"Unboxing" Science and Exploration as
We Move off the Planet

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INTRODUCTION

Thank you. I am deeply honored and humbled to be with you today. The subject is truly overwhelming: Science and Exploration. I, of course, checked Google to note 908 million results for "science." For exploration, I only found 88.6 million results. Together that is almost a billion sources. That is a difficult number to grasp. I am sure that some of those articles were undoubtedly written by some of you. I am equally certain that there is not one person in this room who does not know more about science and exploration than I do. But that will not stop me. Nor did it stop Joachim from inviting me.

I could probably tell you everything I know about science in a moment or two, but I do know and care about space, simulation supporting space science and exploration. I care especially about the need for us all to constantly expand our network--as we will be doing here-- and our information resources so that we can all advance both the credibility and visibility of the work we all do—and so that we can move off the planet.

BAD IDEAS FLOURISH

Have you noticed -- and I am sure you have -- that bad ideas seem to proliferate. They grow and grow. We see it everywhere. We shake our heads and wonder, "What were they thinking?" Bad policies, bad designs and poor quality abound. How come those people with such bad ideas seem to sell them? And why is it so hard to get our own so-much-better- ideas accepted? I have a fat folder of wonderful ignored or rejected projects. Mostly ignored, I call them Future Improvement Projects or FIP. They do not get turned down so much as wither away. Like the world according to T.S. Eliot, they expire "not with a bang but a whimper."

I am sometimes able to dust one off, add a new date and cover and--miraculously-- it gets accepted. Is it timing, the environment, luck or something else?

Can we find a way to pose new questions or do something that makes the abyss between proposal for a good idea and its acceptance into a manageable gap? Can we, for example, move exploration and science more to the center of our life and times?

What works? Good stories work. They resonate. That *is* science. I will get to that later. Years ago a colleague in DC years said to me "Rumors work. Tell someone a rumor and they never forget it." He suggested that we call rules rumors if we want people to remember them.

RUMOR: WE WILL MOVE OFF THE PLANET THIS CENTURY

Well, I have a rumor for you. **We are going to move off the planet in the twenty-first century**. Pass it on.

Will that work? Why do rumors stick? In part, because they pose questions and open our minds to new situations which we can expand with our own experience. Some say they express and gratify "the emotional needs of the community." as "sense making" statements, aimed at collective problem solving. Others define rumor as a kind of persuasive message involving a proposition that lacks 'secure standards of evidence. There is a communal or collective theme here. Rumors ride on uncertainty and rapid diffusion of information, often oral. Remember the childhood game of "telephone"? We laughed at how the message changed as it passed from person to person and often became meaningless. Listeners *lose, select* or *distort* the details. This puts the ball in our court.

Rumors may resonate, but they lack structure. We can turn rumors into stories that by definition—unlike rumors -- do have logic, structure and are not haphazard. Despite our intention, listeners hear a story and make it into their own which is never what the teller told. That is why I remind people that it is the listener's story that counts.

A story builds evidence and makes it meaningful. The unexpected story gets attention. The concrete story has universal appeal. The credible story encourages belief. The emotional story leads to empathy and identity. The story itself leads to action.

I'm going to tell you my story of science and exploration in terms of"unboxing" science and exploration so we can move of the planet. This story is about wicked problems, perception, fragments and resonance and simplicity. But you will –if you are listening—make it into whatever you want. A young colleague told me to have a great opening and close because people would drift off in the middle. Maybe so. We'll see. I will be interested in your story.

DEFINING MOMENTS

In the last Century, we all became explorers. Up until then, rich people explored and—in my family--we read the *National Geographic*. But when we landed on the Moon in 1969, the whole world held its collective breath. Together, we experienced a defining moment of this century, maybe, millennia. For centuries and around the world, people told, wrote and illustrated hundreds and hundreds of stories describing voyages to the Moon. Not one of those stories envisioned that we would be there. No one imagined the technology and planning that allowed us to be witnesses to exploration.

Fred Hoyle had predicted in 1949 that when we could see the Earth from Space it would change everything. And, of course, it has. Snapped by an astronaut returning from what turned out to be the last Apollo mission to the moon, that picture—the Blue Marble-- hangs in 3rd grade classroom around the world. It has sold every product imaginable (no return to NASA) Imagine if we had gotten a penny for every time that picture appears on television, in movies, o on a calendar, a postcard, the Internet, in print… we could have explored Mars and beyond on a pay-as-you-go basis.

