SPACE STUDIES INSTITUTE
Established 1977

INTRODUCTION TO THE G-LAB PROJECT

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The G-Lab Project

After a half century of research and development, and perhaps as much as a trillion dollars of worldwide expenditure on national space programs, it is shocking to realize we simply have no evidence that humans can thrive – or even long survive – on worlds beyond Earth. Research in micro-gravity has given us clues to the fundamental importance of gravity in Earth's biological systems. The question we must answer is how much is needed if we hope to permanently settle our own Moon and other worlds. Every attempt to answer it has fallen to political priorities and constraints. In order to investigate the long-term effects of partial gravity on humans and other vertebrates, the Space Studies Institute (SSI) proposes the private development of a co-orbital free-flying laboratory, in trail ~10 km aft of and station-keeping with the International Space Station (ISS).

Rationale

US National Space Policy (2010) calls for consideration of permanent human expansion into space:

> *"Fifty years after the creation of NASA, our goal is no longer just a destination to reach. Our goal is the capacity for people to work and learn and operate and live safely beyond the Earth for extended periods of time, ultimately in ways that are more sustainable and even indefinite."*

The Augustine Commission also concluded:

> "*...the ultimate goal of human exploration is to chart a path for human expansion into the solar system.*"

The National Research Council's Decadal Survey on Biological and Physical Sciences in Space 2011 reported:

> *"Finally, despite its awareness that the [NASA] large centrifuge program has little likelihood of being restarted, the ...Panel would be remiss if it did not strongly recommend an animal centrifuge capable of accommodating rats/mice at variable gravity levels."*

In spite of these findings and policy, for the foreseeable future NASA interest remains fixed on brief "flags and footprints" style missions beyond low Earth orbit. This is fundamentally a redux of Apollo, and is likely to result in the same boom-bust outcome of four decades ago.

Steps to an Answer

Any attempt to answer the question will require long-term human presence in partial gravity, but such a step is beyond the financial reach of SSI until the price of space transportation falls by an order of magnitude. In the interim, a feasible and useful approach would be to study smaller vertebrates (rats or mice) at partial gravity equivalent to that of the Moon and Mars. This approach was recommended by a previous NRC Decadal Survey and a centrifuge was fabricated and scheduled for installation on the ISS. Budget pressures and the high potential for interference with other ISS experiments led to its cancellation in 2005. While considerably less costly than a full-sized rotating station, a free flying centrifuge laboratory will still be an expensive undertaking.

In 2011, SSI recognized that this NASA work (and potentially some of the already-built and stored hardware previously planned for use on ISS) might be repurposed into a private free-flyer facility at affordable cost. We have initiated the process of obtaining a Space Act Agreement with NASA Ames Reach Center in order to leverage this prior effort.

Our plan calls for a three phase program to plan, design and develop an orbital laboratory that we have designated "G-Lab." The conclusion of these three phases would result in a flight-ready spacecraft that could be ready for launch by one or more medium or heavy-lift launch vehicles in late 2016 or early 2017 provided sufficient funding is available.

Once in orbit, close proximity to the ISS would allow SSI researchers to share crew and cargo rides to the ISS, greatly reducing operating expenses. The new commercial visiting vehicles such as Dragon and Cygnus would also allow crews from one platform to easily visit the other.

