performance of the systems. In the 1969 Agnew report, nuclear thermal propulsion was the latest technological innovation, approximately doubling the trans-Mars space ship performance. In the revival of the 1980s, the literature contained substantial data and information about the Apollo lunar samples. This database of information brought a new perspective on exploration. A lunar base study by the University of Houston suggested the use of indigenous resources for propellants, life support and construction.

The Planet Surface System Office at the Johnson Space Center sponsored the development of a surface system and operations simulation model. This model, developed by the Large Scale Programs Institute in Austin, Texas, demonstrated that the use of lunar produced propellants reduced the costs of space transportation to the lunar surface by 1/3.

industry of Kentucky. KSTC is chartered to advance science and technology in the state of Kentucky. In 1991, KSTC entered into discussions with NASA to seek common interests in technology developments that were aligned with the Space Exploration Initiative.

THE DUAL-USE PROCESS AND RESULTS

Strategy and Planning.

In the initial strategic planning discussions, as much effort was given to the methodology of cooperation as to the content of the cooperative technology developments themselves. In the beginning, we wanted to be successful and we saw many problems with the typical approach of NASA as technology customer and the KSTC associates as technology supplier:

- NASA's commitment to follow-through is unilateral and may be terminated without regard to the interests of the KSTC partnership

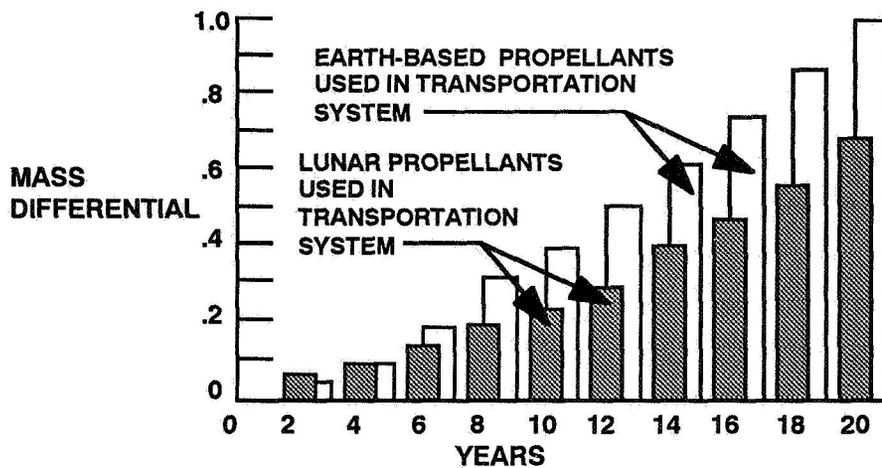


Figure 1. For a fixed mission set delivered to the lunar surface, the use of lunar propellants in the lunar transportation system can reduce the transportation costs (~mass delivery requirements) to the lunar surface by 1/3 and shows a return on investment for the mining and processing equipment in 3 years.

With this new perspective, NASA needed access to new skills and began to cultivate new government, industrial and academic partners. These partners included Bureau of Mines, Department of Energy, US Army Corps of Engineers, architect and engineering firms, construction industry, mining and processing industries, and the energy industry.

One of these interested parties was the Kentucky Science and Technology Council (KSTC). The KSTC works in partnership with the State Government of Kentucky, the colleges and universities of Kentucky, the Kentucky Public Education System, and the mining and processing

- The resulting technologies will be focused for application in space, and upon completion of the space objective, there is no basis for continuing commitment to the KSTC partnership
- For long term commitment within the state of Kentucky and the mining and processing industry, direct benefits must be designed into the program from the beginning

Thus, we made an early decision that we would not proceed with the concept of NASA as technology customer and the KSTC associates as technology supplier.

We agreed to go forward with a joint technology development approach ("Dual-use" was not yet coined). Unfortunately, there were no cookbooks on how to proceed.

Process

The process was not initially formalized, but was allowed to evolve as we learned how to proceed. We kept our focus on the main goal that this project would develop joint technologies equally benefiting all parties involved. We then employed short-term procedures as needed. We were very conscious of the competing needs of imposing structure to assure convergence, versus the need to remove boundaries to assure the emergence of creative concepts. The lessons learned from this experiment could be helpful in meeting the balance in future initiatives of this type.

The Getting to Know you Stage. Our first meeting was informal. It was for the purpose of introductions and learning who each potential partner was and discovering each other's skills and needs in very general detail. The meetings were kept small and limited to only a few representatives of each interest, however, *every* interest was represented. The purpose was to gain enough information to plan the next meeting. It was determined that the next meeting was to be introductory, addressing skills, capabilities, and needs, but open to a much larger participation and in a more formal presentation format.