Getting to know our solar system, seeing the invisible universe, seeing evidence of the Big Bang, comprehending Quasars and -getting a sense of the Universe. —are just a few of the defining moments of the last century—thanks to science and exploration?

NOT ON THE POLITICAL LANDSCAPE

Despite what I would regard as amazing events and adventures, it is noteworthy that Space exploration is not on the political landscape. I did not see it in European

newspapers and news programs. It is not a big topic on the US presidential campaign trail One candidate did say all the right things--from our perspective-- when he addressed a meeting in Titusville, right across the Indian River from the Vehicle Assembly Building. But it got no play in the media beyond Orlando.

The last time, a State of the Union address, a big event in America, mentioned space was when, by chance, a phase of mine went up through channels and made it to a George Herbert Walker Bush State of the Union Address. I could hardly believe it when I heard it-- "We will go back to the Moon--to stay." To stay. Alas, no funding followed and, you can see 20 some years later where we are. Space does get moderate support. About two thirds of the US public approves the Space program. The numbers rarely vary and, today, translate to little more than half a cent on each tax dollar, $.0058.

In what seems like another life, I was a student of Restoration dramatic literature and a major theme throughout that era was the impact of the "New Science, that as John Donne, said, "Put all in doubt." Although humans were no longer at the center of things with the knowledge that the Earth revolved around the sun; the idea of the sun being at the center of the known universe, as it they understood it, was on everyone's mind. The literature is full of it—broadsides, poems, essays, plays and sermons. The "New Science" was the talk of the town, the talk of the new and popular coffee houses.

Not so today. Despite all that science and exploration add to our treasure and lives, they remain on the periphery. Moving them to the center should be on our minds.

CHALLENGING CHALLENGE

Imagine people sitting around Starbucks talking about science and exploration. Not an easy sell, space science and exploration are challenging challenges. I was reminded recently that typical—distant-- extraterrestrial space is more unfriendly that our little piece of the universe which a former astronaut reminded me " is odd but not so strange as it used to be. "

Typical space, distant extraterrestrial space, is strange. It is an incredibly dark and cold and distant vacuum. There is admittedly a lot of real estate with minerals and resources that we would find useful—especially if we solved problems like fusion. Too many people outside the space program remain unenthusiastic and say that it looks pretty bleak. We must admit that without terraforming technology it lacks trees or flowers or streams or blue skies.

TOO MUCH FOR MERE MORTALS

The numbers in science and exploration are also simply too much for mere mortals. I try to wrap my mind around the concept of multiverses, billions of universes. I grew up in New Jersey where someone told of meeting Einstein and asking him about multiple universes." "What is between them?" he asked

Einstein, I'm told, stood silent and finally said," I do not know. I will get back to you." But he never did.

It is difficult to identify with Carl Sagan's "billions and billions of stars." And, of course, it dismays almost everyone when they attempt to understand the cost of exploration and science in terms of billions and billions of dollars, Euros, pounds and yen. We need to relate things to a human scale.

Instead of speaking in terms of millions of dollars and lives, health organizations, for example, speak of saving one child at a time from deadly dehydration with Oral Rehabilitation Therapy (ORT) made of one half teaspoon of salt, a teaspoon of baking soda, 8 teaspoons of sugar and a liter of water. We can "get" that.

When managing the KSC Commercial Development of Space program I divided the total program budget by the number of taxpayers to find that it cost each taxpayer a dime. At community and professional meetings, I would spill out a bag of dimes and tell the audience that I would give them back their dimes if, when I finished, they thought the program was not worth it.

No one ever asked for one dime. In fact, a friend at NASA Headquarters in Washington DC called me one day to ask, "Elfrey, what are you doing? Someone just called me and asked where he could send his dimes." Human scale. We need more of that.

A HARD SELL

No matter what we do-- it is a hard sell. I was recently watching the television news show, *60 Minutes* where the reporter kept asking about the payoff for building the Supercollider. He could not relate its 9 billion dollar cost to a comparable return on the investment. Forget search for truth or building blocks of the universe. The interviewee suggested teleportation could be in the future and that connection with Star Trek satisfied.

Entertainment is a start. But even George Lucas, Steven Spielberg, Tom Hanks, Carl Sagan and Gene Roddenberry have been able to do but so much.