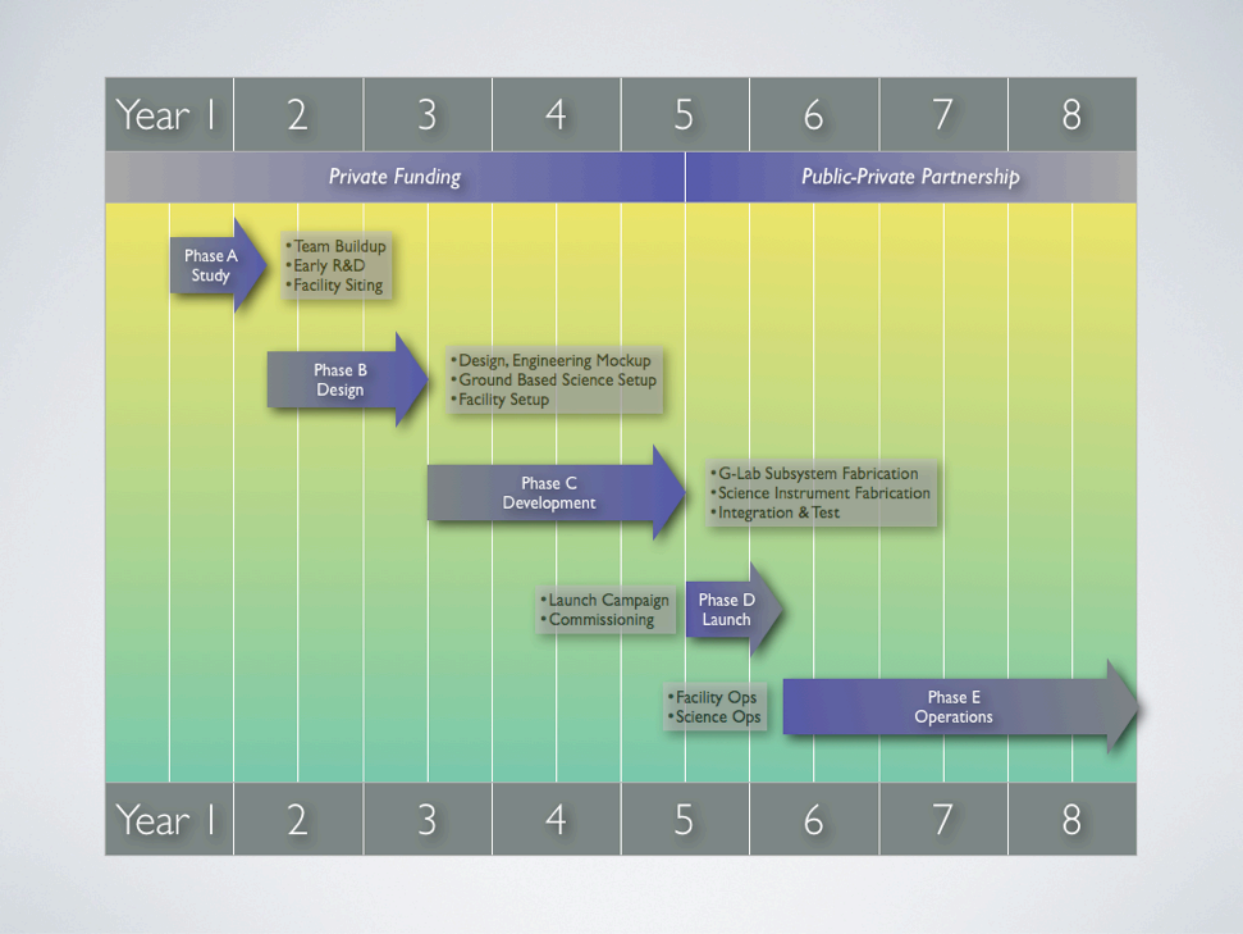
The SSI Plan

Our SSI approach calls for these initial three phases to be funded exclusively by private contributions or sponsorships. Our reasoning is that a private effort will proceed with more dispatch – and can more easily incorporate innovative solutions to developmental problems – than if there was any major early government controlling interest. A truism of aerospace engineering is that 85% of the life-cycle cost of a program is set by the requirements and design definition process in the first few months. It is critical that this design phase be focused, milestone driven and unencumbered by unnecessary process or procedure.

While the laboratory is being developed and readied for launch SSI will seek to broaden funding participation from purely private to a public-private partnership. Our long experience in the aerospace and government funding world suggests to us that having a hangared spacecraft ready for flight will be an powerful inducement to several national space agencies and other institutions to participate in the project. Participation could take the form of in-kind contributions, for example free or heavily discounted launches, crew visits, or re-supply missions. This philosophy was adopted by participants in the current ISS program with great effectiveness.

Our approach leverages early private funding to create a "multiplier effect" similar to the way prizes for technical accomplishment induce expenditures larger than the prize value itself. In the case of G-Lab we see the availability of the facility as the "prize" worth the further expenditure of public dollars for launch and operations.

Of course, some risk attaches to this approach. We estimate the total cost to reach the end of the development phase will be about $100M. If no launch was forthcoming, this money would be wasted. To avoid such an unpleasant outcome, we propose to divide the initial "private" phases into three milestones of increasing value. After Phase A, approximately $2M would have been risked, and in cooperation with Phase B and C donors we would face a "go/no-go" decision point. If the decision is "go" and funding for Phase B and C is secured, the project proceeds. If not, the effort may be terminated with minimal downside. Internal to the Phase B and C efforts, additional milestones would be crafted in cooperation with funding sources. See the milestone table and schedule below for further details.



