

EXCERPTS FROM ROCKETS AWAY

-Writing Samples-

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Rockets Away! - An Ezine Devoted to Commercial Spaceflight -

"Our Future Lies Out There, Somewhere Among the Stars"

'The Adventures of Ganymede Jones,' a 1970's radio show

THE JEFF GREASON INTERVIEW

Jeff Greason, CEO of XCOR, has injected a sense of relentless determination and thorough follow-through into his vision of creating a company that will provide an affordable route to sub-orbital flight. When one looks at the strength, integrity and commitment of his staff as they relentlessly design, test and refine engine after engine, igniter after igniter, pump after pump, you can see why he believes that he is building on a foundation that can lift his company to the outskirts of space. Everything about XCOR is thought out, tested thoroughly and carefully evaluated. Johnny Blue Star, Managing Editor, did the print interview



Jeff Greason, CEO of XCOR

What is XCOR's niche in the private space world?

XCOR develops rocket engines, rocket propulsion systems and complete rocket-powered vehicles for commercial and cost-sensitive government applications. We offer design and development services for customers who need them. We offer components like engines, pumps and tanks to vehicle developers. We are developing complete rocket-powered vehicles; we will initially sell the services of those vehicles and we will sell the vehicles themselves to independent operators when the market is ready for that. These vehicles are targeted to suborbital payload markets, nano-satellite and micro-satellite launch, and commercial human spaceflight.

You just announced a new contract with NASA to develop a composite cryogenic tank to hold liquid oxygen (LOX). What is NASA looking for in this device? How will this be an improvement over other LOX containment tanks?

These are composite liquid oxygen tanks. Composite materials offer weight advantages over conventional metal tanks, but a more significant advantage is their low coefficient of thermal expansion. Conventional metal tanks shrink significantly when exposed to cryogenic temperatures, which poses major limitations on how they can be integrated into complex structures and reusable vehicles. Composite tanks shrink so little that they can actually form part of the overall vehicle structure, and it is this integrated design that offers the more significant advantages. But composite LOX tanks are not a new idea - others have been made. The composites used in those tanks become very brittle at cryogenic temperatures and tend to have short life for that reason. They are also flammable and pose a potential safety hazard when containing a strong oxidizer like LOX. The tanks we are developing for NASA employ patent-pending techniques we have developed over the last few years and a completely different set of materials, which remain flexible and tough at cryogenic temperatures and which are intrinsically fire-resistant, for greater safety.

Another recent coup for XCOR was the acquisition a new joint agreement between Beyond-Earth. Apparently Beyond-Earth wants to develop small payload launch vehicles at affordable rates, and you will provide some of these components? What kind of components will XCOR manufacture to fulfill this contract?

Our relationship with Beyond-Earth Enterprises is a vendor-to-supplier relationship. Beyond-Earth Enterprises have their own vehicle architecture tailored to their markets. Under our relationship, we will supply them with a propulsion core (engines, tanks and valves) for their vehicle at an agreed-upon price.

Obviously, with SpaceShipOne, a lot of people are looking at hybrid propulsion systems. Why have you chosen to develop a liquid rocket engine?

We examined the advantages and disadvantages of different technologies when we started the company and concluded that liquid rockets could be made as safe, or safer, than hybrids with substantially better performance and substantially lower recurring cost per flight. Everything we have learned over the last six years has convinced us even more strongly that we are on the right technology path.

Last year you announced the development of a cryogenic liquid oxygen pump. Explain how this pump differs from turbo-centrifugal hardware. Why do you need a piston pump?

The reciprocating or piston-pump technology is very simple in concept: a piston moves back and

forth - on the intake stroke, check valves admit propellant to the cylinder, and on the pumping stroke, the propellant is pushed by the piston out of check valves into the rocket engine. The challenge is in the details of making it work. We have made a lot of progress on check valves suitable for liquid oxygen work at the cycle speed we're using (60 cycles per second). A rocket engine pump is just another kind of mechanical engine; it handles mechanical power. If you look at other applications, like aircraft engines, you find that turbomachinery dominates in large engines, while piston machinery dominates in small engines. The reason is that turbomachinery is relatively expensive, but that cost does not rise very quickly with size. Below a certain size, piston machinery is cost-competitive. We believe the piston pump is very competitive below 10,000-20,000 pounds of rocket thrust, and may have use in some especially cost-sensitive applications up to 60,000 pounds of rocket thrust.