I have wondered about pinning my hopes on Will Waite whose post *SimCity* game, *Spore,* offers people the chance to build (and destroy) their own planet in almost no time. Waite suggests that the real science timeline is another number that is simply too difficult to grasp. He suggests that toys and games—by design—are more human scale.

Freeman Dyson also points to toys. He suggests a do-it yourself biotech robot toy, reminding us that computer as well as simulation success started with toys. In Philadelphia in the late nineteenth century, my great-great grandfather, William Redfearn invented and patented a simulator called the Dry Land Swimming Machine. As its name implies, people learned to swim in it, practiced different strokes and then did them in the pool. It was fun. It worked.

The Link Simulator, the Blue Box, which trained over 50,000 pilots in World War II only survived economically, at first, as carnival entertainment. Later, according, to historians at Navair, it was a toy for those who could afford $200 for 90 minutes with the promise of learning to fly.

But Dyson's idea of biotech creatures that we can make ourselves from kits raises all sorts of images and questions. He suggests that we send such toys out to populate the Universe because they could be designed to do what would be hazardous to our health—since humans are too fragile and short-lived for Space exploration. These toys could travel from place to place over daunting distances and remain "alive" in the cold dark hostile vacuum of space. Dyson sees humans moving out with their created species, toys, to see if life is out there, perhaps to find it. If not, we would bring these new species of biotech creatures with us. This might be one resolution of the Fermi paradox and provide an affirmative (if worrisome) answer to that question: "Where is everybody?"

BEYOND TECHNOLOGY

When will all this happen? We use the term, “multi-decadal.” In 20 years, 30? Moving off the planet will, perhaps, take longer. Everything does. This grand adventure, “Moving off the planet” will be a defining moment for this century. It poses “wicked” simulation challenges that are familiar to all of you engaged in multi-decadal massively complex enterprises. Testing is not an option. The knowledge gaps are painful. Simulation is often the sole solution. Difficult, hazardous long-term projects have a persistent need for simulation from the first insight into a possibly workable idea until the final report—perhaps a lifetime or 2 later—is put in the archive.

Like you, perhaps, we create simulation in small pockets. People work in cold cramped simulation laboratories, in modest cubicles or in a small cluster of a handful of workers. These groups communicate infrequently, if at all, with others doing similar work. Often we struggle with “wicked” problems, aware, perhaps, that others down the hall, across the city or ocean may have a useful clue. That is what outreach like this is about: increasing networks of diverse and expert colleagues-- like you, reliable information resources and promoting the credibility and visibility of the work. It matters because success depends on more than technology.

MODELS LIE

Simulation builds on models: simplifications of our perception of reality based on our selection and abstraction of entities... Everyone, everywhere, bases decisions on models. John Sterman, an MIT systems scientist asserts, “Models are lies” saying we ”cannot validate any model in terms of truthfulness,” The paradox is asking people to bet on a tool that uses illusion to make something seem more real. Sometimes, we ask people to bet their lives on these illusions.

Models are inevitably simplifications, incomplete and therefore, in some way, incorrect. All models, all representations, simplify reality and hopefully leave nothing out that is of consequence, nothing that will impact the outcome in any appreciable way. No guarantee exists and not worrying about that would be foolish.

We do not, however, need “high fidelity” models all the time, of course. We do not need them in the early stages when we are framing our idea, discovering its major elements, looking at structure and logic and enumerating entities before we develop requirements. We could use easy, cheap and quick models, perhaps open source, to promote more common utility and use. We are testing some models. They often disappoint us. We would like a repository of low and medium resolution space-related models that would help us transform a wisp of an idea, a rumor, into a “throw-away” simulation that others could see and grasp.

Sometimes, of course, we need models of incredible accuracy. For that, Sterman urges us help one another develop critical thinking skills and confidence—the courage--to challenge the models. He asks us to help one another to uncover their biases, find the flaws in the models and work together for improvement.

WICKED PROBLEMS

Traditional problem solving states that identifying the problem is halfway to solving it. This is not the experience of far-flung teams working on disjointed elements of very large systems. We face “wicked” problems that are ill defined, complex and, serious. Rittel and Webber in *Dilemmas in a General Theory of Planning* stated, “Planning problems

are inherently ‘wicked’. They cannot be definitively described, defined or solved, are essentially unique and, always, consequential. That idea resonates with our experience.

