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NASA/Industry Joint Venture on a Commercial Materials Processing in Space Idea

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ABSTRACT

Microgravity Research Associates, Inc. (MRA) was formed in 1979 for the purpose of engaging in materials processing in space. Toward this end, it recently became the third company to enter into a Joint Endeavor Agreement with NASA. This is a report on the progress of MRA and the nature and objectives of the joint endeavor. The MRA experience is unique in that this is the first start-up company. to become involved in materials processing in space through a joint endeavor with NASA.

INTRODUCTION

Some people are concerned these days whether the Space Shuttle will be a paying proposition for our country, or whether this costly space transportation system may be headed down a road similar to that of the British/French Concorde airliner. Our government is betting heavily on the Shuttle program, and so are we at Microgravity Research Associates.

To some extent, the outcome will depend upon the degree of success to be found in various projects that are surfacing for commercial materials processing in space. We at Microgravity Research (MRA) are entrepreneurs who are sponsoring one of these projects.

It is interesting to note that MRA is a start-up organization. As such, it lies at the far opposite side of the corporation spectrum from McDonnell Douglas, the large aerospace corporation which was the first to sign a Joint Endeavor Agreement with NASA.

MRA was conceived and organized for the sole purpose of engaging in the production and marketing of materials processed in space. Our plan, from the start, was to enter this business activity through the avenue of the NASA joint endeavor program.

It seems quite clear, in fact, that only through such a program, in which NASA accepts to share the front-end burden, could a small business organization, and especially a start-up organization, find an opportunity to enter into this very promising new frontier of materials processing in space.

MRA is proud and very optimistic about its role as an entrepreneur company entering this new frontier. It is true that we have only recently signed our joint endeavor agreement with NASA. And, in telling the MRA story, we can only share with you at this time the company's early beginnings and the direction it is heading. The main stream of the story will unfold in bold letters, hopefully, over the years ahead while we work through the research and development efforts of the endeavor and follow on to hew out of place for MRA among those companies which are pioneering the commercial opportunities of space.

However, even from our beginning experiences--from whence we have come, how we got here, and where we propose to go, something might be seen about the versatility of the joint endeavor program and how this program might open opportunities for other companies, even small business organizations, to participate in the opening of the space frontier.

THE PROPOSAL

The joint endeavor idea that MRA proposed to NASA was that we develop and demonstrate the capability to produce high quality electronic materials in space by use of the electro-epitaxial process. This process for growing crystals was developed by the Massachusetts Institute of Technology and is believed to hold promise for producing high quality crystals in bulk amounts in the microgravity environment of space.

As most are now aware, the essence of the joint endeavor program is that NASA offers incentives and assistance to encourage companies to come forward with promising proposals for materials processing in space. In our case, as in others, NASA will provide mission integration and flight services aboard the Space Shuttle. MRA will develop the packages to be flown, including the supporting hardware, and will develop the capability to market the product at the conclusion of the joint endeavor.

NEGOTIATIONS

Our proposal was first presented to NASA by letter in April, 1979. This was before the formal announcement of the joint endeavor program. But even then, NASA had stated its intention to enter into a program of this nature. Our proposal was accepted for consideration, but was put on hold until NASA could work out and publish its rules of the game. This was accomplished by the latter part of 1979, and the following January we began formal negotiations on wording of a joint endeavor agreement.

A period of more than two years of negotiations transpired before the agreement was signed. This period spanned such major causes for frustrating delays as a governmental change of administration, major NASA budget cut-backs, and change-over of key NASA personnel. However, there were other significant reasons why such a long period of negotiations was experienced in our case.

One such reason was that of MRA being a start-up company. We had no track record to point to, no plant or facility, and only an embryonic organization. We were something new to the NASA team members--a completely different breed of company from that they had known and with which they felt comfortable. How could the capability and merit of this young upstart, MRA, be measured? And what level of confidence could be placed in the soundness of its proposal, and in its ability to see the project through? And what of the dedication and commitment of its people? These were difficult questions for NASA. It took time and patience to work them out.

