

United States Space Foundation

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Space Technology – A Study of the Significance of Recognition for Innovators of Spinoff Technologies

Annual Report
1993 Activities/1994, 1995 Plans

NASA Grant NAGW-3322

January 1994

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Space Technology--A Study of the Significance of Recognition for Innovators of Spinoff Technologies

(NASA Grant NAGW-3322)

1993 Activities/1994, 1995 Plans

During the past 30 years as NASA has conducted technology transfer programs, it has gained considerable experience--particularly pertaining to the processes. However, three areas have not had much scrutiny: the examination of the contributions of the individuals who have developed successful spinoffs; the commercial success of the spinoffs themselves; and the degree to which they are understood by the public. In short, there has been limited evaluation to measure the success of technology transfer efforts mandated by Congress.

Research conducted during the first year of a three-year NASA grant to the United States Space Foundation has taken the initial steps toward measuring the success of methodologies to accomplish that Congressionally-mandated technology transfer.

In particular, the US Space Foundation, in cooperation with ARAC, technology transfer experts; JKA, a nationally recognized themed entertainment design company; and top evaluation consultants, has inaugurated and evaluated a fresh approach including commercial practices to encourage, motivate, and energize technology transfer by...

- Recognizing already successful efforts (**Space Technology Hall of Fame Award**)
- Drawing potential business and industrial players into the process (**Space Commerce Expo**)
- Informing and motivating the general public (**Space Technology Hall of Fame public venues**)

This report documents first year efforts and outlines directions for the future.

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Executive Summary

Under NASA Grant NAGW-3322, 1993 efforts were focused in three major areas, each designed to contribute to the technology transfer process. The **Space Technology Hall of Fame Award** annually recognizes successful efforts in the technology transfer process. The **Commercial Space Expo** attracts, motivates, and educates business leaders and technology specialists about the possibilities of joint technology development or licensing commercial applications. **Hall of Fame public venues** are designed to communicate the excitement and benefits of space to the general public.

Space Technology Hall of Fame Award

The Space Technology Hall of Fame was established in 1988 to recognize the innovators of NASA technology for their contributions to the nation's economic well-being and quality of life. The 1993 awardees included the developers of liquid-cooled garments and physiological monitoring instrumentation. This year's activities in conjunction with the award included:

- Selection process

The selection process for the Hall of Fame award is a comprehensive, multi-step procedure orchestrated by the U.S. Space Foundation and ARAC. During 1993, eight candidate technologies were nominated and then evaluated by a nationally recognized, highly qualified panel of judges including the Editor-in-Chief of Popular Science, present and former congressmen, and industry and NASA leaders. Technologies were evaluated across five dimensions, and the results from the 14 judges were aggregated to select the two winners.

- Recognition

The ceremony to induct the two 1993 winners into the Hall of Fame was conducted in conjunction with the Ninth National Space Symposium, also sponsored by the U.S. Space Foundation. The Hall of Fame Banquet is a highlight of the Symposium, attended by government and industry space leaders from around the world. **Daniel Goldin**, NASA Administrator, presented the awards and was the featured speaker for a crowd of over 750 guests at the event.

- Evaluation

This year for the first time, a formal research process was begun to determine potential effects of the award on the technology transfer process itself. Top research specialists designed and conducted in depth interviews with engineers and entrepreneurs involved with the liquid-cooled garment technology, looking for critical junctures in the technology transfer process and motivation that could be generated by recognition.

Commercial Space Expo

- Event

The Commercial Space Expo, held in conjunction with the Ninth National Space Symposium drew over 150 participants--about half from government and half from industry--who attended stimulating presentations on a variety of subjects including biotechnology, materials processing, and space business. An exhibit hall with displays and demonstrations of technologies supplemented the presentations. A main result of the conference was the establishment of many relationships which will facilitate technology transfer. One director of a Center for the Commercial Development of Space (CCDS) said he made more valuable contacts at the Commercial Space Expo than at three other major space technology events. Overall, the event was very successful for a first time effort.

- Research on reactions to sessions

Evaluation was an integral part of all activities under this grant. In this case, the researchers developed an instrument that allowed them to see what government and industry people gained from the sessions. Data show that the sessions were of high quality, well received, and useful to the participants.

- Research on exhibit reaction methodology and exhibit reactions

A key component of this research project is to investigate how to gather real time reactions of people to space-related exhibits and to analyze those reactions. Five computers were set up in the exhibit hall of the Commercial Space Expo. One of the top-rated exhibits featured Akro Fireguard--a down-to-earth application of space technology. The research also shed light on the data gathering process which was incorporated into exhibit reaction designs used later under this grant.

Hall of Fame public venue

- Design concept

This year considerable work was done on a display intended to show the general public in an entertaining and interactive way how the Hall of Fame technologies are enriching or enhancing our lives. One thing is clear. The public must be approached in more interesting and entertaining ways than have been used in the past. Therefore, the United States Space Foundation, took a fresh approach and enlisted the assistance of JKA, Inc., of Pomona, CA, an industry leader in themed entertainment design.

- Prototype Exhibit

JKA designed an exhibit which previewed the Hall of Fame. It was installed for its first exposure at the Technology 2003 Exposition, December 6, 7, Anaheim, CA, where it was seen by hundreds of people. The purpose of the exhibit was to impress on the general public the benefits of space technology and how NASA encourages innovation that benefits American business.

- Further research into exhibit reaction methodology

The Technology 2003 exhibit was used for further research into the data collection process as well as collecting explicit feedback on the new exhibit.

Bottom line

Each of these activities pursued during 1993 made a particular contribution to the technology transfer process. As a result there will be more understanding of the process, a broader circle of businesses knowing where and how to look for space technology applications, and a general public more aware of the importance of space technology in their everyday lives. The efforts planned for the next two years will build on the success of 1993 to make even larger contributions to NASA's role in stimulating America's competitiveness with space technology.

1993 Activities

Three major areas, each designed to contribute to the technology transfer process, were pursued in 1993.

- **Space Technology Hall of Fame Award** annually recognizes successful efforts in the technology transfer process

- **Commercial Space Expo** attracts, motivates, and educates business leaders and technology specialists about the possibilities of joint technology development or licensing commercial applications of space technology

- **Space Technology Hall of Fame public venues** are designed to communicate the excitement and benefits of space to the general public.