Every effort to solve a “wicked” problem has cost, impact, and, often, penalty. We make a short-term fix and find that it made needed structural change more difficult and more expensive. Solving one “wicked” problem may create other, different and more difficult problems.

Even apparent similarities can be deceiving. Many said, moving off the planet seems to be like going to the Moon during the Apollo era. But, it is not. The technologies, teams, systems and subsystems are different. Direct transfer of any past solutions might prove useless, even, and harmful. With “wicked problems the aim “is not Truth but improvement. We like answers so “improvement” is a difficult idea for us professional problem solvers to accept. It may be the best we can do.

PERCEPTION

“We see the world as we are not as it is.” The Talmud is among the first teachings to note the power of perception. We see the world “as we are.”

Our worldviews, knowledge, skills, experience, biases, health--even how we feel on a given day--determine the choices we make, even, how we select ideas for research or development and the methods we follow. These factors frame the variables we consider. They can obscure experiences and ideas that might alter findings and make us change our minds.

The common attribution error which says we pay too much attention to the personal and too little to the situational is but another warning. Daniel Goleman notes that this problem is compounded because so much that we are aware of happens outside our awareness. The study of the match between the mind and the environment is in its infancy. The environment includes our surroundings but is not limited to multi-disciplinary, multi-lingual, and multi-national factors. Being open to the knowledge and insights of others is necessary. ==

This suggests that we need to ask hard questions about the suitability of the model to the stated purpose. We must as Sterman says, look for faulty data, be aware of biases and prejudices, critical assumptions, pay attention to those who need the model, “but be decisive & take personal responsibility.” That is a lot to ask of mere mortals—even rocket scientists. These factors will come into play more and more as dispersed teams work here and there across the universe. If we cannot see the world as it is—the world we know—what will we do on other worlds?

INTEGRATION OF COMPLEXITY

A central challenge of massive complexity is getting all those pieces to work effectively together. A system or project is not complex because it is large or intricate or has many entities. Integration of all those elements makes it complex, as does the uncertainty of the outcome. The aggregation of the parts will produce something different from what anyone can determine ahead of time. And any change can change everything.

No one can guarantee outcomes. I worked on Spacelab for 10 years and can affirm that interconnected parts may--and often do-- interact in unanticipated ways. Anticipating all possible unforeseen consequences is impossible, unnerving and exhausting.

Complexity rules but optimal simplicity is our goal. Like you, I am too busy and am ever grateful to George Miller, emeritus Princeton professor whose 7+/-2 finding makes my daily life easier. His research indicated this was the limit of short-term memory. He recommended, “chunking data together" into blocks of 3 and 4 suggesting why US telephone numbers with a 3 number exchange followed by 4 numbers is easier to remember than a our credit card numbers. Later research suggests that people cannot remember 7 items anymore. Is it a matter of too much information or too little attention?

We know that fewer parts make easier assembly with less opportunity for failure and could keep some complexity in check, reduce waste, rework and training time as well as prevent unwanted and costly changes Sometimes complexity is the best we can currently, cautiously, achieve. We need to be easy on one another and ourselves. We are, however. reminded daily by The Columbia Accident Investigation Board (CAIB) finding that “unanticipated interactions can occur that can lead to catastrophic outcomes."

PERSISTNT HIGHLY DISPERSED TEMS

Large complex systems require persistent dependence on highly dispersed teams. Increasingly multidisciplinary, multinational, they must share a common vision and operate over decades as teams, technology and missions change.

Many European, Japanese and US studies convincingly affirm that multi-disciplinary teams planning intensively from the beginning of a project show promise for innovation and success in risky businesses—as much as 30% reduction in unplanned and costly changes. Few have seized this leadership opportunity. And, most books on the subject assume a choice between being virtual or working face-to-face. It is not so simple. Space science and exploration will mean that some teams, especially those 34 million miles apart, can only connect virtually. Face-to-face is preferable, but it is important to face the difficulties and start from there.

Interactivity is no job for amateurs. It requires skill in the little known practice of persistent, unending, give and take.

SHARED STORY

If we are to take on a “wicked” problem; we need to know *why*, to see the value of the story and understand our roles. When we move off the planet, we will in time be residents. This is a truly awesome idea. The changes that will follow are incalculable.

To achieve such a shared model we must start the correct story correctly and keep it up-to-date and on target. That is easy to say but not so easy to do. It matters because teams lacking a shared vision or model lose focus and may lose sight of their mission and goals.