You are offering \$11,000 for a steam engine. Why is XCOR so interested in a new steam engine? How would this be used in space?

This is another outgrowth of the piston pump work. We have been developing two different gas-driven motors to drive the reciprocating piston pump. We were aware of a community of hobbyists who build their own steam engines. We thought a prize might stimulate some of those hobbyists to come up with innovative ideas for the drive motor which we had not thought of yet. The winners of that contest may very well develop ideas we can use to improve how we drive our piston pumps. There has been quite a bit of interest from the steam hobbyist community, but no winners yet.

You identify one of the three markets for the Xerus as micro-gravity research. Explain what this is and why it is a likely target for research dollars.

An existing community of researchers need their experiments exposed to microgravity or taken above the atmosphere. These researchers previously used the NASA-funded sounding rocket program, small payloads on the Space Shuttle or experiments on the ISS. Recent changes in government priorities mean these opportunities have been dramatically curtailed, and there is a back-log of work. Furthermore, we believe there is a larger pool of industrial researchers who from time to time have considered microgravity as a tool for their private-sector work. Those efforts have not borne fruit, in part because industrial customers need a combination of low cost, high flight rate and full protection of their proprietary information. We believe we can meet those needs and grow the field of microgravity and exoatmospheric research far beyond the traditional customers.

Richard Branson has ordered a number of ships from Scaled Composites, presumably based on hybrids? Is Virgin Galactic a competitor? How do you look at other companies entering into the space tourist field? And who do you think are the serious contenders?

We believe that there will be a transitional period in which we need to operate our own spacecraft, while the market, the regulations and the operations and maintenance practices for reusable spacecraft develop together. We believe that Virgin Galactic plans to be owner/operators of spacecraft rather than developers. Therefore, while our businesses may slightly overlap in the near term, we believe they are a potential future customer. There are certainly other entrants, and we believe the market will support several successful companies. As to who is a serious contender, that will be decided in the marketplace.

On your website, you say, "The four engines and igniters used during the EZ-Rocket flight test program have achieved our goal of being reliable, reusable, and restartable in-flight, ushering in a new era of rocket engine technology." Why are these advances

revolutionary? Haven't there been other reusable and re-startable liquids? Aren't the engines on the Shuttle Orbiter reusable and restartable?

There have been reusable liquid-propellant rocket engines before, intended for aircraft applications, such as the HWK-109, SEPR 844, XLR-11 and XLR- 99. Our engines have longer life and require much less maintenance than most of these, and employ low-cost, non-toxic propellants. Few of these engines could be re-started in flight. The capacity for in-flight restart gives us great trajectory flexibility and allows us use reserve rocket propellant as margin for landing adjustments. I am not sure that any one of these capabilities is revolutionary by itself, but by combining all of these features, we attain nearly maintenance-free operation and the very low operating costs necessary for profitable operations.

The Space Shuttle Main Engines are not restartable. And I would characterize them more as refurbishable than reusable, since many of the components have a very short life, and the cost of returning the engines to service between flights is very high.

We understand that you have a very quick and efficient design/development/testing protocol. How is this different from other space-based companies, and how do you actually accomplish this?

All of the senior staff have worked before with state-of-the-art analysis and design tools for rocket development. We found that a very rapid analysis can give us an approximate design solution, and more sophisticated analyses can refine that answer. But when we actually try the solutions in practice, we find unexpected things that invalidate the analysis. Simple, practical things, like fittings, seals and how you arrange the sensors can be problems as often as fundamental design elements - and you don't find those problems in simulation. At XCOR, we have focused on how to shorten the design, prototype and testing process. In most cases, we can design the components to be fabricated quickly in our in-house machine shop. We co-locate all the elements of the team, and we do new prototypes often enough that all the contributors keep in constant practice. It is quite common for us to find a problem in testing, and in days or even hours to have modified the design, modified the engine or fabricated a new part, repeated the test and confirmed that we have fixed the problem.

This is quite different from practice in traditional aerospace contractors, who have emphasized more sophisticated modeling rather than rapid prototyping.

XCOR'S EZ-ROCKET - FIRST STEPS TO SUB-ORBITAL

EZ-Rocket is a rocket-driven airplane, which was essentially developed by placing a rocket propulsion system in a small conventional aircraft, the Long-EZ, a popular, easy-to-assemble aircraft. They have used it to test and showcase their rocket propulsion engine. It is not a consumer product. The goal has always been "profitable transportation to Earth orbit." The next step is the Xerus.



