1. Laurie Leshin, Dean, School of Science, Rensselaer Polytechnic Institute

"Human Exploration of the Solar System: Dreams and Realities from the Latest Planetary Science"

Dreams of sending humanity into the solar system are longstanding. Planetary Science has just celebrated its 50th anniversary. In that time we have gained knowledge that greatly motivates future exploration by humans, and learned of the dangers that await these explorers. In this talk, we will explore the scientific questions that can be addressed through human exploration of other worlds and the latest understanding of the risks involved.

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2. Asif Siddiqi, Fordham University

"Cold War's Shadow: New Space Beyond the United States"

In the past decade or so, there has been a marked shift in the discussion on the future of human spaceflight. If for the first forty years of the space era we identified space exploration largely with the nation-state—the American space program, the Soviet space program, and so on—more recently, new players have complicated the possibilities of spaceflight. Referred to variously as private entrepreneurs, "New Space," or commercial spaceflight, their promise has energized a significant portion of both space enthusiasts and lay people. In conjunction with "New Space," there has emerged a comparable set of expectations and hopes pinned on international cooperation as the future of human spaceflight. Building on the experience of the International Space Station (ISS), planners, prognosticators, and futurists predict more international collaborations, ultimately perhaps leading to the first human missions to Mars. At a fundamental level, the hopes pinned on both commercial spaceflight and international cooperation are predicated on the notion that nation-states are becoming increasingly obsolete as leading actors in human spaceflight. In other words, the Cold War model of nation-centered competition is irrevocably over. Yet, a commitment to these two models of future space exploration ignores the continued vibrancy of the national model of space exploration that is not only alive but thriving beyond the United States, particularly in Russia but also newly mature space powers such as China, India, and Japan, all of whom continue to justify and organize their space programs (in particular, human spaceflight) on the basis of *national* imperatives. In the paper, I explore the historical roots of the three processes that have guided space exploration so far—nation-centered space exploration, international cooperation, and commercial activities—and show how all of these trends are intersecting in unusual and provocative ways in the programs of the next space powers to master human spaceflight—China, India, and Japan. My conclusions suggest that the Cold War era model casts a very long shadow over these new space powers, even as the United States moves into newer models based on international cooperation and commercial spaceflight.

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3. James F. Kasting, Department of Geosciences, Penn State University

"Habitability: Creating a Biosphere and Finding other Habitable Worlds"

NASA's manned and unmanned space programs have too long been viewed as separate entities. In reality, the synergy between the two programs is strong. Humans can one day help both to explore nearby planets and to service large space telescopes. The latter operation, of course, has already been performed multiple times with the Hubble Space Telescope (HST). Humans will likely not be able to terraform entire planets, but they should be able to construct domed or buried outposts from which to explore the Moon and Mars. If life exists today on Mars, it probably resides in deep, subsurface aquifers that can only be sampled by manned deep drilling rigs. The search for evidence of past life on Mars will also be greatly aided by the presence of humans. Sending men to Mars is an expensive proposition, however, and may not be the first goal to pursue. We may be able to look for evidence of life more easily, and with better chance of success, on planets around other stars. This can be done by using large, space-based telescopes to locate nearby Earth-like planets and examine their atmospheres spectroscopically. Such telescopes could operate in either the visible/near-IR wavelength range (NASA's TPF-C and TPF-O mission concepts) or at thermal-IR wavelengths (NASA's TPF-I and ESA's Darwin mission concepts). TPF-C and TPF-O are the coronagraph and occulter versions of NASA's proposed Terrestrial Planet Finder mission. TPF-I and Darwin are envisioned as free-flying infrared interferometers. All of these missions, when they eventually fly, are expected to be positioned at the Earth-Sun L2 Lagrange point, roughly 1.5 million km from Earth, or about 4 times the distance to the Moon. Completely unmanned versions of these missions have been studied and may represent the quickest, cheapest way to do them. But all of these missions would benefit greatly if they could be serviced, either robotically or by astronauts, allowing them to remain in operation for long time periods, like HST. A long-lived space observatory at L2 could also be used to make many other kinds of observations, thus providing a key tool for the entire astronomical community. Developing the capability to launch and service such a telescope is a worthy goal for NASA, ESA, and their partners in space exploration across the globe.