In reviewing mishap studies, I find that technology is rarely the culprit-- that teams without a shared model face a likelihood of failure. A shared vision, resonates, energizes and drives collaboration When such the story works, over time, no one remembers where it began or with whom. That is all right because; the listener’s story is what matters. What really matters is what the listener does. It takes discipline, skill and effort to create a story that is so clear, so sound intellectually and emotionally that new people can carry out the mission for years and years telling, retelling with less and less attribution and acting on it as their own. A shared vision is critical to a sporting victory, a successful opening night in the theater, a political campaign or a commercial technology

break-through just as it is to the grand adventure of space exploration. It, too, is no job for amateurs.

TOO IMPORTANT FOR SCIENTISTS AND ENGINEERS

I always say lightly—but not really jokingly—that Space s too important to leave to scientists and engineers. It just is. Diversity is just healthier.

Many believe that Jimmy Carter's failure to win a second term as President was because his circle of advisors was too small and parochial. The news commentator, Walter Cronkite said, "Good ideas could not get in."

Buckminster Fuller told the story of a conference where an antropologist gave a presentation on tribes that went extinct. At the same conference a botanist told of plants going extinct. Neither knew the other or the other's work. Both said that over-specialization led to death. Darwin, remember, attributed survival not to the fittest or the strongest but to the most adaptive.

When I have advanced the idea of building on different points of view, different skills and experience, heads do nod affirmatively. When I suggest that multidisciplinary teams working intensively at the beginning of projects have records of success. They also nod their heads but I see little action.

In the same spirit, we have, probably like you, a policy of supporting education in science, technology, engineering, and mathematics, the STEM disciplines. Considering both how the disciplines are breaking down as well as the need increasingly lifelike simulation—this seems very last century to me. My opinion is that, adding attention to visualization and other sensory input as well as, story and ethics—means we need the arts—liberal, fine, applied, even performing-- to create STEAM.

WORLD DIVIDED IN TWO

We have an old and not terribly funny joke that the world is divided in two between those who believe the world is divided in two and those who do not. That joke reflects much that divides us: conservative vs. liberal, PC vs. Mac, print vs. digital media, reason vs. emotion, art vs. technology. The art vs. technology schism goes back to the Greeks. It favors analytic, skeptical and risk-aversive thinking while under valuing the intuitive, speculative and creative. It need not be either or. It can be both art and technology.

As associate dean of Yale College, I directed career advising and post-graduate plans and action. Anxious students asked if their Yale experience related to work. Of course it did. They learned to find the light switch in the dark, to work with information of dubious and unproven origin, address complex, even, wicked, problems, excel at oral and written communication and computation, analyze, synthesize and produce lots of high quality work on tight deadlines and also work well with others. Despite these commonalities with the work we do and our need for innovative thinking, an abyss remains.

A chief scientist at a major corporation who has repeatedly thanked me for my ideas on the story—its structure and logic—in simulation balked at this notion. He told me that talk of a multidisciplinary team made the hairs stand up on his neck. He could not see any value. It is back to the drawing board for me. I know commonalities exist that would narrow the gap. It is a challenge. You may agree with my friend, but remember that some define a scientist as someone who looks at what everyone else looks at and sees

something different. We call this insight, intuition or creativity. It is the essence of simulation. It is the mark of the scientist, and also the entrepreneur, the innovator -- and the artist.

FRAGMENTS

Although our days and work seem so fragmentary as to call for consolidation --although simulation itself has endless application and potential --I advocate for more fragments.

Recently in Orland, I asked people representing NASA, ESA and 2 corporations to speak on simulation issues and solutions for large complex systems. This was a new focus. The answers were cogent and interesting. They also reminded me of the story of the elephant and the blind men who each, depending on their experience, think the elephant is a pillar, a wall, a hose, a rope or a plowshare. Some say this is a story about half-truths. Others say it shows the truth can be stated in many ways. All, I know is that we need more fragments of this story—more experiences and applications-- if we are to see the elephant

Much remains to be done. Although every conference I attend is extremely valuable, I miss many. I could write a paper a week but would shortly have no time to develop content. I belong to SISO, SCS, and Liophant, have attended I/ITSE, ITEC and am LinkedIn. Last month in the US, we had at least 2 simulation conferences—in Virginia and in Florida. The timing hurt both. At the same time, I was the absentee program chair of a highly successful conference in southern Italy. It went off splendidly without me thanks to my wonderful Calabrian co-chair who did all the work.