XCOR's EZ-Rocket

To understand the direction of XCOR, one must always return to their goal of creating "safe, reliable and reusable rocket engines." Their whole six-year history showcases their unrelenting focus on this goal, whose ultimate aim is to create engines that can take the vehicles to sub-orbit.

Let us briefly look at some of their successes during this period.

Two months after they incorporated, XCOR began work on an igniter. Following their heavy emphasis on accelerated design/fabrication/testing protocols, a month later they were running that proprietary igniter on all their rocket engines. With 2000 test firings behind them, the igniter is a proven success.

It took until March of the very next year to begin work on the "briefcase motor," fondly referred to as the "tea cart," a portable, tiny motor that allowed for rapid fabrication and testing. In April of 2000, the motor was demonstrated at Space Access Society's meeting in Scottsdale. By 2001, this engine had achieved 1200 test firings, utilizing nitrous oxide oxidizer and ethane fuel.

Simultaneously, during the "briefcase," testing, they began work on another level of test engines, a 160- lb.-thrust, which ran on isopropanol and liquid oxygen and was run in October 2000. The next engine, a 400-lb.-thrust LOX/alcohol engine, would become the propulsion system of the EZ-Rocket. In addition to these motors, XCOR received a small government contract to develop and test a 50-lb.-thrust rocket engine that would run on nitrous oxide and alcohol.

The production of these four engines and igniters achieved a goal revolutionary in the history of rocket engine technology: These engines were all safe and reliable, but also reusable and even restartable in-flight.

Another igniter has already been developed that will accompany an 1800-lb.-thrust Kerosene engine that will be used in the Xerus suborbital vehicle.

- **THE XERUS**
Going Sub-Orbital the XCOR Way



XCOR's XERUS (Animation)

The next generation of private commercial space travel is on its way. XCOR LLC is currently in the design stages of the Xerus rocket. The proposed Xerus rocket will be a sub-orbital vehicle that reaches 100 kilometers or 62 miles. The proposed maximum speed is Mach 4. The reason the Xerus will be successful is that its predecessor, the EZ- Rocket airplane, has been flown multiple times, giving some idea of its capacities with similar liquid rocket engines.

The Xerus will be a two-seat RLV or reusable launch vehicle that is capable of taking off from the runway and soaring to 65 kilometers on its main engines. It will then use its rocket engines to cruise to 100 kilometers or sub-orbital space. The craft will be able to retain reserve fuel to land back at the airstrip like a regular small plane. Cost and reusability are a major advantage of this design in this arena.

XCOR plans to use the Xerus for three markets. The first market is the most obvious - space tourism. XCOR already has an agreement in place with Space Adventures. Space Adventures will handle the booking and reservations for the first 600 sub-orbital flights. For \$98,000 a passenger would experience a one-hour flight with three minutes of weightlessness. Space Adventures already has over 100 flights booked.

The second market for the Xerus is a sub-orbital payload. This would allow for scientific experiments that are currently chiefly secondary payloads. Now they could be launched inexpensively and on demand. Some examples of experiments might include those involving materials processing and zero-gravity effects on small payloads. These flights are currently done by one-time rockets and cost approximately \$2 million each.

The final market for Xerus is micro-satellite delivery. The Xerus would function as a reusable primary stage with a secondary stage that is released and then launched. The secondary stage is capable of carrying a micro-satellite into LEO or low-earth orbit. The micro-satellite could weigh up to 10 kilograms and would cost approximately \$500,000. The current minimum cost of \$12 million as well as the ability to launch on demand instead of being secondary payload makes this a lucrative market.

XCOR also plans on selling and leasing their vehicle services to other companies. The Xerus is currently in the design phase and has not been funded for construction. After construction begins, XCOR says it will take 18 months of test flights before carrying passengers. The three markets, the EZ-Rocket testing, the detailed aerodynamic research and design, and the fact of having received the second launch license in FAA history all put XCOR on track to be a leader in sub-orbital space.