Space Technology Hall of Fame Award

The Space Technology Hall of Fame was established in 1988 in response to a growing belief that NASA technologies and innovators were not receiving adequate recognition for their contributions to this nation's economic well-being and quality of life. Since the award's inception, 16 technologies have been inducted into the Hall of Fame. Activities under the 1993 grant include:

- Selection (completion of 1993 award selection, preparation for the 1994 award)
- Recognition of the 1993 selectees
- Evaluation of the potential impact of the award process on technology transfer

- Selection

Initially an ad-hoc selection process was implemented. Subsequently, the process has been further refined to produce an objective selection process for the thousands of NASA generated opportunities evaluated. The selection process is as follows:

- Nominations are solicited from NASA Center Directors and technology transfer staff throughout NASA.
- A nomination packet with sample materials and selection criteria is provided.
- Nomination material is reviewed for completeness.
- Space Development and Application descriptions are prepared in uniform format.
- A prestigious panel of outside judges is selected (businessmen, astronauts, politicians, journalists). For a list of judges for the 1993 award, see the Space Technology Hall of Fame Banquet program in Appendix 1.
- Selection is based upon the judges' numerical response to a set of objective criteria. For the judges' packet for the 1994 award, see Appendix 2.

- Recognition

The ceremony to induct the two Hall of Fame 1993 winners was conducted in conjunction with the Ninth National Space Symposium. The Hall of Fame Banquet is a highlight of the

Symposium, attended by government and industry space leaders from around the world. Daniel Goldin, NASA Administrator, presented the awards and was the featured speaker at the event which drew more than 750 guests. In keeping with Foundation policy to keep events upbeat, drawing on the best of the entertainment and business industries, Jon Cypher, who plays Major General Marcus Craig on the CBS comedy series **Major Dad**, was also featured at the 1993 awards banquet. The 1993 technology inductees, Liquid-cooled Garments and Physiological Monitoring Instrumentation, first were presented in brief videos. Then, to the sound of trumpets, more than 30 individuals representing these technologies from government and industry were introduced and presented awards by Mr. Goldin. For a brief description of the technologies, along with lists of responsible individuals, see the Space Technology Hall of Fame Banquet program in Appendix 1.

Evaluation

This year for the first time, a formal research process was begun to determine potential effects of the award on the technology transfer process. Top research specialists designed and conducted in depth interviews with engineers and entrepreneurs involved with the liquid-cooled garment technology, looking for critical junctures in the technology transfer process and motivation that could be generated by recognition.

Research/evaluation specialists Dr. Darwyn Linder of Arizona State University's Department of Psychology and Dr. Robert Ewell, president of *Creative Solutions*, working with Dr. Peter Clarke of the Annenberg School of Communication, University of Southern California, devised an interview format to explore the technology transfer process. Key people identified by Dr. Timothy Janis of ARAC were asked questions such as:

To what extent would the possibility of recognition such as the Hall of Fame influence the selection of research projects, project priorities? In what ways would the recognition affect your professional activities?

To what extent are you aware of previous or parallel developments in the technology when you start your research?

Can you explain the process by which space technology is developed into spin-off commercial applications? What are the features, critical junctures, or decisions?

How is the database of projects/ technologies maintained and accessed so that the information gets out?

What are the most important factors in moving from space technology for space to spin-off commercial applications? Recognition? Specific contract/tasking for military non space applications? Entrepreneur vision? Good idea? Risk to develop? Initiative?

Are you familiar with NASA Spinoff, published annually by NASA? How thoroughly/ often do you read? What do you learn from the book(s) about the process of developing spin-offs from space technology?

The researchers found the following factors encouraging spinoffs:

1. NASA support of its engineers
2. Outside requests/challenge of a problem
3. Creativity
4. NASA support to industry
5. National Interest
6. Pride and enjoyment of meeting a need
7. Profit
8. Recognition

The researchers also found the following possible impediments to spinoffs:

1. Not enough NASA support or PR
2. Not enough tech transfer funding
3. Too much separation between government and industry
4. Difficulties unique to the medical community

The researchers concluded this initial assessment by noting:

- The complex inter-relationships among entities involved with technology transfer
- The importance of people: "bringing the right problem to the right people."
- The importance of resource availability
- The significance of intrinsic motivation

Finally, the research postulates the direct and indirect influence of Space Technology Hall of Fame recognition on the technology transfer process and recommends the process be continued to verify results.

For a complete report on the findings and conclusions of this initial research effort, see the companion volume **A Case Study on the Impact of the Space Technology Hall of Fame Award, December 1993**. This report also includes a history of the liquid-cooled garments project as an appendix.

Commercial Space Expo

- Event

The Commercial Space Expo, held in conjunction with the National Space Symposium drew over 150 participants, about half from government and half from industry. The purpose of the 1993 Expo was to provide a venue to connect NASA's interest in commercializing space technology in the private sector and promote new business opportunities with the CCDSs. Goals of the Expo included:

- Develop and present a program through which the broad area of space commerce and new space-related business opportunities would be concisely presented to the participants.

- Design and offer exhibit opportunities that would complement the program and allow the NASA CCDSs as well as other companies and organizations to showcase their specific technologies.

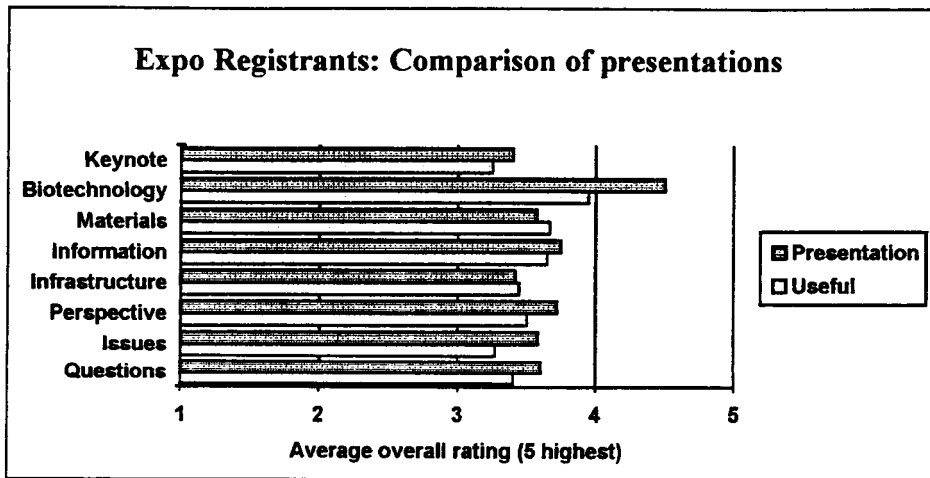
- Attract an audience of participants interested in learning how to develop new business opportunities using existing or emerging space technologies through the various government programs designed for that purpose.

Participants attended stimulating presentations on a variety of subjects including biotechnology, materials processing, and perspectives on space business.