I am concerned that we develop a cohesive, self-energizing professional society, an organization that seriously addresses how we meet, greet and work together, mandates a code of ethics since we make our living making stuff that is not real, promotes a recognized body of knowledge, international certification, educates sponsors, and assembles clear education and research tracks. This includes, hopefully, a proposed international master's degree in simulation for large systems and logistics and other efforts to increase our networks, information resources and the credibility and visibility of the work. Considering our professions, maybe we should model the simulation community and see if we cannot leverage our efforts and, as we say, "get more bang for the buck,"

A LONG AND BUMPY RIDE

Much remains to be done. We recognize important knowledge and technology gaps. We have enumerated, I am sure like you, hundreds of entities and processes. We have captured collaborative team activities sorting them into sharing data, using time well, tracking and storing the work accessibly and safely. Recently, a colleague said he had been asked to store our data for 1000 years. We know it matters for we have almost no data on the Apollo program and we see, as no generation before us, how quickly data is outdated and even inaccessible. We know we need interoperability of data, simulation, hardware (including robots) and humans. We have built on game technology to create a Distributed Observer Network (DON) that links our NASA simulation teams across the country. My office is working on a proposed study group in interoperability and standards for game technology applied to simulation (including avatars, GPS and telemetry). Our engineers, like you, want new faster than the speed of light and easier tools. We want optimum simplicity, exemplifying A.J. Clarke's third rule about mature technology being indistinguishable from magic.

Teams working on massively complex projects handle thousands of entities: things, sketches, models, hardware, wires, tools and equipment. Such entity-based simulation is not yet a high-volume application. Daunting? Cryogenics had little market before the Space program proved its value. Airplanes were considered toys for the rich and television languished for over 20 years. The manufacturer was reluctant to make cordless tools for the Moon seeing no market for them. Simulation that is entity-based may be but another challenge for our imagination.

CELEBRATE

The grand challenges are just beginning—will never be finished-- and will require innovation as never before as well as untold stamina and flexibility. We did an innovative project to depict Discrete Event Simulation data working with two interns. .It was so successful that a contractor hired one of them. The results resonated to the extent we are developing a use case and plan to tell the story in San Diego in the Spring.

I have mentioned *resonance* several times; so let me tell you a story about resonance and Michael Pupin. He learned lessons as boy herding sheep in Serbia that contributed to his fame as the scientist for whom the physics and astronomy building at Columbia University would be named. He invented the loading coil that made long distance telephone calls possible before the invention of the vacuum tube.

To communicate with one another during the night, Serbian shepherd boys would drive identical knives into the ground. By striking the handle, they sent messages to their distant friends, put their ears to the "receiving knives heard the taps of 'transmitting' knives. Those identical knives were in resonance with vibrations from one causing the other to move in sympathy creating energy waves that produced maximum result across many miles. Pupin also heard bagpipers adjust their instruments until they were in sympathy with the notes produced by the others. When Pupin adjusted electrical circuits to respond to incoming waves, remembering those bagpipes, he used the word "*tuning"* to describe the process. To this day, we "tune" receivers to resonate with specific transmitters.

We know that if a disturbing force is tuned to it, we can stimulate anything in the physical world to an excessive response. Crystal glasses break, bridges fall down and windows rattle. In the physical world, resonance, sympathetic vibration, is the way to get maximum transfer of energy.

In the world of the mind, including the world of simulation, resonance is the way to get a maximum transfer of idea content. This requires arrangement of elements that create stories, lessons or games and toys that resonate with the "receivers." Sensory and concrete detail makes resonance more likely. To understand what the story is and how best to tell it is the challenge for turning rumors into stories and simulations that resonate.

At this conference on exploration and science, I am happy to honor you as you deal with the pressures and frustrations of unending wicked problems. Since no one ever gets too much applause, I want to recognize you respecting these daunting multi-decadal timelines and unforgiving environment so the world can--in time-- enjoy the results of these endeavors in science and exploration--including moving off the planet.

Not everyone who is here to day will experience the defining moments we seek. A meeting like this is not only an opportunity to build your network and information resources but also, to keep the rumors alive and well. Look around to see who is here

now, celebrate your good work **a**nd, when the great adventures take place -- drink a toast to friends who are here now but not there then but who would be if they could. Thank you. You have been a wonderful audience--now, let's go exploring.

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