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4. Mario Livio, Astrophysicist, Space Telescope Science Institute

"THE GREATEST SCIENTIFIC ACHIEVEMENTS OF THE HUBBLE SPACE TELESCOPE"

I will review the most important scientific achievements of the Hubble Space Telescope. I will cover topics ranging from Dark Energy to Extrasolar Planets, and from the age of the universe to Supermassive Black Holes.

I will also present results of some of the most recent observations, starting with the last shuttle servicing mission to Hubble in 2009,and up to the present. Finally, along the way, I will briefly discuss open questions in astrophysics for the next decade.

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5. W. Patrick McCray, University of California, Santa Barbara

"Gerard O'Neill's Visioneering for the Humanization of Space"

Starting in 1969, Princeton physicist Gerard O'Neill began to imagine different approach to human space exploration. He imagined that what he called the "humanization of space" could provide a safety valve for a crowded, hungry, polluted, and energy-depleted planet. Space, in other words, could be not just a government-run *program* for astronaut elites but a *place* where wider array of citizens could live and work. His ideas were a direct response to the dire warnings of eco-catastrophe such as those presented in *The Limits to Growth*.

Whereas earlier visionaries offered largely descriptive speculations, O'Neill deployed extensive mathematical calculations and careful but bold extrapolations of existing technological trends to develop rigorously detailed plans for space settlements. He continued to refine and improve on his initial designs, taking into account new data he collected and critiques from colleagues which he solicited. O'Neill followed up on this pen-and-paper work by tirelessly promoting his vision to colleagues, interested citizens, politicians, and journalists throughout the 1970s. As a result, O'Neill's program for the humanization of space sparked a small-scale social movement in the wake of the Apollo program as well as his award winning 1977 book *The High Frontier*.

We lack a suitable word to call someone who undertook such a diverse set of future-directed activities. To fill this gap, I propose *visioneer*. This talk presents O'Neill as a "visioneer" -- someone who imagined, designed, and built exploratory technologies. Besides framing O'Neill's work the larger social, economic, political, and environmental concerns of the 1970s, this paper develops "visioneer" as an analytical tool that helps us understand the development and promotion of new technologies along with explaining how various publics respond to them. Finally, it places his activity within broader streams of technological utopianism and the response to perceived planetary limits.

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6. Jacques Arnould, The French Space Agency (CNES), Paris, France

"The first among us. **No future for humanity without space exploration"**
Humanity has never done more to create and fulfil its destiny than by stepping outside the bounds of its houses, fields and countries, by venturing into the unknown. There have been many terrae incognitae, cradles of an ever-evolving humanity: the continents of Africa, Europe, Asia and America settled by our migrant ancestors, boundless territories roamed and created by the cultural imagination and

the spiritual quest, large and small infinities gradually discovered and surveyed by the modern sciences.

These endeavours in exploration have always been and still are distinguished by the fact that they are singular, and perhaps even exceptional: the first among us to cross a border, to reach out for a new horizon, to discover new worlds. Alongside the nomads and conquistadors, artists and mystics, physicists and biologists, today astronomers and astronauts are contributing to the singular adventure of human exploration. In the famous words from Star Trek: for humanity, "space [is] the final frontier".

Like explorers of matter or the mind, space explorers have to uphold and comply with three conditions, namely consciousness, risk and responsibility.

- First and foremost is consciousness, or self-awareness. There can be no exploring, no going outside of ourselves, outside our knowledge and certitudes, without first having a certain awareness of our human identity: our inherent ties to planet Earth, our characteristics and physical and mental abilities, and our intellectual and spiritual aspirations.
- Risk must be assessed and understood according to the most current criteria and references. Technical progress and changing attitudes have had a major effect on apprehension, comprehension and management of risk in our societies. Space exploration cannot go on without asking the question of the risk to be taken by both individuals (the astronauts) and human societies (e.g. the Mars Sample Return). In its own way, space exploration questions the value placed on existence.
- Explorers have a variety of responsibilities to those who stay behind in the known territories. Explorers must be reasonable in how they manage the means they are granted. They must take care to protect the health and safety of their fellow humankind and to preserve the integrity of their environment. And they must also take seriously the task of reporting their discoveries, of telling the stories.