A main result of the conference was establishing many relationships which will facilitate technology transfer and new business opportunities. One director of a Center for the Commercial Development of Space (CCDS) said he made more valuable contacts at the Commercial Space Expo than at three other major space technology events. For a complete report on the event itself with detail on how it was planned and conducted, see the companion volume **Commercial Space Expo-USA, 1993**.

- Research on reactions to sessions

Evaluation was an integral part of all activities under this grant. In this case, the researchers developed an instrument that allowed them to see what government and industry people gained from the sessions. The following summary chart shows that the sessions were of high quality and useful to the participants.



For a full report on participants' reactions to the Expo including breakouts by industry/government attendees, see the companion volume, **Commercial Space Expo, Preliminary Report, May 1993**.

- Research on exhibit reaction methodology and exhibit reactions

A key component of this research project is to investigate how to gather real time reactions of people to space-related exhibits and to analyze those reactions. Five computers were set up in the exhibit hall of the Commercial Space Expo. One of the top-rated exhibits was one featuring Akro Fireguard--a down-to-earth application of space technology. The research also shed light on the

data gathering process which was incorporated into exhibit reaction designs used later under this grant. For a full report on lessons learned in this process, especially about real-time data gathering, see the companion volume mentioned in the previous paragraph, **Commercial Space Expo, Preliminary Report, May 1993.**

Space Technology Hall of Fame Public Venue

- Design concept

During 1993, considerable work was done developing a design for the Space Technology Hall of Fame. A prototype exhibit was developed to expose the Hall of Fame technologies to the general public in an entertaining and interactive way and show how they are enriching or enhancing our lives. To achieve a fresh approach and incorporate the best commercial practices, the Foundation surveyed show designers and entertainment companies in the Los Angeles area. JKA, Inc., of Pomona, CA, an industry leader in themed entertainment design was selected to do the initial design. The Foundation directed JKA, Inc. to:

- Design an exhibit that depicts the Hall of Fame purpose and the current inductees with some subset being hands-on experience opportunities for the visitor.
- Design the exhibit to be modular and expandable to accommodate various show size opportunities and be able to add new technologies as they are inducted into the Hall of Fame.
- Design the exhibit so that it can eventually be adapted to become the permanent Space Technology Hall of Fame Component of the Space Discovery Center.
- Incorporate into the design United States Space Foundation and NASA identification.
- Include a mechanism for interactive visitor response to how they feel about this aspect of the space program so that we can evaluate over time how to improve the impact of the Hall of Fame program on attitudes about the space program.

- Prototype Exhibit

With the help of JKA, an exhibit was built and installed for its first exposure at the Technology 2003 Exposition, December 6, 7, Anaheim, CA, where it was seen by hundreds of people. The purpose of the exhibit was to impress on the non-space-literate general public the benefits of space. A photo of a portion of the exhibit is shown at right.



- Further research into exhibit reaction methodology

The Technology 2003 exhibit was used for further research into the data collection process as well as collecting explicit feedback on the new exhibit. A computer-based survey was set up as part of the display.

Based on experience from the Commercial Space Expo in April 1993, the survey was designed to be very short, and the computer to collect the data was within the exhibit area. The computer was programmed to ask the following six space-related questions and two demographic questions:

- On a 5-point scale, how AWARE are you about technology spinoffs from space and aviation?

5: very much aware...1: not at all aware

- On a 5-point scale, how RELEVANT to your life are technology spinoffs from space and aviation?

5: very relevant...1: not at all relevant

- In your opinion, has the space program ACCELERATED the development of TECHNOLOGY?

5: yes... 3: somewhat...1: no

- Would greater exposure of space technology spinoff success stories stimulate more activity in this area?

5: yes... 3: somewhat...1: no

- On a 5-point scale, what was the IMPACT of this exhibit on your perceptions of space benefits and space technology?

5: A real eye opener

4: Significant positive impact

3: Some positive impact

2: Little positive impact

1: No change

- On a 5-point scale, how SUPPORTIVE ARE YOU of continued involvement of the United States in space exploration and technology?

5: Very supportive...1: not supportive

- When were you born?

- What kind of INVOLVEMENT WITH SPACE or space technology do you have or have you had?

1: None

2: Government including NASA, military, or government contractor

3: Commercial

4: Space advocacy organization

5: Personal interest

6: Two or more of responses 2-5

7: Other

During the conference, 54 people responded to the survey. US Space Foundation personnel conjectured two reasons for the relatively low response rate:

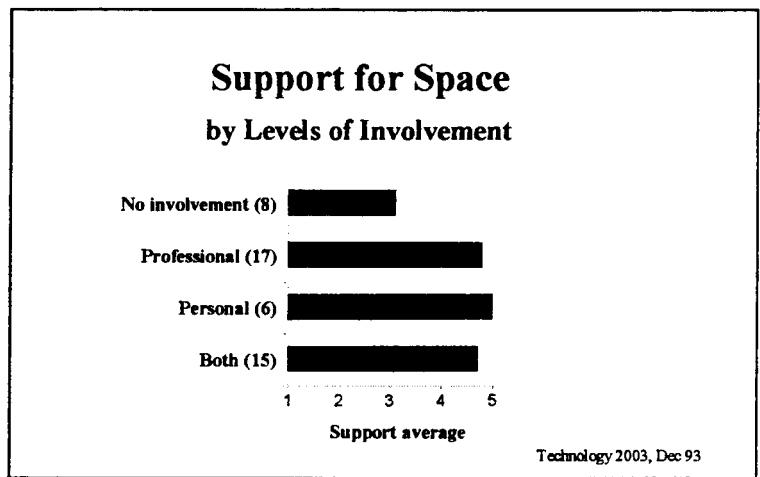
- The booth attracted a lot of attention but did not compel people to actually enter. Many observed from outside the booth's confines.

- Once in the booth, nothing on the computer display compelled people to investigate and answer the survey. Therefore, the exhibit attendant began inviting people to answer the questions.

Note: both of these issues are being dealt with as the exhibit is modified for further evaluation.

For a full account of the data collection process and an analysis of the data, please see the companion volume, **Technology 2003 US Space Foundation Exhibit, Analysis of Data.**

One chart from the report is instructive, however, capturing the dilemma of space advocates. While 84 percent of the respondents expressed strong support for space (ratings of 4 or 5 on a 5-point scale), the support is much lower among those with no space involvement. The following chart shows that those who had no involvement (including personal interest) with space rated their support at an average of 3 (50% at 3, 25% below 3, and the other 25% split between 4 and 5) while those with personal or professional interest were nearly all 5s.



This strongly supports the notion that in order to build a strong base of support for space programs, we need to get the message to the general public!

1994/1995 Activities

For 1994 and 1995, the United States Space Foundation will continue to encourage, motivate, and energize technology transfer in the same arenas begun and continued in 1993.