Another new and different aspect was that MRA would be operating solely with investor provided dollars. It had no other source of reserves or income, as would be the case with large, on-going organizations. MRA would be particularly sensitive to such eventualities as program delays, cost over-runs or early competitive incursions. It was important that the provisions of the agreement address these sensitivities. Also, since MRA did not have its own plant and facilities, it was a necessary concept that contractual support be arranged for the tasks we would be responsible for under the joint endeavor. We arranged for the services of the MIT electronic materials laboratory to accomplish our ground based research and to develop the specifications of our crystal growth apparatus. This was the very laboratory where the original development work on the electroepitaxial crystal growth process has been performed. In addition, we arranged to have as our scientific consultant the noted MIT professor who had pioneered this process, and who had previously been the principal investigator on two successful experiments involving crystal growth in space. We also began seeking out a competent experienced engineering firm for the design and fabrication of the necessary crystal growth hardware and support equipment.

To fill the need of high level technical management capability, we added to our staff a recent NASA retiree of proven track record and demonstrated competence who had been performing at similar levels of responsibility within the NASA organization. We assigned this top flight individual to be the MRA joint endeavor manager.

We were pleased that during the negotiations we did not encounter any doubt about the potential value of the MRA proposal for processing electronic materials in space. The importance of such improved materials in support of state-of-the-art advances in electronics and eletro-optical technologies found ready support. With mutual confidence that the goal was an important one, the details of the agreement were worked out, item by item, and we are happy to say that a final wording was found satisfactory to both sides.

THE NATURE OF THE JOINT ENDEAVOR

With this background, let us now look more closely at the particular idea for material processing which MRA proposed, and at some of the details of the joint endeavor agreement.

I have mentioned that the proposal involved developing and demonstrating aboard the Space Shuttle the capability of producing high quality electronic materials in bulk quantities for the market. We chose gallium arsenide as the material to work with. This particular product was selected for its superior electronic characteristics, its wide range of potential applications and broad market potential. As compared to silicon, for example, gallium arsenide offers ten times more performance.

NASA agreed to provide seven flight opportunities at no cost to MRA in suppport of the endeavor. An eighth flight will be provided on the basis that MRA may reimburse NASA on a deferred basis for the cost of this flight. This will allow some return from early sales before MRA must commence payment of the heavy costs of space transportation. All subsequent flights will be paid for in accordance with NASA's standard charge policies.

The total span of the joint endeavor is divided into three identifiable phases, each representing a major step toward the objective of achieving a full-fledged commercial space processing capability.

Phase I will consist of two experimental flights to conduct research on the basic process, operating in a microgravity environment, and to obtain data for design of space flight equipment and apparatus.

Phase II will consist of four flights. These flights will be used to verify the production facility components and sub-system designs and the operational procedures. They will provide the basis for design and operation of the facility for bulk product to be flown in the following phase.

Phase III will consist of two flights. These flights are to verify the full-scale production facility design and to demonstrate the capability to conduct two full capacity runs of the crystal growth equipment in space in a twelve month period.

The three phases, including time required to prepare for the first flight, are expected to require a period of about six years.

At the conclusion of the joint endeavor, MRA will become a regular full paying customer of the Space Transportation System. From that point on we will utilize space on at least two flights per year to meet production requirements.

Our equipment will take up a cross-section of the cargo bay about 3 to 5 feet in depth. The crystal growth apparatus will be fully automated except for turn-on by the crew, and the crystal growth process will be completed during the normal on orbit time of the Shuttle mission.

As the joint endeavor progresses, MRA will expand its organizational base, adding talent and facilities to meet growing needs. Our primary concern, initially, will be the design of the flight experiments and the procurement of necessary furnaces and support equipment for the crystal growth process. Further along, emphasis will shift more to marketing concerns. As early as possible, we will want samples of space produced materials in the hands of laboratories and potential customers for their own characterization and experimentation. This will help to whet the appetite of industry for our unique high quality product.