This initial meeting was very beneficial in that a small investment transferred a significant amount of understanding of each other's needs. Most importantly it identified the diversity of the needs. All needs were "technology related" but not necessarily "technology-focused". For example, the Kentucky University System "needs" to retain its doctoral graduates in the state and a high-technology initiative in the State is a contributing objective. The mining industry is required to return "value" to the regions in which it is removing resources; supporting a high-technology initiative is one possible means towards this end.

Formal Presentations of Skills, Capabilities, and Needs. The format of the second meeting was formal presentation with ample time allowed for discussion. The attendance (about 40) was limited by invitation-only but broadly covered the KSTC/NASA interest group. This meeting was very effective in providing detail of each participant's skills and capabilities, but fell short of identifying *mutual* needs. The predominate paradigm of the meeting was one of "understanding NASA's needs and how to meet them" as opposed to the objective of joint needs. Several times the question was asked "What [technologies] does NASA want us to do?" which clearly indicated the difficulty in effecting the desired paradigm shift *from:* customer-supplier *to:* customer-customer,

then supplier-supplier. Figure 2. illustrates the desired paradigm shift.

This was our first discovery of how to improve the process. That is, the greatest difficulty in identifying dual-use technologies is creating within the participants the concept that in the initial phases of definition, NASA is a "customer" on par with every other participant.

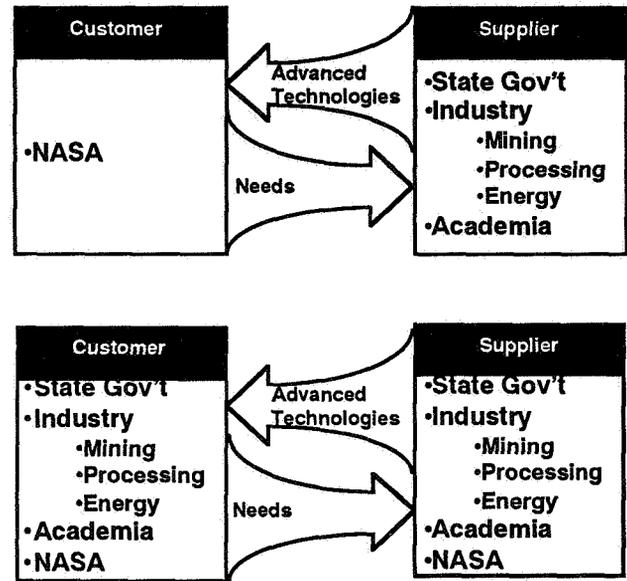


Figure 2. The greatest problem was getting the participants to internalize the desired paradigm shift that NASA was on par with all other participants as a customer.

Figure 2 is intended to graphically depict this problem. Had we known a priori the extent of this difficulty, the use of a graphic similar to Figure 2 may have helped.

The next stage was to be a needs workshop with open attendance with announcements in technical publications and by mailings. In order to better set the stage, the needs workshop was organized into (1) Identifying the Customers and the Needs, and (2) Meeting the Needs.

The Needs Workshop. The needs workshop was well attended, exceeding expectations by 50%. This was a clear indicator of the interest in dual-use technology initiatives in the mining, processing, and energy industries. The workshop was organized into alternating sessions of working groups and plenaries with a kickoff of keynotes to set the stage. On the first day, the working groups were focused on identifying the customer and the needs. On the second day the working groups were focused on meeting the needs. Although the paradigm shift problems continued to predominate, it appears as though consensus was achieved on a vision and an initial objective.

Results

It is important to caution the reader that the results reported herein are preliminary in that they were assembled post-workshop and have not had the review and concurrence of the attendees.

Vision. It was clear that the vision of this emerging consortium was to be a part of the solution to the world energy problem. There is overwhelming evidence that the energy requirements for the world's populace will outstrip terrestrial supply early in the next century (see Figure 3). It was also very clear that the solution was going to require a broad range of new technologies involving space and terrestrial applications.

potential dual-use technologies that meet most of the customers' needs.

Near-Term Objective. There is growing consensus that to meet these needs, a robotic system test bed is required. Some initial discussions have begun to organize a consortia to develop the robotic test bed in Kentucky.