Space Technology Hall of Fame Award

- Recognition and ceremony

The 1994 award process is already well under way, and recipients will be honored at the Space Technology Hall of Fame Award Banquet at the Tenth National Space Symposium. Mr. Norm Augustine, Chairman and CEO of Martin Marietta has agreed to be the featured speaker at the banquet. By the end of 1994, the selection process for the 1995 inductees will be well under way.

- Follow-on research

The research begun under the 1993 grant will continue, broadening the scope of the target population and deepening the investigation to confirm 1993's hypotheses or introduce new technology transfer factors not previously observed. The researchers also intend to identify professional and consumer **communities** that have adopted or benefited from spinoffs and develop instruments to assess the knowledge they have of the spinoff process, and part they may have played in posing problems or identifying needs that stimulated spinoff development. Analyzing these data, the researchers will attempt to construct one or several templates of the spinoff process and continue to assess the role of the Space Technology Hall of Fame recognition in facilitating technology transfer, both as a direct motivator for innovative applications, and as means of disseminating the processes by which successful transfers are achieved.

Space Commerce Expo 1994, 1995

- Event

The Commercial Space Expo concept is alive and well, existing under a new name for 1994. The 1994 event has already been scheduled to be held in conjunction with the tenth National Space Symposium. Now called Space Commerce Expo '94, the event promises to be bigger and have greater impact than the first year's program.

- Research

The research begun in 1993 on both the Expo's effect on the participants and the space technology exhibits' effectiveness in communicating the space message will be continued.

Hall of Fame Public Venues Design Process

Based on the conclusions of 1993's efforts that more aggressive public exposure is essential to building stronger support for space programs, several activities in this all-important area are planned for 1994.

- Installation of prototype exhibit into Chapel Hills Mall

The prototype Space Technology Hall of Fame exhibit designed for and displayed at Technology 2003 in Anaheim is being modified based on public reaction and feedback from its initial exposure. The concept is to incrementally modify the experience in response to the public's reaction until it reaches the highest effectiveness possible in communicating the message. The next venue for this prototype exhibit is in Colorado Springs, CO, outside the Foundation's Space Discovery Adventure area at the Chapel Hills Mall (the second largest in the city). Public reaction to the display will continue to be assessed.

- Display of prototype Space Technology Hall of Fame exhibit at the Tenth National Space Symposium and Commercial Space Expo '94.

In addition to its display in the mall, the exhibit will be temporarily relocated to the exhibit areas of the Tenth National Space Symposium and Space Commerce Expo '94 to evaluate the reactions of the more space-involved audience.

- Operation of Space Spin-off Exhibit

Finally, the United States Space Foundation is planning to operate a large, museum-quality Space Spin-off Exhibit in a special area of the Chapel Hills Mall to gather additional public reaction to space technology's application to everyday life.

- Research

In conjunction with all these displays will be the active search for the best way to use technology to assess the public's opinion of the technology. The data gathered from these events will continue to augment knowledge about how to facilitate technology transfer into the public arena and how to capture the public's imagination and support on space.

Summary and Conclusions

Efforts under this grant have been and will be focused in three major areas, each designed to contribute to the technology transfer process.

The **Space Technology Hall of Fame** annually recognizes successful efforts in the technology transfer process. In-depth research is building the knowledge base on the processes and motivations of technology transfer.

The **Commercial Space Expo** attracts, motivates, and educates business leaders and technology specialists about the possibilities of joint technology development or licensing commercial applications. Again, ongoing research continually analyzes data to ensure the best approach.

Space Technology Hall of Fame public venues are communicating the excitement and benefits of space to the general public. This program continues to respond to public perceptions, diversifying venues and collecting and analyzing public opinion.

Each of these activities made a particular contribution to the technology transfer process. As a result there will be more understanding of the process, a broader circle of businesses knowing where and how to look for space technology applications, and a general public more aware of the importance of space technology in their everyday lives.

Appendices

1: Hall of Fame Banquet Program

2: Hall of Fame sample ballot

3: JKA Brochure

Appendix 1

Space Technology Hall of Fame Banquet Program



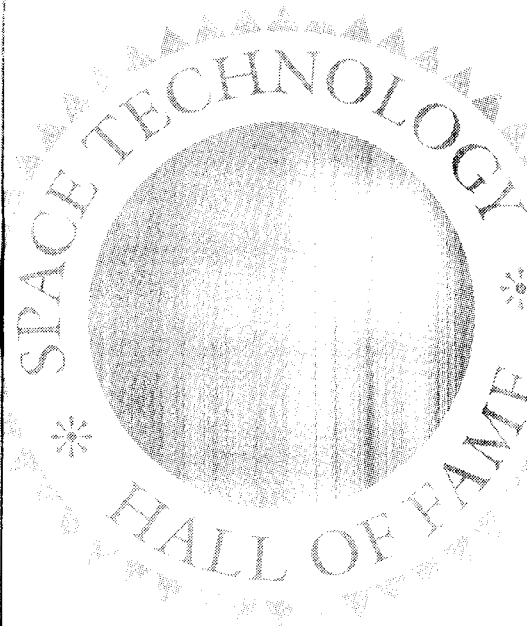
United States Space Foundation

NINTH
NATIONAL
SPACE
SYMPOSIUM

Space Technology
Hall of Fame Banquet

6:30 p.m.

Thursday, April 15, 1993



Broadmoor Hotel
Colorado Springs, Colorado

Appendix 2

Space Technology Hall of Fame Sample Ballot Packet

ARAC

Specialists in Technology Transfer

611 North Capitol Avenue
Indianapolis, IN 46204
(317) 262-5003
FAX (317) 262-5044

TO: Chuck Zimkas
FROM: Tim Janis J
RE: HoF Candidates
DATE: November 10, 1993

Please find enclosed originals of the writeups and scoring sheet for the 1994 candidates. Also enclosed is a floppy with the same information in WordPerfect 5.1 and ASCII.

If you have any questions or need additional information please let me know. We are looking forward to having the returns from the judges by December 31, 1993.

Please contact me before you begin to tally the results. This year we should use a normalized system which will reduce the potential error due to disparities in scoring style (i.e. some judges scoring everything high and others everything low). I'll explain the system to you or you can send the raw data to me and I'll do the work up.

In case we don't chat - Happy Thanksgiving to you and everyone at the Foundation.