PORTRAIT OF THE SPACE ARTIST AS A YOUNG MAN



By Johnny Blue Star

It is safe to say that, as man's conquest of space continues, the topic of space, for art as well as literature, will grow increasingly important. In the last half of the 19th Century and the first half of the 20th Century, man's groundwork for space was laid in the foundations of science fiction and its ever-present companion, science fiction art. It is safe to say that man traveled to space in his imagination and in books, magazines and electronic media long before his rocket's broke out of Earth's gravitational field. But now as private entrepreneurs push forward with their own plans to conquer space, the need for investment capital will be pushing conceptual space artists into new positions of importance. Those seeking capital will need to be able to envision these imaginative new projects. It is for this reason that one can see Nyein C. Aung as a new breed of artist, whose efforts feed an organization built on an imaginative concept- but whose art work is the precursor to technological realities not just books or movies.

In fact, Nyein Augn is the ambitious Concept Artist / Industrial Designer of the Liftport Group. Nyein says, "My main objective is to help people (our staff and the general public) capture the idea of a space elevator visually. Basically I make a lot of drawings. I am responsible for most of the drawings you can find on our website and the drawings used in the media from our company."

What sort of projects does he currently tackle? "Let's see, currently I have been talking to two Mechanical Drafting/CAD experts to help with generating more realistic and hopefully even working drawings. Start attacking technical issues visually with their help. On the more Artsy side, I am making plans to build a diorama of our project. Also I am looking for Animators to help create a short animation clip. Then, of course, there's the usual drawings that I do every week."

Although a young man, only twenty-one, Nyein's power for conceptual drawing is prodigious. Nyein solves problems in terms of size shape and form, also build non-animated 3D models. Nyein is originally from Yangon, Myanmar and came to United States in 1999 where he went to The Art Institute of Seattle to obtain an Associates Degree in Industrial Design. How he came to work for Liftport Group is an interesting story in itself.

"I came to this country from Yangon, Myanmar, when I was 15 back in 1999. I went to high school in San Lorenzo California and then I got a scholarship from the Art Institute of Seattle. That's why I came out to Seattle- to study Industrial Design. I graduated college with honors and I received the best portfolio award."

"And that's how Michael found me. He actually came to my portfolio review. My interview with Michael is one of our favorite stories at LiftPort. After that he invited me to meet him and Dawn, our marketing intern at the time, at the University of Washington Cafeteria for an interview. So I went down there and this place is noisy, packed, and there were hundreds of students walking around us. He then asked me to present my portfolio again."

"And he asked me how long it would take me to do a few of those images and I said, 'Well, I'm pretty fast. The smaller, simpler ones should take 1-2 hours and the larger, more complicated ones, might take 3-5 hours.' When I said this, a look of disbelief came over Michael's face. (I didn't know it at that the time, but Michael was having trouble because of the speed of execution of his current artists). So, he picks up Dawn's cell phone and sets it down in front of me and says, 'Draw this!' I thought to myself, 'Wait, is this guy serious.' He says, 'Yeah, draw that, I'll be right back.'

"And he gets up, starts talking on his own cell phone and leaves me there with Dawn. I say to myself, 'Well, Nyein, this is the moment of truth. Let's do it!' You see, back in college, I actually tutored students drawing, perspective and rendering so I have had some practice drawing in front of people but never for a job. I was a little nervous but I took a deep breath and I just went at it. Michael came back four minutes later and he looked at my paper. I've drawn four different detailed perspective views of the phone he asked me to draw. Michael goes, 'Well, that's what we're looking for' 'and that's about all there is to how I got hired at LiftPort."

"I'm really glad I took up the offer from LiftPort. I had a few other companies that were making offers that paid more and had more benefits but they required me to move away from the city and it was stuff like designing tooth brushes and plastic boxes. I'm 21 years old, I'm not looking just for money, I'm looking for adventure and excitement and a chance for me to make a name for myself. ('Adventure, Excitement- a Jedi craves not these things" - isn't that what Yoda says?) And that is EXACTLY what LiftPort has offered me."

"How do I work? I do a LOT of sketching and doodling. Once I'm happy with the sketches and the thumbnails, I pick my favorite and render that on a larger, nicer page. Then I scan it in to the computer and do very minor edits. Once the team is happy with some of them, I go over to the computer to make a 3D model. Sometimes I would make images that has nothing to do with our project, just images that were inspired by the Space elevator. What that does is, it gives my mind some time to breathe and have fun. And of course, I have the mood boards and the toys and stuff in my studio to keep my head going. The light saber in my studio is A COMPLETE NECESSITY.