DESCRIPTION OF G-LAB PROJECT PHASES					
PHASE		**TYPE**	**TASKS**	**TIME**	**$**
A	Study	Private	Establishment of requirements, technical and scientific teams, facilities evaluation and siting, preliminary design	9 months	2M
B	Design	Private	Design, engineering mockup fabrication and evaluation, ground facilities setup, initiation of ground based science activities	15 months	20M
C	Development	Private	G-Lab first module subsystems fabrication, science instruments fabrication, integration and test	24 months	80M
D	Launch	Public-Private	Launch Integration, Launch, On-orbit checkout and commissioning	6 months	TBD
E	Ops	Public-Private	On-orbit and ground operations	10 years+	TBD

The Space Studies Institute

SSI has a long history and a solid legacy, based on the vision of Professor Gerard K. O'Neill and his colleagues. With over a dozen SSI conferences completed, along with research into a number of technologies important for space settlement, the Institute is well positioned to play an important role as a key primary international entity that will create the ways and means of true space settlement. This is an appropriate goal to honor Professor O'Neill's vision.

The core SSI vision is to enable permanent independent space settlements beyond Earth, established by individuals and private organizations. Unlike advocacy organizations, SSI's focus has always been on physical demonstrations that yield measurable steps towards establishing self-sufficient space settlements. More details may be found at www.ssi.org.

The Space Studies Institute G-Lab Phase A Project Team

SSI is in the process of recruiting a top notch scientific and technical team for the G-Lab Project. We are working closely with NASA Ames, which is the lead NASA center for space biology, to identify key scientific personnel and have begun interviewing possible team leaders. Meanwhile, we have assembled an initial volunteer management team to see the project though Phase A. Bios of selected individuals associated with the project are listed below.

Gary C Hudson (Chief Designer) is President and a Trustee of the Space Studies Institute, and former CEO of AirLaunch LLC, a small-business government contractor with sales of more than $38 million during the past eight years. He is co-founder of Transformational Space Corporation (t/Space) and in 2004 was awarded a $6 million NASA contract to architect the return to the moon as part of the Vision for Space Exploration. t/Space's work led directly to the establishment of the current NASA Commercial Orbital Transportation Services Program (COTS). Mr. Hudson was also founder and Chairman of the Board of Directors of Rotary Rocket Company. At Rotary he oversaw development of the Roton ATV, which was the first rocket-powered vehicle to fly at Mojave Spaceport. He is the designer of the Phoenix VTOL/SSTO family of launch vehicles. This work led to the establishment of the DC-X program. He is a former Board Member of the Space Transportation Association, a member of the Board of Advisors of the Space Frontier Foundation and the Space Studies Institute, and was a member of the Board of the California Space Authority. He has presented testimony before the U.S. Congress on several occasions. He was also a founding member of the Citizen's Advisory Committee on National Space Policy that directly advised President Reagan from 1980-1988. Mr. Hudson has conducted seminars for the US Naval Postgraduate School, the Institute for Space and Astronautical Sciences of Tokyo University and taught graduate-level launch vehicle design at Stanford University. He is a Fellow of the British Interplanetary Society and an Associate Fellow of the American Institute of Astronautics and Aeronautics. In January 1994, for his role on the DC-X project, he received a "Laurel" Award from Aviation Week & Space Technology for "…the vision, drive and competence that have pushed [reusable launch vehicles] to the front of the U.S. launcher agenda." In 2007 he received the prestigious Founders Award from the Space Frontier Foundation for his lifelong contributions to entrepreneurial space.

Eric Laursen (Chief Engineer) is the Chief Technical Officer for Lockheed Martin Commercial Launch Services where he is the technical lead on configuration, performance, mission design and operations for commercial launches of the Atlas V family of launch vehicles. Prior to

that he was a founder, and Vice President and Chief Engineer, at International Launch Services where he was pivotal in the establishment, growth, and success of ILS as a market-leading supplier of international commercial space launch services on both the Atlas and Proton launch vehicles. Mr. Laursen's previous positions include Engineering Development and Management, Business Development, Program and Corporate Management, Sales and Marketing, and Finance, and has been responsible for representing his companies to commercial customers, US and foreign Government regulatory and implementation agencies and the space insurance industry. He has participated in more than 100 commercial and government launches on multiple launch vehicles, and has worked on launch vehicle and spacecraft design and systems engineering. He holds a B.S. degree in mechanical engineering and a M.S. in aeronautical and astronautical engineering, both from Stanford University.