1994 JUDGING SHEET

Technology	Assign a value of 1-10 for each criterion, with 10 the highest rating and 1 the lowest.					Total
	Economic Benefit	Public/Private Partnership/Investment	Public Awareness Factor	Application Diversity	Longevity	
Automated Waterjet Stripping						
CLIPS-An Efficiency Tool						
Digital Imaging						
Electric (Ion) Beam Generators						
Laser Angioplasty						
Magnetic Fluids (Ferrofluids)						
Parawings (Hang Gliders)						
Productivity Tool for Computer Software						
Rapid Measurement Clinical Thermometer						
Underwater Location Aid (Pinger)						

CRITERIA

- Economic Benefit The economic activity resulting from the technology. (i.e., Has the technology been the basis for a successful product and/or generated a new company?)
- Public/Private Partnership/Investment The significance of the development efforts. (i.e., Was the initial development effort an example of a significant partnership between NASA and the private sector, and/or did the transformation of the NASA technology to the market version require significant commitment and investment by the private sector?)
- Public Awareness Factor The technology's public appeal. (i.e., Can the spinoff application be easily grasped by the general public and does it have promotional value?)
- Application Diversity The breadth of use of the technology. (i.e., Has the technology been used in multiple applications or a singular use?)
- Longevity The technology's commercial life. (i.e., How long has the technology and/or its application been in use?)

AUTOMATED WATERJET STRIPPING

SPACE TECHNOLOGY DEVELOPMENT SUMMARY

NASA determined that it would be efficient, cost effective, and increase safety to reuse the solid rocket boosters that are used to launch the space shuttle. In 1981, NASA was confronted with the unprecedented task of refurbishing the outer structure of the booster. The task of preparing it required removal of massive amounts of the original protective materials. Furthermore, this had to be done without damaging the integrity of the wall, which left out hand chiseling, sanding, or toxic chemical washing.

In a novel approach, NASA Marshall Space Flight Center combined a high-capacity pumping technology, developed to cool the launch tower structure, with a water cannon. Marshall and a support contractor developed a control system that would transform the resulting waterstream, which could cut a hole in a steel plate, into a precision stripping tool.

While the new tool was highly efficacious, it was a hand process that required up to 55 days to completely clean a booster. In 1986, a robotically controlled automated waterjet stripper was brought online at the Kennedy Space Center. This unit, which utilizes one of the world's largest robots, reduced the stripping time by almost 96%.

SPINOFF TECHNOLOGY DEVELOPMENT SUMMARY

In 1990, a contractor developed for NASA a mobile, robot-controlled version of the waterjet system to do a quick and dirty oceanside wash to remove the thickest insulation. This technology became the basis for a new company, Waterjet Systems, Inc., a wholly owned subsidiary of the Pratt & Whitney Division of United Technologies Corporation.

The primary products of the new firm are automated robotic maintenance systems. These systems integrate an ultrahigh-pressure waterjet with precision robot control in a closed-loop system that utilizes only filtered and recycled water.

The first commercial unit was sold in 1992 to Delta Airlines to be used in airplane paint-stripping operations. Sales of all systems in 1992 were almost \$3 million. In 1993, Waterjet Systems, Inc. provided units to Pratt & Whitney, United and Northwest Airlines, and the Air Force and Navy. The company also received approval from the Boeing Company to use the technology to strip paint from their aircraft. System sales of \$13 million are projected for 1993 and estimates of sales grow to \$17 million by 1995. Other applications may emerge as the company has received numerous inquiries from automotive to food-packing firms to investigate the applicability of this novel technology.

The waterjet stripping technology is a successful example of a "dual-use" technology. NASA and Waterjet Systems have both contributed to its development and have realized space program and commercial benefits, respectively.

CLIPS—AN EFFICIENCY TOOL

SPACE DEVELOPMENT TECHNOLOGY SUMMARY

Critical to a successful space program is the ability to increase operational efficiency without sacrificing efficacy. In 1984, NASA Johnson Space Center began examining the use of intelligent computer programs in support of space missions. So-called artificial intelligence or expert systems were being developed; however, they were done primarily in a research environments using esoteric programming languages. As such, they were very costly and generally applicable for a single purpose. This situation did not fulfill NASA's desire for increased efficiency.

In 1985, a project team of experts was formed whose objective was to produce a tool that would enable NASA to add artificial intelligence to existing applications. The requirements for the new tool were that it had to be written in a conventional computer language. In addition, it needed to be usable in applications written in various computer programming languages.

The outcome of their efforts was the C Language Integrated Production System (CLIPS). The characteristics of the system included: computer hardware independence, ease in learning its use, and most importantly, ease in applying it to existing applications at low cost. CLIPS was transferred and is in use at every NASA center. It was the first expert systems tool used in shuttle mission control. It more than fulfilled the goal of operational efficiency.

SPINOFF TECHNOLOGY DEVELOPMENT SUMMARY

NASA developed CLIPS because no commercial product was available to meet the agency's needs. Upon completion, CLIPS was provided to NASA's Computer Software Management & Information Center (COSMIC) for distribution to U.S. organizations. Almost 6,000 copies have been distributed. It is estimated that there are over 10,000 users of CLIPS. In 1990, the first CLIPS users' conference was held with 60 presentations describing uses of CLIPS in areas such as aerospace, genetic engineering, and agriculture. Today all branches of the military and numerous government organizations are using CLIPS or some modification of it. The Air Force saves 1,900 work-hours and \$120,000 per year through CLIPS use.

The impact of this development has been significant; however, it goes beyond simply dissemination. To date, three companies have CLIPS at the core of one of their products. Inference Corporation acquired and enhanced the original CLIPS for use on specific computers and applications. Their product is called ART-IM (Automated Reasoning Tool for Information Management) and is copyrighted. Haley Enterprise successfully markets a product called Eclipse and Pelidom, Inc. markets Cognate. American Airlines developed a system using CLIPS that recommends contingency plans when schedule reductions must be made. The average cost of a planned cancellation is over \$50,000. An unplanned cancellation can be as much as three times that amount. CLIPS has become a popular teaching tool. At least two textbooks have been written for university courses. Two companies repackage and distribute a modified CLIPS system for use in "hands-on" instruction.

Creating an operational efficiency tool for NASA and transferring it to the private sector is yet another successful space spinoff.

DIGITAL IMAGING

SPACE TECHNOLOGY DEVELOPMENT SUMMARY

One of the requirements of the space observation program was to have the means of sending information obtained in space back to earth. How would a satellite capture information, transmit it, and then have it made visual (with proper color, resolution, etc.) to viewers on earth?

This NASA requirement catalyzed the development of a new field of digital image processing. NASA Jet Propulsion Laboratory led NASA's development of techniques to capture spacecraft image data. The highly complex process involves taking normal images and turning them into digital form, and then transmitting the digital information to a receiver on earth. A computer is then used to convert the digital signals back into pictures. NASA's problem, however, was that it was taking pictures from thousands of miles away and attempting to resolve images as small as railroad cars from that distance.