A lot of people think my job is easy because I draw pictures for a living but, trust me, creativity and drawing is one thing, creativity and drawing ON DEMAND is totally something else. Picture your boss coming into your studio saying, 'Hey, I

need you to come up with an artistic and creative solution for this- Oh yeah- and I need it by Lunch.' I spend all day, drawing and dealing with various visual projects and I come home all tired and beat so to relax, I draw another picture. But really though we have such a long way to go that everything I'm doing right now are just early stage concepts. I'm sure everything is going to evolve so much that if you talk to me again next year they'll all look completely different."

"Sure, it's a bit of a crazy choice to make, to go work on a space elevator but I'm a sucker for good stories and I believed that the life of a Space elevator concept artist will make a much better story then the life of the guy that designed the Pink Barbie Toothbrush."

For more information, contact Nyein at nyein.aung@liftport.com.

INTERVIEW WITH KATHY ALLEN

By Johnny Blue Star

It was a real honor for me to be able to interact with the immensely talented Kathleen Allen Ph.D., a professor in the Greif Entrepreneurship Center and the director of Center for Technology Commercialization in the Marshall School of Business at the University of Southern California. Kathy has helped develop the Space Billionaires Thought Leader Forum for the USC Marshall Center.



Dr. Kathleen Allen

Kathy, like Peter Diamandis, John Spencer and many others at Space Billionaires forum, represents the vanguard of serious, entrepreneurially sophisticated people who want to bring their expertise to the task of creating appropriate foundations for a new industry. The whole schedule for this amazing event appears directly beneath

this interview.

Kathy, it appears that the Marshall Center for Technology Commercialization is an attempt to close a gigantic gap in our educational system between engineering and scientific disciplines and entrepreneurship. If this is true, why, in a country so fundamentally active in the development of technology- has the gap between science and the commercialization process been virtually ignored for so many years?

Until the Bayh-Dole Act in the mid-1980s, universities did not own the technologies they developed using government funding, so there was no incentive to commercialize. Moreover, commercialization always was in conflict with the fundamental tenets of basic research at universities, which is to publish and share knowledge. But in the past few years, federal agencies that provide funding to research institutions have been under pressure to justify that the taxpayers' money ultimately results in products and services that benefit society. So universities have been under pressure to commercialize the applied technologies they develop.

And, is it not true, that not only has this gap not been adequately addressed, but the protocols and methodologies of entrepreneurship itself have been ignored by the academic community?

Although there are now entrepreneur programs in more than 1,600 universities in the U.S. alone, the practical nature of entrepreneurship has always been at odds with the ivory tower of academe, which tends to focus more on theory. The battle for acceptance goes on every day, but we know that entrepreneur programs create value and the university knows this as well even when it doesn't always admit it. Most of the buildings and endowments given back to the university have come from entrepreneurs.

You are one of the founders of this program. Tell us something about its origin and what compelled you to undertake such an extensive rewriting of American education?

What is now the USC Marshall Center for Technology Commercialization began as a collaboration of the schools of business, engineering, and medicine over 7 years ago. With my engineering colleague, Dr. George Bekey (now emeritus), we spied an opportunity to bring together researchers and students in the three schools to find ways to bring some of the technologies being developed at USC to market. What compelled us to do this was a passion for technology and recognition that the most critical aspect of the commercialization process is business, and that had been the missing link in the equation at USC. We began by finding some technologies in the Integrated Media Systems Center that appeared ready for market and formed teams with the engineering researchers and MBAs to undertake feasibility analysis. That effort led to the founding of a company in the virtual reality area for dealing with psychological phobias. Another collaboration eventually resulted in the founding of Language Weaver, one of the more successful spinouts from the university after September 11 because their technology could do real-time translation of documents in Arabic with an extremely high accuracy rate. USC was one of the first universities in the country to do this kind of collaboration; today most of the major schools have followed with technology entrepreneurship programs.

The Marshall Center is more than an educational community. It appears to

be a place for active synergy between educational and private interests in which the courses and certification processes are only a component. In what sense, is the Marshall Center a unique type of institution?