Livingston Holder (Project Manager) has a B.S. in Astronautical Engineering from the United States Air Force Academy, and an M.S. in Systems Management from University of Southern California. While serving in the Air Force, Holder was a Titan III launch crew member at Vandenberg AFB, California. He also served in the Office of the Secretary of the Air Force, Special Projects organization, Los Angeles AFS, California, on a classified satellite program. Holder trained and qualified as a manned spaceflight engineer and Space Shuttle payload specialist from 1982 to 1988. He earned an assignment to fly as a payload specialist on the Challenger, but never flew. Later he managed the International Space Station (ISS) international integration activities with responsibility for the ISS Habitation Module. In 1994 he became the program manager for the Sea Launch program during initial development. From 1995 to 1996, Holder led Boeing's Future Space Transportation organizations, which included Boeing's participation in the X-33/Reusable Launch Vehicle Program. Holder served as the Chairperson for COMSTAC at the US Department of Transportation from May 2000 until October 2003. In 2002, he joined Andrews Space as Vice President Space Systems, where he was responsible for the company's space system design, development, and new business activities. He led the company to its first DoD contracts on the Falcon program, a joint DARPA/USAF effort. He was also the manager for a joint effort between Northrop Grumman Corporation (NGC) and Andrews Space in the NASA funded 2nd Generation Reusable Launch Vehicle (RLV) program. In 2006, Holder joined AirLaunch LLC as Chief Program Executive. Under his leadership AirLaunch achieved several technical milestones including the largest and heaviest object ever dropped from a C-17 and the largest and longest Vapor Pressurized rocket engine firings in history. He currently heads Holder Aerospace. He remains active in supporting youth education through the Space Foundation.

Charles Duelfer (Government and International Affairs Advisor) was most recently the Special Advisor to the Director of Central Intelligence for Iraq Weapons of Mass Destruction and directed the Iraq Survey Group in Baghdad, a unique team of 1,600 military and civilian staff. He produced the Comprehensive Report on Iraq WMD for the President and Congress. Mr. Duelfer was Deputy Executive Chairman of the United Nations Iraq weapons inspection organization called UNSCOM from 1993 to 2000, where he directed the efforts of monitoring and inspection teams throughout Iraq. Previously, Mr. Duelfer served in a variety of positions in the Political Military Bureau of the Department of State, including serving as a Deputy Assistant Secretary for Political Military Affairs. Among his responsibilities were policy and licensing functions related to aerospace and defense trade. Earlier, Mr. Duelfer was responsible for the review of Defense budget plans for space, strategic nuclear, and communications programs at the White House Office of Management and Budget. He holds a BA from the University of Connecticut and an MS from the Massachusetts Institute of Technology.

Debra Facktor Lepore (Special Advisor) is President of DFL Space and Industry Professor at Stevens Institute of Technology School of Systems and Enterprises. A rocket scientist and "serial entrepreneur," she has over 20 years experience in the aerospace industry, nearly all of which involved start-up projects or companies. In 2005, she became President of AirLaunch LLC. Prior to AirLaunch she was Vice President for Business Development and Strategy at Kistler Aerospace Corporation. Ms. Lepore played a key role at Kistler since joining the company in 1997 in raising over $600 million in private capital. Her first entrepreneurial venture came as the Cold War ended, when she lived and worked in Russia as chief of Moscow Operations for the ANSER Center for International Aerospace Cooperation to facilitate joint aerospace partnerships with the former Soviet Union. Over the course of her career, she has conducted business and interacted with government and commercial entities around the world, including the U.S., Russia, Ukraine, Europe, Japan, Canada, India, Australia, and South Korea. Ms. Lepore is President of the Women in Aerospace (WIA) Foundation, Past Chair of the WIA Board of

Directors, and former chair of the Aerospace Industries Association (AIA) Space Council. She is an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA); an Academician of the International Academy of Astronautics (IAA) and former Secretary of the IAA Commission on Space Policy, Law and Economics. She is a member of the U.S. Department of Transportation's Commercial Transportation Advisory Committee (COMSTAC). She earned a Bachelor of Science degree (magna cum laude) in 1988 and a Master of Science degree in 1989, both in aerospace engineering from the University of Michigan. She is an alumna of the International Space University 1989 summer session program in Strasbourg, France.