Highly complex computer programs were developed to process and enhance massive amounts of data. These programs have enabled NASA to produce detailed images of whole cities, individual streets, buildings, farmland, oceanic flora, almost an unlimited number of applications.

SPINOFF TECHNOLOGY DEVELOPMENT SUMMARY

While NASA was not the inventor of the digital imaging concept, its early pioneering work stimulated the development of the technology. Today it is one of the most pervasive technologies in existence. Almost every visual image is enhanced or improved by some form of digital processing.

Medical diagnosis and treatment has been a primary beneficiary. Virtually every diagnostic modality, for example, x-ray mammography, ultrasonics, and magnetic resonance imaging, utilizes digital imaging to enhance the information. In fact, without digital imaging modern radiology would not exist.

NASA's early contributions were in the 1960s when Jet Propulsion Laboratory scientists used some of their processing techniques to enhance microscope and x-ray images. In the 1970s, NASA Stennis Space Center worked with Mallinckrodt Medical Institute to apply digital image processing to the concept of magnetic resonance imaging (MRI scanners).

A NASA technology that permitted producing detailed images from space now allows us to see many things more clearly here on earth.

ELECTRIC (ION) BEAM GENERATORS

SPACE TECHNOLOGY DEVELOPMENT SUMMARY

Effective propulsion systems for spacecraft are most important to NASA. Propulsion systems can be placed in three categories: earth to orbit, in orbit, and extraplanetary. Chemical systems have been the primary propulsion system utilized by NASA. These systems are controllable and capable of producing the necessary power to lift and maneuver spacecraft. Unfortunately, these systems consume large amounts of fuel; thus, for extraplanetary missions other forms of propulsion may be necessary.

One such system was developed in 1960 by Dr. Harold Kaufman at NASA Lewis Research Center. His "electric rocket," or more appropriately ion beam thruster, produces less power than its chemical counterpart; however, it can operate for much longer periods of time. Furthermore, the electric engine can operate continuously, thus increasing a spacecraft's speed to nearly that of light. To date, no mission has flown using the ion beam source; however, development continues for possible use in deep space missions.

SPINOFF TECHNOLOGY DEVELOPMENT SUMMARY

Some of the research on these electric engines was directed toward the effect the ions (electrically charged atoms or molecules) would have on the rocket materials. It was found that the ion beams modify the surfaces of many materials; in several instances in useful ways. An important application that was discovered was thin-film deposition of coatings on solar cells and optical equipment. The ion beam dislodges atomic-sized material from the surface and replaces it with the desired film material. Another application, possibly more important, is etching microcircuits for electronics applications.

These applications would not have come about without the availability of an ion beam source (sometimes called "Kaufman sources"). In 1970, the results of Dr. Kaufman's engine efforts were directed toward commercial use. His technology became the primary source for the development of ion beam sources for commercial generators.

The largest U.S. supplier of industrial generators is Commonwealth Scientific Corporation. Dr. Kaufman serves as a member of its board. The company's sales of its own beam products exceed \$1 million annually. It is estimated that the 1993 U.S. market for ion beam generators will be over \$15 million.

It is likely that applications for ion beam generators will be growing. Partnerships among industry, NASA, and universities are producing new applications. One introduced in 1993 is the deposition of diamond-like films as scratchproof coatings for eyewear. As the applications grow, so will the demand for the "Kaufman sources."

From rocket propulsion to deposition of atomic-size material, this is a unique transformation of a NASA technology that has enabled the development of new products and processes.

LASER ANGIOPLASTY

SPACE TECHNOLOGY DEVELOPMENT SUMMARY

The composition of materials in space is very important to NASA. This includes materials not only in deep space and near-earth orbit, but also in the earth's atmosphere itself.

Over the years, different sampling systems have been developed to collect atmospheric gases for composition measurements to be made on earth. NASA Jet Propulsion Laboratory has been actively involved in developing techniques for making remote measurements especially for satellite-based systems.

One tool that was developed and patented by NASA scientists was an excimer, or "cool," laser analysis system. This tool has permitted the accurate remote measurement of gases in the earth's atmosphere.

SPINOFF TECHNOLOGY DEVELOPMENT SUMMARY

Atherosclerosis is the buildup of fatty deposits called plaque in human arteries. As plaque builds, the arteries become clogged, leading to life-threatening conditions including heart attacks.

One method of dealing with the blockage is to surgically bypass the clogged vessel. This is a high-cost and generally risky procedure. A nonsurgical alternative was sought by physicians. One approach is to insert a balloon on the tip of a catheter and to inflate it at the point of the arterial blockage. This balloon angioplasty can be effective; however, it does not remove the plaque and quite often the artery collapses or is reblocked.

For several years researchers have been searching for an alternative that would be nonsurgical and would remove plaque. The concept of using a laser on a catheter to "blast" the plaque was studied. The problem is that the laser is so "hot" that it can also destroy the blood vessel.

In 1984, Advanced Interventional Systems, Inc. obtained an exclusive license for the excimer laser technology from NASA, recruited key scientists (including two NASA researchers who worked on the excimer laser system), and developed a "cool" laser angioplasty system. The product, the Dymor 200+ Excimer Laser Angioplasty System, emerged. It began undergoing clinical trials in 1987. Today many research hospitals have the system. In 1992, FDA approval was received and sales of systems in 1993 are estimated to be \$14 million.

A NASA technology utilized to excite molecules in the atmosphere to obtain measurement information has been transformed successfully to help remove plaque in human arteries.

MAGNETIC FLUIDS (FERROFLUIDS)

SPACE TECHNOLOGY DEVELOPMENT SUMMARY

One of the concerns facing a young space program in the 1950s was how to move fuel from the tank to the engine. On earth, gravity with pump assistance is the common mechanism. In space there would be no gravity.

A possible solution to the dilemma was to create a magnetic fuel. This fuel could then be moved using magnets. Scientists at NASA Lewis Research Center developed the concept of dispersing finely ground iron into the fuel producing a magnetic fluid. This method proved to be more complicated than necessary and was not implemented.

In the 1960s, NASA reinvestigated use of magnetic fluids as a coolant for spacecraft systems. Again, alternative systems proved to be more efficient.

SPINOFF TECHNOLOGY DEVELOPMENT SUMMARY

Two scientists working under NASA contract at Avco Space Systems Division were the designers of the magnetic fluid coolant concept. While the technology did not seem to have utility for the NASA requirements, the scientists believed the technology had many applications. Drs. Ronald Moskowitz and Ronald Rosensweig left Avco, obtained a license from NASA for the magnetic fluids, and started a new company, Ferrofluidics Corporation. As President Moskowitz stated, "We had no products and no customers. We were a company with a solution looking for a problem."