The Center for Technology Commercialization is unique in that it develops educational programs and applied learning environments in ways that suit today's student rather than relying solely on traditional academic courses. We know that students in the professions are ultimately looking for a job, but we help them see that entrepreneurship is a viable career path and that even if they decide to go for a more traditional job, they can at least think like entrepreneurs and better respond to a dynamic marketplace. In our programs, they experience what it's like to be an entrepreneur, with all the highs, lows, and uncertainties inherent in the entrepreneurial journey.

Now, in reviewing the various programs that you have developed on your website, it appears that space technology has not been a central focus. One would seem that, with the participation of the Marshall Center in the Space Billionaires' program, that this is about to change. What has happened and how do you see the Marshall Centers' participation in the emerging private space industry, especially in regards to space tourism?

The space business initiative came about in a rather interesting way – one that entrepreneurs often only dream of. Key leaders in the private space industry came to me to discuss their need for a center of excellence for the industry. There was a lot of new activity and excitement about space entrepreneurship and tourism, but nowhere to focus all the energy. They wanted to associate with a major university that could provide education and research, and since USC is known for entrepreneurship and research, it was a good fit. John Spencer of the Space Tourism Society was the key gateway for us to meet literally everyone who could help in this effort. We are in the process of exploring how to best serve the industry and give our students the opportunity to think about space from a business perspective. The engineering side of space is covered – what we want to do is look at how we can help the industry develop new business models to sustain it until the technology allows some of the grand visions for space tourism to happen.

Looking over many of these companies, particularly, say, those that competed in the Ansari X Prize- companies like XCOR, Armadillo Aerospace, the Golden Palace Space Program empowered by the DaVinci Project, Rocketplane, PlanetSpace, etc.- do you think that this industry will be a fertile plane for the emergence of new public space companies- like, for instance, SpaceDev?

I absolutely believe that. When you see NASA with a new venture capital fund to support private development and the big guys in the traditional space industry collaborating with small private companies, it tells you that something big is about to happen. No industry can sustain itself without entrepreneurs. Entrepreneurs are the innovators; they take the risks needed to move the industry forward. The big public companies can't justify some of these developments to their shareholders. Private companies have much more freedom to explore new territory, and that's what we're seeing now.

In encountering these companies and their struggles, do you think that the type of system you have developed in Technology Commercialization

programs will help jumpstart the financing of these companies and assist them in competing more effectively in the Marketplace?

One of the things we do best is help companies prepare for funding and that includes helping them determine the best applications for their technologies, the best markets to enter, and the most effective business models to insure success.

Your keynote speaker, Peter Diamandis, is not only the CEO of the X Prize Foundation and the Zero Gravity Foundation, but he is also the founder of Space University. Notwithstanding his many accomplishments, why did you choose Peter as your keynote speaker?

Because he is an icon in the industry; he is fundamentally dedicated to the success of this industry. Creating the Ansari X Prize put enormous excitement back into the industry and got many companies energized to step up their efforts so they could compete. It also attracted billionaire entrepreneurs, a naturally competitive group, who had achieved their success in other industries – online commerce, software, hotels, airlines – to enter the game and test their entrepreneurial skills at a much higher level. His entrepreneurship successes notwithstanding, his great interest in education and preparing the next generation of space entrepreneurs was also very important to our mission.

Tell us a little bit about the Roundtable participants and their involvement or potential future involvement in the Marshall Center's technology commercialization programs.

We wanted this forum (it's not a conference) to be provocative, interesting, and enlightening. We're opening with The Honorable Andrea Seastrand of the California Space Authority, another icon in the industry. She will provide her view of the industry and where it's going. The morning roundtable is focused on the industry and John Spencer will be moderating that panel, aptly represented by Dr. Fred Best, who coordinates all of NASA's eleven research and commercialization centers, Bill Collins of the Starboard Ventures, an investor in space-related businesses, Rick Bartram of Sponsorship Strategies who is an expert in marketing for these types of ventures, and Rick Searfoss, former shuttle commander, and test pilot for XCOR Aerospace. This will not be your typical presentation style panel – rather, it is designed to be more of a point- counterpoint style to raise important issues and discuss them.

The afternoon panel is focused on the kinds of programs the industry wants to see to prepare the right kinds of talent to support the industry and insure continued entrepreneurship. This roundtable is moderated by attorney/entrepreneur Rick Citron of Citron & Deutsch. Members of the roundtable include Karen Randall of the SETI Institute, Tom O'Malia, Director of the Greif Entrepreneurship Center at USC, Janice Dunn of the California Space Authority, Guillermo Sohnlein of the International Association of Space Entrepreneurs, and Madhu Thangavelu of the Space Design Studio at USC. We'll conclude with a great networking reception to give the audience a chance to speak with some of these people and, of course, network.