Taking these conditions seriously, imposing them at every stage of exploration – is this not simply allowing humans to be what they are? Yes, taking space exploration seriously is something that the future of humanity cannot do without.

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7. Cynthia A. Evans, NASA Johnson Space Center

"A Dynamic Earth: 50 Years of Observations from Space"

Observations of the surface of the Earth began more than a half century ago with the earliest space missions. The global geopolitical environment at the beginning of the space age fueled advances in rocketry and human exploration, but also advances in remote sensing. At the same time that space-based Earth Observations were developing, global investments in infrastructure that were initiated after World War II accelerated large projects such as the construction of highways, the expansion of cities and suburbs, the damming of rivers, and the growth of big agriculture. These developments have transformed the Earth's surface at unprecedented rates.

Today, we have a remarkable library of 50 years of observations of the Earth taken by satellite-based sensors and astronauts, and these images and observations provide insight into the workings of the Earth as a system. In addition, these observations record the footprints of human activities around the world, and illustrate how our activities contribute to the changing face of the Earth. Starting with the iconic “Blue Marble” image of the whole Earth taken by Apollo astronauts, we will review a timeline of observations of our planet as viewed from space.

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8. Emeline Paat-Dahlstrom, VP, Operations, Singularity University

“Private Spaceflight: The New Era of Exploration”

Traditionally, government space programs have been directed through policy and politics, and indirectly through public support. Advances in technologies and policies have begun to open up space activities to public involvement and participation. Greater public participation can potentially access economic resources far greater than government space budgets. The dream of space tourism has been pursued for decades, and the driving force has been individual entrepreneurs and investors following their vision. For more than 10 years, orbital tourism has been demonstrated through Soyuz flights to the ISS. After long development, suborbital tourism close to reality. We are experiencing a transformation in space activities, and a broader experience of spaceflight. Private spaceships are being built for transportation, orbital stations, robotic lunar landers, asteroid surveys, and potentially piloted lunar missions. At the same time, rapidly advancing technologies are enabling a new generation of do-it-yourself entrepreneurs to further broaden private activities in space.

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9. Leslie Gertsch
Sr. Research Investigator and Deputy Director, Rock Mechanics & Explosives Research Center, Missouri S&T

“Developing Space Resources”

The knowledge and expertise of the aerospace, mining, and manufacturing industries must be combined to enable a permanent and sustainable escape from the resource limitations of a single planet. While aerospace and manufacturing, and mining and manufacturing, have developed long-term ties with each other, the aerospace and mining industries do not know each other well. That must be remedied if space resources are to be developed effectively.

Mineral deposits form wherever natural processes have concentrated a mineral. A mineral deposit becomes an orebody when it can be extracted at a net benefit. Mines are designed to extract valued minerals from orebodies in the most efficient manner possible, given the state of geologic, technological, and economic knowledge at the time. Advances in any of these three areas may change the optimum configuration of a mine, yet mines can continue to function as long as the fundamental equation of business is satisfied: Total Benefit is greater than Total Cost.

These are core concepts of mining engineering, and do not change if the mineral deposit is located on the Moon, Mars, an asteroid, a comet, or any other place in the universe. What do change are the terms of the equation. Total Benefit is controlled most by the demand for the mineral commodity, which is difficult to forecast for the long lead times required to develop space resources. In addition, the market may not be wholly terrestrial. Total Cost, on the other hand, is controlled most by the properties of the mineral deposit. This is where the differences between terrestrial and non-terrestrial locations show most clearly.

Space resource development is just beginning at the present time, starting from the current state of the aerospace, mineral production, and manufacturing industries. Yet all industries have the equation of business in common. In addition, aerospace and mining have complementary strengths. Thoughtful hybridization must be exploited to allow humanity to spread beyond its current limitations. The consequences – economic, technological, and sociological – will be profound.