In 1970, Ferrofluidics introduced its first product, a virtually wear-proof seal for a rotary assembly used in the production of semiconductor chips. From this start Ferrofluidics expanded rapidly into areas that required highly reliable, virtually wear-proof seals.

Rotary seals are used in high-technology products such as ion implantation devices, plasma etch, chemical vapor deposition, lamp manufacturing, and laser systems. They also found their way into the space program as a component of space simulators.

Probably the most common application of magnetic fluids is the exclusion-seal product used in computer disk drives. This magnetic seal prevents lubricants and other microscopic particles from entering the disk head enclosure.

The company has over 300 employees, approximately half in the United States and half in Europe. Annual sales are in excess of \$25 million.

Ferrofluids are an example of a technology conceived for space purposes whose value was only realized when it was transformed into commercial applications.

PARAWINGS (HANG GLIDERS)

SPACE TECHNOLOGY DEVELOPMENT SUMMARY

In 1948, Francis and Gertrude Rogallo developed what is known as the parawing for use on inexpensive private aircraft. This technology is a flexible, controllable, fabric airfoil designed in a V-shaped configuration. At the time, Francis was an employee of the National Advisory Committee for Aeronautics (NACA), the precursor to NASA. With NACA approval, he obtained a flex-wing patent on the parawing in 1951.

In 1958, NASA became interested in the possible use of the parawing to land space payloads. Mr. Rogallo was the project engineer and began extensive research and development efforts at NASA Langley Research Center. Many patents emerged from his work, as well as the development of a significant flexible airfoil technology base.

SPINOFF TECHNOLOGY DEVELOPMENT SUMMARY

While NASA chose not to utilize the parawing to land spacecraft, the military was interested in its use for parachuting. In the mid-1960s, two parachute companies, Pioneer Aerospace and Irvin Industries, obtained a license from NASA and proceeded to manufacture parawings. In 1965, the Army's Golden Knight precision parachute team were the first to jump these parawings and demonstrate their unique steerability. This initial use birthed what is now a \$50 million annual industry known as hang gliding.

Dozens of companies have been formed in the United States as well as overseas. These companies produce parawings, hang gliders, and powered gliders. These firms have also generated a second tier of supplier firms of materials, clothing, and ancillary equipment.

A national association, the United States Hang Gliders Association, has been established. Hang gliding schools have been formed and several international magazines on the sport now exist.

In 1994, the Hang Gliding Club of Switzerland will be celebrating its 20th anniversary. Its guests of honor will be Mr. and Mrs. Rogallo.

While not well known by the public, "those hang gliders colorfully winging their way along beaches and sand dunes are a spinoff from space."

PRODUCTIVITY TOOL FOR COMPUTER SOFTWARE

SPACE TECHNOLOGY DEVELOPMENT SUMMARY

Computer solutions for analytical problems or information management needs often require multiple programs. Sometimes the programs are very numerous and quite complex. Interrelationship can be a significant undertaking, especially where application software can cost more than the associated computer hardware.

NASA has developed a tremendous number of highly complex programs. It became apparent to NASA that a tool that could assist in interrelating these programs would be very important.

In 1980, NASA Goddard Space Flight Center began development of a tool that would support greater utility of the image processing and remote sensing software developed at Goddard. The results of the effort was the production of a software management system known as Transportable Applications Environment (TAE™).

TAE proved to be highly useful, so much so that development continued to make it a more general productivity tool that was easy to use. The new system, TAE™ Plus, cut the cost of producing the interface between disparate computer programs and users in half. It has been conservatively estimated that NASA has realized cost savings of \$150 million by using TAE. The significance of TAE was recognized by the Inventions & Contributions Board of NASA when it provided the innovators with the second highest monetary award ever given.

SPINOFF TECHNOLOGY DEVELOPMENT SUMMARY

TAE Plus was one of the first portable software interface tools created. In 1990, NASA began sharing this tool routinely through its distribution by NASA's Computer Software Management & Information Center (COSMIC). It has been one of the most requested programs from COSMIC. Over 300 user sites now exist. These include other government agencies, universities, and industrial firms such as Boeing, Computer Sciences Corporation, EOSAT, Harris Corporation, and Philip Morris to name a few.

TAE was transferred to Century Computing, Inc. in 1993. Century will continue developing commercial applications of TAE Plus. As part of the agreement, NASA receives new releases and retains the right to use it in any NASA project. In the late 1980s, General Sciences Corporation incorporated TAE into one of its products, METPRO, a comprehensive weather forecasting system. In 1989, the disaster of Typhoon Sarah was minimized in Taiwan because of the forecasting capability of METPRO.

This complex system is an important software tool. Its contribution to U.S. business productivity should continue to grow as it has been estimated that as much as 80% of new computer programs are dedicated to producing the link between the user and the program.

TAE Plus, originally a NASA computer tool has been "spun out" and is now greatly reducing the programming effort to produce interfaces in many software environments.

RAPID MEASUREMENT CLINICAL THERMOMETER

SPACE TECHNOLOGY DEVELOPMENT SUMMARY

The Jet Propulsion Laboratory is a NASA center involved in unmanned deep-space exploration. A question confronting scientists early in the space program was how to detect the temperature of space bodies.

Over the past thirty years NASA scientists have developed numerous instruments that can detect temperature remotely. Most of these instruments measure emitted infrared radiation (nonvisible heat radiation) which can then be translated into temperature.

The technology has been successfully flown on many satellites and spacecraft. One major use was on the Infrared Astronomy Satellite telescope.

SPINOFF TECHNOLOGY DEVELOPMENT SUMMARY

In the United States, almost two billion clinical temperature readings are taken annually. Almost half of these readings are taken in acute care environments.

Diatek Corporation, a world leader in the development and production of electronic thermometers, was looking for a faster measurement system. They discovered that by making measurements of infrared radiation emitted from the bottom of the ear canal, they could obtain a temperature in 2-3 seconds, a desired goal.

To assist with their development of an infrared sensor suitable for use in a clinical thermometer, Diatek enlisted the assistance of NASA Jet Propulsion Laboratory through its Technology Affiliates Program. Joint efforts resulted in a product that weighs only eight ounces, can be operated with one hand, and makes temperature measurements within 2 seconds. The instrument has a disposable probe cover which makes it almost infection proof.

Sales of the infrared thermometers were over \$1 million in 1992 and are estimated to be over \$4 million in 1993. Diatek projects that by 1997 sixty percent of all clinical thermometers will utilize infrared sensor technology.

NASA technology and knowledge utilized to measure the temperature of celestial bodies has been transformed to make a quick, accurate temperature measuring instrument for humans.