The Next Steps. The next steps are to:

- (a) Develop a strategic plan:
 - (1) Carefully craft a vision statement
 - (2) Develop the goals and objectives that define ends towards achieving this vision
 - (3) Prepare a SWOT analysis (Strengths, Weaknesses, Opportunities, Threats)

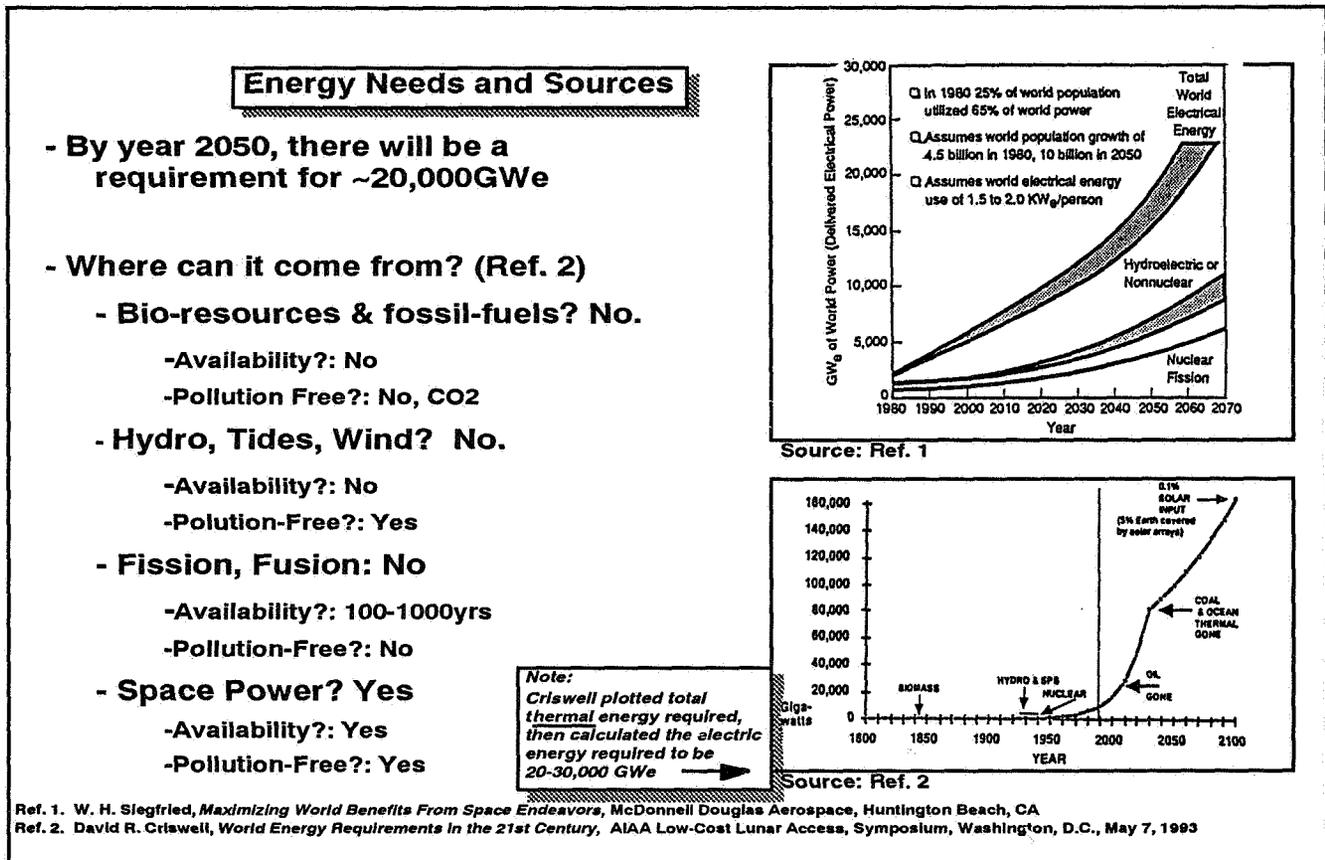


Figure 3. Energy demand will surpass the total terrestrial energy supply early in the 21 st century.

A possible vision and strategy is shown in Figure 4. The vision is to move the energy industry into space and the near term objective is to begin the development of the robotic mining and processing technologies that are needed for both (1) energy from space and (2) increased mining efficiencies to bridge the gap from terrestrial energy supply to space supplied. Figure 4. fades to gray in the out-years to indicate the increasing uncertainty in the future. Figure 5 and 6 are possible mappings of the

- (b) Define the near-term program:
 - (1) Define the needs and achieve consensus among the "customers"
 - (2) Analyze the needs, execute trades and develop requirements for the robotic test bed
 - (3) Prepare concepts for the test bed, develop proposals
 - (4) Develop business p'ans and consolidate the consortium