PRICING THE PRODUCT

An important marketing consideration, of course, is the price at which space produced materials can be offered. It is an axiom that high costs of space transportation will demand that materials produced in space bring a high market price per unit weight. We expect, for example, that space produced gallium arsenide may have to be marketed at a price, initially, as high as $1,000 per gram. Later, as the market grows and production is expanded, this price should come down. But, even so, the high cost of space transportation will be the dominant factor in pricing. Any future reduction in this cost will have significant favorable impact on the price at which space processed materials can be sold.

Still, we are talking about very high costs, and we should expect applications for electronic materials processed in space to be severely limited by their price. The market for these materials will probably develop within those areas where technological complexities and requirements for the highest levels of performance demand the use of the highest quality and best performing materials available.

Quality and performance will be the key. As substantially improved electronic materials become available from space processing, this will surely support important advances in new generations of electronic and electro-optical devices. We expect future markets in these areas to be exciting, to say the least. More to this point later.

PROJECT RISKS

One factor thatshould be discussed because of its importance to any joint endeavor project is that of risk. Without a doubt, ours must be considered a high risk venture.

There is technical risk involved with proving that the electroepitaxial process, which works in the ground laboratory, will actually produce high quality crystals in space, and that the process can be scaled up from laboratory size to bulk processing size.

There is risk involving the space transportation system itself. This risk looks smaller now, with three shuttle flights behind us. But even so, a disaster involving a Space Shuttle flight, especially one carrying our equipment, could prove a devastating blow to the program.

Also, any lengthy delays in the flight schedule could strech out the program, adding to the financial burden and time to get to market.

Schedule delays might arise from such causes as technical problems, NASA budget cuts or cargo bumping to accomodate other priority projects.

Another risk is that technological advances or new directions which cannot be foreseen might overrun the market requirement for the material we plan to produce.

Yet another, and this can be especially serious for a small business, is the risk that after we have eliminated all other risks, and shown that the job can be done, other large companies with vastly greater resources will quickly come in to capture the markets we have opened.

All these risks considered, and in view of the long time span required to get to market and large sums of money at risk, our project falls well outside the pattern which attracts today's standard venture capital firms.

THE OUTLOOK

Yet, here we are! And we are enthusiastic about the outlook! We believe that the promise is well worth all the risks. We are convinced that new and better materials from space will prove to be of great significance in the years ahead. We believe that these materials will provide the cutting edge for many new technological advances, and that these advances will provide a significant stimulus to business and industry. The benefits of this stimulus will flow back to the government and to the tax payers in terms of higher productivity, more jobs, and a stronger economy. We believe the Shuttle program will prove to be a wise and profitable investment, indeed.

In support of this optimistic view, I will cite an example from our own joint endeavor project. Good quality gallium arsenide has been extremely difficult to produce on earth. This is largely due to imperfections set in by gravity-driven convective currents in the molten material in which the crystal is forming. Out of 100 microcircuit chips now made of gallium arsenide, only a few can be used. The rest must be thrown away. Such inefficient production makes gallium arsenide chips very expensive -- comparable, in fact, to diamond.

However, processing gallium arsenide in space, where gravity-driven convective currents are not encountered, holds promise of achieving very high quality crystals with a much better yield of good chips.

An exciting prospect is that if the yield of good chips can be gotten to the point where most all of the chips on a wafer of the crystal are useable, then the whole wafer can be used as a chip. This would make possible a gallium arsenide superchip containing many millions of microscopic electronic components connected in a truly supercircuit.

If we can produce gallium arsenide of a quality to support this development, and well we might, this could revolutionize the computer industry. It would have a major impact as well on many other high complexity electronic based systems.

Such promising prospects surely lend justification to the NASA joint endeavor program and bode well for the future of the U.S. Space Transportation system.

We will be pleased if the progress which MRA achieves in its joint endeavor with NASA will help to encourage other companies to come forward with new and promising ideas for materials processing in space. I am sure NASA will agree there is room for more, and the time could not be better.