UNDERWATER LOCATION AID (PINGER)

SPACE TECHNOLOGY DEVELOPMENT SUMMARY

Because NASA chose to utilize water landings for many of its space payloads, it wanted to be certain that they could always be located. A system was required that, upon landing, would send out a location signal. The system had to be simple, rugged, long-lived, and furnish precise bearing.

In response to these requirements, researchers at NASA Langley Research Center developed an underwater beacon. The Pinger, as it was dubbed, utilized sonar to send out a homing signal to guide the recovery team.

The Pinger was a tremendous success. No water-landed payload has been lost. The technology was honored in 1967 with an IR-100 award.

SPINOFF TECHNOLOGY DEVELOPMENT SUMMARY

In 1968, the technology was licensed to Dukane Corporation and to Burnett Electronics. An early commercial application was as an attachment to "black box" flight recorders in aircraft that flew over water. This has been extended to all aircraft, ships, military equipment, and other valuable items that might otherwise be lost in a water environment.

More recently the Pinger has been used to mark underwater sites and relics. It is used on transported hazardous cargo to ensure recovery in case of accidental loss.

Dukane Corporation has produced over 50,000 beacons in 25 years of business. Recently it received a letter of commendation from the Navy for use of its beacons on land mines in the Red Sea. These beacons greatly improved shipping safety.

This NASA technology is one of only a small group of government-developed technologies that required modest private sector development during commercialization. It was a product ready-made to "ping."

ORIGINAL PAGE IS
OF POOR QUALITY

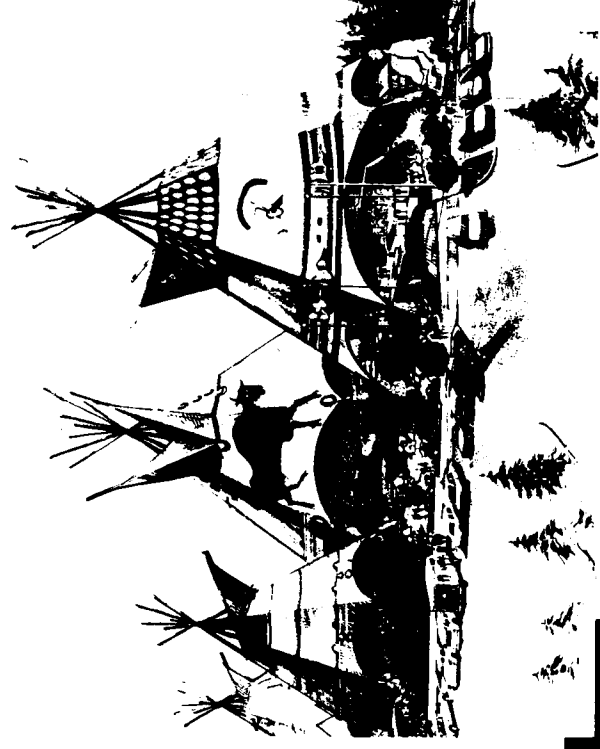
JKA, inc

Most leisure attractions, including gaming, must now appeal to and provide activities for the entire family.

offers creative talent, technical skills & industry experience

our multi-disciplinary team has developed highly successful entertainment projects throughout the world.

FIVE PEAKS CASINO & CONVENTION CENTER - Montana



Principals John Kasperowicz & Howard Jouts are professional architects with over 40 years combined experience directing the planning design and implementation of themed entertainment projects.

Cost-effective design is obtained through combining architectural knowledge, program development capabilities, thematic and show design experience and general experience in creating & implementing a lot of unique projects.

KNOTT'S BERRY FARM CAMP SNOOPY - Anaheim, California



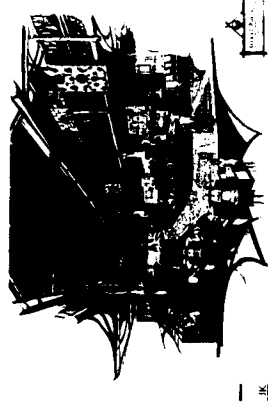
The family entertainment center concept has gained popularity because it provides a secure, clean, controlled recreational environment at reasonable prices and within local driving distances.

We ask ourselves what visitor experience we are trying to achieve and how we can most reasonably produce that effect.

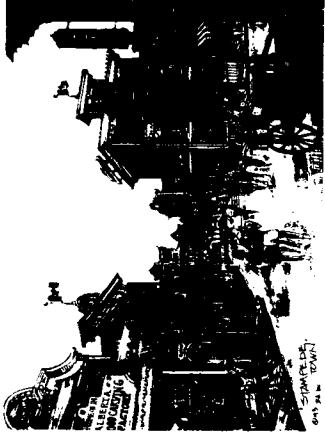
PHANTOM FLEET - Seagaming Attraction



GRAND PORTAGE LODGE & CASINO - Minnesota



STAMPEDE TOWNS - Alberta, Canada



Industry gaining facilities provide tremendous opportunities for the presentation and expression of the culture and heritage of tribal groups. The history, symbolism and architecture of the tribe are integrated throughout the design and presentation of the entire project.



MONORAIL STATION - County, California

FAMILY ENTERTAINMENT CENTER - Los Angeles



creativity is our hallmark

supported by sound programming, market analyses & budgetary criteria

concept development

THEME PARKS

programming

FAMILY ENTERTAINMENT CENTERS

master planning

CASINOS

design development

INDIAN GAMING FACILITIES

construction documentation

RESORTS

story development

FAIRS & EXHIBITIONS

ride layout

THEMED DINING & SPECIALTY RETAIL

set design

WATER PARKS

model making

RECREATIONAL FACILITIES

budgeting

RIDES, SHOWS & EXHIBITS

project management

HISTORICAL BUILDINGS

entitlements

clients

Academy of Art University
ABC Imagination Air
BellSouth Group of Hotels
Cablevision Systems
CAW OMT SA
Chaffetz Communities Cultural Center
City of Rancho Calajoniga, California
City of Pomona, California
College of Osteopathic Medicine of the Pacific
Commerce Construction
County of Los Angeles Department of Parks & Recreation
Creative Games Technologies
Crow Agencies
Disney Development Company
Disneyland
Euro Disneyland
Lamprey, Los Angeles County
Gamma International
Grand Portage Hotel Group
International Gaming Network (IGN)
IH International
Knott's Berry Farm
Landmark Entertainment Group
Majestic Realty
Management Resources
Pulsford Property
Raging Waters USA
Ray Cammack Shows
Reunion Organization Ltd
Superick
Universal Studios
Upland Town Center Economic Development Corporation
US Space Foundation
Vision Masters
Walt Disney Imagineering/WDI
Zack's Look



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Appendix 3

JKA, Inc. Brochure