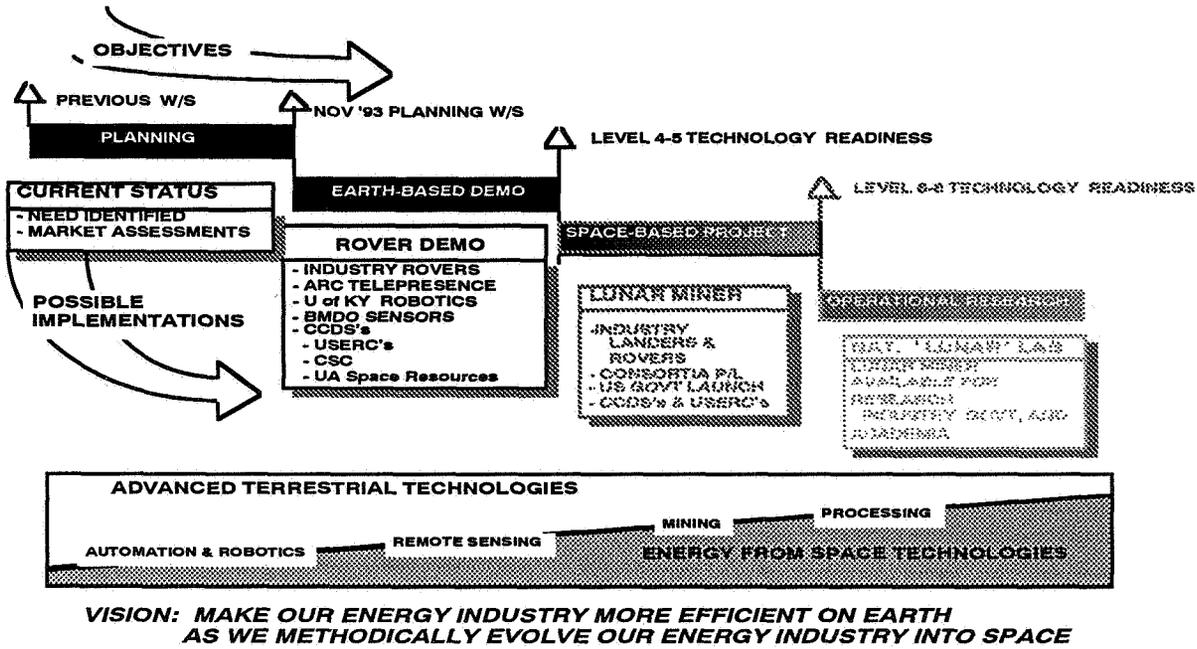


Figure 4. The workshop participants were gravitating towards a vision that they wanted to be a part of the solution to the energy problem by contributing technologies that solve near-term energy problems as well as long-range energy problems