What do you hope to gain from developing a forum like this and how do you think the Marshall Center will be able to handle its participation in an industry that seems to be developing at such a rapid pace?

What we hope to gain is a clear understanding of the needs of the industry and how

we can work to help the entrepreneurs in the industry make it to the next level. Speaking as an entrepreneur myself, rapid change is exciting and affords many opportunities to do great things. I have no doubt that our center can add value to the industry and I look forward to working with everyone.

INTRODUCTION TO OUR SOLAR SAIL ISSUE

By Johnny Blue Star

A strange thing happened on the way to Earth Orbit last month. The spaceship, Cosmos I, proclaimed to be carrying the first solar sail, disappeared. As the story unravels, it appears it was a launch failure, but at one point, while certain participants believed it had fallen in the sea, other observers believed they were picking up signals from space. This strangeness is a bit reminiscence of the amazing amount of disappearances, accidents and failures in communication in the myriad of Mars missions.

Launch plus 3 hours 14 min and fourteen minutes after launch on June 21st, the Planetary Society issued this official statement:

The Cosmos 1 spacecraft was launched today but we cannot, at this time, confirm a successful orbit injection. Some launch vehicle and spacecraft telemetry data gave ambiguous information during the launch. Since the orbit insertion burn, no signal has been received from the spacecraft. There are continuing efforts to receive a signal from the spacecraft

Louis Friedman, who directed the project and has been involved with solar sail missions for three decades, emphatically refused to look at the project as a failure. He lists many of these achievements in his Solar Sail Update on the Planetary Society's website. These include the creation of the first solar sail vehicle, a vehicle which may even briefly have achieved orbit (this is still ambiguous); an international confederation of partners which leverages limited resources to a full blown mission; the first launch of a mission that was directed by a space-advocacy group (as opposed to government, military or private entrepreneur organizations); as well as generating funding from a unique partnership between the Planetary Society, a private interest group, and a science entertainment media company, Cosmos Studios.

Sometimes, in *Rockets Away!*, we have spoken of the importance of the private, commercial space industry representing a noble, personalized quest for adventure. But we should not forget, that besides the commercial space industry itself, there are a number of space advocacy groups, like the Planetary Society, which also represent private individuals in a non-governmental, non-military quest to learn about space and to explore its infinite possibilities. We applaud this type of mission- because it represents a concerted attempt by the interested people of the world to actively participate in the adventure.

No, this was not a failure. But perhaps there is a built-in irony to all this. Perhaps it took something like a gigantic mishap headlining media outlets of the world to bring the idea of the solar sail into full public view. Perhaps, despite the inconvenience and embarrassment, the event has made the solar sail into a new "brand name" as a reasonable, progressive solution for certain propulsion alternatives.

In this issue, we will have a lot of in-put, including a full audio interview with Greg Matloff, a teacher, scientist and writer, who has also explored the solar sail for a full three decades. For those who want to peer behind the headlines, I think this will be a valuable opportunity to look at a non-toxic, inexpensive and ingenious method of propulsion.

Years ago, Greg and I participated in a multi-media science fiction adventure series, which primarily surfaced on radio. One of the lines of a song, a kind of Space Chantey, written back then, goes like this:

Hoist Up Ye Solar, Sails, M'Lads
And Raise the Rockets High-
We're Bound for Worlds That Gleam Like Gold,
Like Bright Jewels in the Sky.

SOLAR SAIL PROPULSION AN INTERVIEW WITH GREG MATLOFF



Dr. Greg Matloff is an Assistant Professor of Physics and Astronomy at New York City College of Technology, CUNY, and a Consultant to the In-space Propulsion Technologies Research Team at Marshall Space Flight Center in Huntsville, Alabama. For a complete picture of Dr. Matloff's work and publications in space exploration, astronomy and physics, [click here](#). He is interviewed by Johnny Blue Star, Project Manager and Producer for Rockets Away Media!

Greg, you have done so many things, as a scientist, writer and teacher. How would you describe your current interests and activities?