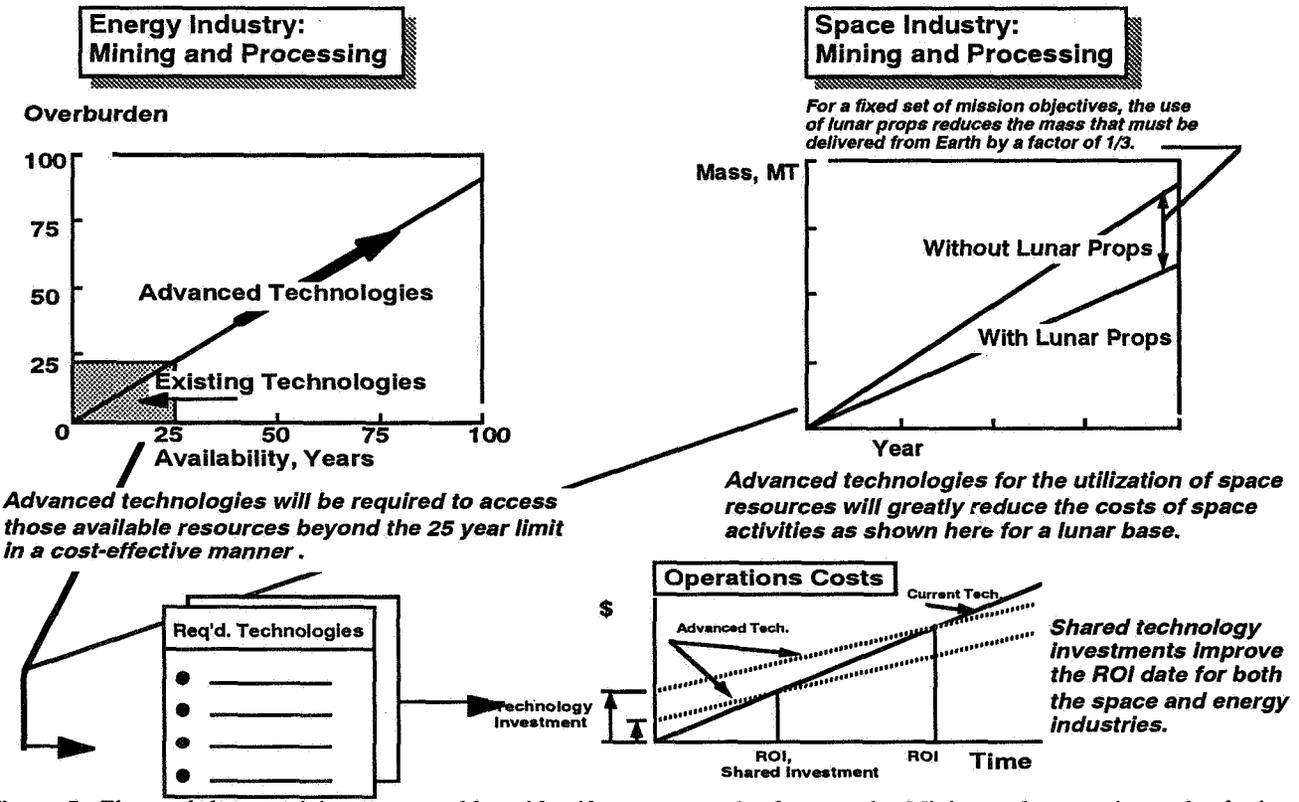


Figure 5. The workshop participants were able to identify common technology needs. Mining and processing technologies that are needed now can directly contribute to future space missions

Terrestrial Application	Technology	Space Application
<ul style="list-style-type: none"> •Mineral Analysis, Yield Estimation - Deep Mine Vein Location and Tracking •Wall and Ceiling Integrity 	<ul style="list-style-type: none"> •Advanced Sensors 	<ul style="list-style-type: none"> •Mineral Analysis, Yield Estimation •Surface Mineral Analysis and Resource Location
<ul style="list-style-type: none"> •Deep Mine Robotic Operations <ul style="list-style-type: none"> • Mining • Beneficiating • Removal 	<ul style="list-style-type: none"> •Advanced Robotic Mining 	<ul style="list-style-type: none"> •Surface Mining Operations <ul style="list-style-type: none"> • Mining • Beneficiating • Transportation
<ul style="list-style-type: none"> •Improved Automated Processing; Increased efficiency 	<ul style="list-style-type: none"> •Automated Processing: Advanced FDIR 	<ul style="list-style-type: none"> •Remote, Low-Maintenance, Processing
<ul style="list-style-type: none"> •Reliable, Low-Pollution Personal Trans. •Regenerable Energy Economies •Small, Decentralized Power Systems for Remote or 3rd World Applications 	<ul style="list-style-type: none"> •Alternative, Regenerable Energy Economies <ul style="list-style-type: none"> • Methane/O2 • H2/O2 	<ul style="list-style-type: none"> •ISRU Based Engines •Regenerable Energies •Hi-Density Energy Storage
<ul style="list-style-type: none"> •Environmentally-Safe Energy Production 	<ul style="list-style-type: none"> •Space-Based Energy Generation & Transmission 	<ul style="list-style-type: none"> •Surface Power Gen & Beaming

Note: Technology "Spin-In" = 
"Spin-Off" = 
"Both" = 

Figure 6. This is a tabulation of the common technologies identifies by the workshop participants

CONCLUSION/LESSONS LEARNED

Regarding the Program

- There is a need to begin developing technologies that jointly contribute to future energy supply solutions (some involving energy from space) and bridging the gap by improving the efficiency of terrestrial mining capability.
- The near term needs are highly automated mining and processing technologies.
- There exists potential support within the attendees to begin a discussion of a potential robotic test bed.

Regarding the Process

- The *approach* appears to be viable and properly focused on the needs of the "customer".
- The *execution* was flawed, but not stymied, by a paradigm shift problem.
- The basic lesson-learned was that it is very difficult to communicate the concept of all participants being on par as customers as well as suppliers --dual roles.
- Many "needs" are abstract, relating loosely to the technologies, such as the need to retain Phds in the state, or the need for the mining industry to return "value" to the mined regions. These needs are sometimes the strongest ones and must be openly considered.

REFERENCES

1. Sacknoff, Scott, Jennings, John, Lacobie, Kevin, "Technology Transfer: Models, Methods, and Summaries, Futron Corporation, Bethesda, MD, December 15, 1993.