Although my principal interest is deep-space propulsion, I have also contributed to research in atmospheric photochemistry, spacecraft navigation, atmospheric extinction studies and wind-energy systems. I have consulted for the New York City Dept of Parks and Recreation, where I organized a sky-observing program, and I have participated in private studies of the urban environment. I have been studying the solar sail for at least three decades.

What do you think about the sail as a vehicle for interstellar exploration?

The sail is one of the few methods we have to explore interstellar realms. Sails can

reach beyond the solar system in one of two manners. One: they can be directed to perform a "sundiver" maneuver in which they are unfurled as close to the Sun as possible and are blown out of the solar system by the intense near-solar photon flux. Two: a solar-pumped laser in the inner solar system can be used to direct a beam of collimated photons against the surface of a sail in deep space. But interstellar travel will be time-consuming--the thinnest possible sails will still require centuries to cross to the nearest star.

What about today's solar sails, ones serving interplanetary or orbital functions?

Today's solar-sails are three-layer sandwiches. Facing the Sun is a reflective aluminum layer that reflects as much as 90% of the sunlight striking it. Next is a plastic substrate. Facing away from the Sun is a layer of some material such as chromium that emits any solar radiation absorbed by the reflective surface facing the Sun. Many refinements are possible to ultimately create solar sails capable of reaching 1,000 km/sec velocities. The plastic substrate could be removed in space if it evaporates under the influence of solar ultraviolet after sail unfurlment. A space manufactured bi-layer or monolayer might combine reflective and emissive properties in a very thin sheet, without the plastic substrate (which is necessary in today's sails because they are ground-launched). In the farther future, nanomesh sails with perforations less than a wavelength of light could greatly reduce sail mass without compromising performance.

What is the history of solar sail theory?

Although James Clerk Maxwell theorized about photon momentum in the mid-19th century, this phenomenon was first quantified by Albert Einstein in 1905. Two Russians--Tsilokovskii and Tsander--were the first to theoretically apply these principles to the concept of sailing in space during the 1920's and 1930's. American theoreticians begin to get into the act after 1950.

Have sail experiments been flown in space?

The sail principle was applied for steering/attitude-control during the Mariner 10 1970's vintage flyby of Mercury, in which the craft's solar panels performed as sails in the photon-rich Mercurian environment. During the 1990's, the first test sail was unfurled successfully, but not controlled, from space station Mir. In the same time frame, the US shuttle opened an inflatable antenna that could have functioned as a test sail. And two sails folded using Origami(!) were successfully unfurled from a sub-orbital Japanese rocket in summer 2004.

Has solar radiation pressure been used in operational spaceflight?

As I just mentioned the Mariner 10. It has also been applied for thrustless attitude control on at least one geosynchronous-orbit communications satellite.

What are the sail-development plans of NASA and other space agencies?

NASA is currently developing sail technology for use in a number of space-science missions. In the near future, sails may be used for station keeping of solar observatories positioned closer to the Sun than the Earth, for steering of constellations of small microsats closer to the Earth that could synoptically monitor

Earth's magnetosphere, and to position climate monitors in quasi-geosynchronous high-latitude locations. NASA, ESA, and the Japanese Space Agency are conducting sail- technology studies.

How can the sail be used in near-term interplanetary exploration and ultimately in star travel?

For probes to atmosphere-bearing planets and satellites, sail-aided aerocapture might be considered, where the sail decelerates the spacecraft parachute-like during a single pass through that planet's upper atmosphere. Sails are also useful in conducting out-of-the-ecliptic visits to comets in the inner solar system. Commercially, large sails have application to dragging mined asteroid material to space manufacturing facilities. If we wish to economically deliver payloads to Mars-space to support human exploration and are not concerned with long travel time, the sail is ideal.

If we dip inward towards the Sun and unfurl the sail at perihelion, the sail can be blown out of the solar system. Near-term Earth-launched sails can exit the solar system at 50-100 km/sec, and ultimately space-manufactured sails can reach 1,000 km/sec. NASA and several European study groups have considered using near term sail-technology to explore the Sun's galactic vicinity out to 200-600 Astronomical Units. Space- manufactured sails could be used in a few decades to explore the Oort Comet cloud out to 1,000 AU or so. Especially since the sail can conceivably be unfurled for deceleration at a target star, solar-sails could also launch interstellar probes. But travel time between the Sun and Alpha Centauri approximates a millenium unless some power-beaming approach is applied.