

Lunar ~~Exploration~~ Development

2016 February 6

Good morning everyone and thank you for the kind invitation to speak at this Queen's Space Conference. In my presentation I will tell you **why** we are going to live on the Moon and **how** we are going to make it happen. Let me begin.

"Be adventurous," I told myself. "Try something new," I said. I did. It hurt. I'll explain. I tried starting a conversation with a total stranger with something like "We should go live on the Moon"? How about telling an accountant that you are collecting funds to build a house on the Moon? Yes, these can be great conversation enders and career limiters. But why? Why are people so adverse to technology and the future? Why is it still funny to laugh at the geeks who walk around haphazardly while peering through Coke bottle sized glasses at a piece of paper with illegible script that would make a doctor proud! Perhaps the average person thinks that space shouldn't be done and they react this way to be safe. But I am an adventurous person so, while safely behind my thick glasses, I have started conversations like this. And they hurt.

Has anyone ever led a conversation like this? Show hands. No. Well then what stops you? Perhaps you expect the same response? But good conversations do happen. For example, I've been to countless conferences, seminars and meetings where **like-minded** individuals sagely nod their heads around the table and say that we should travel in space; it will happen soon. Everyone agrees. Then all turn around to head safely back to their tiny non-descript office in the bowels of some concrete tower and bemoan the lack of progress and the lack of direction. Perhaps this gives a clue as to what stops us from making a future in space. From some percepts, our progress looks more like a snail in first gear than a cheetah on steroids. And which would you rather have?

Let's go back to this average person. Maybe it's that they still think of space travel as the realm of science fiction rather than science fact. They'll happily sit enjoying some Lucas space opera; watch as humanity's existence gets saved by a last moment heroic press of a button. Sadly, they're oblivious to nearby worlds. Here're Pluto, Europa and Io. Aren't these simply awe inspiring. While this person, this average person may not know of these nearby worlds, I know that they hold the key to our species travelling in space. So, we need to engage them and talking is the way to do so.

Can you imagine a conversation with someone on living on the Moon? There's the obvious; it's cold, really cold. There's also crazy long days and long nights. And there's nothing really happening there. No wind, no water, no motion, no noise. With so little to offer, we will need to bring a complete ecosystem with us in order to live. Maybe it appears so impossible that the average person has a knee-jerk reaction. But remember astronauts have walked upon the Moon's surface over 40 years ago. And today we have a laboratory that's in space orbiting the Earth. It's been permanently

occupied for over 15 years. These two examples show that humans can deliver, maintain and use habitats in extremely harsh locales. So technically there's no barrier to placing a viable habitat upon the Moon or another world. And biologically there's no barrier to humans living in that habitat. So conversations should be full of possibility of living there. I am not seeing this happen. But I can give you some pointers on what to talk about.

Perhaps you can begin a conversation with a little look back in time. A time when travelling for exploration didn't pose such a problem. I want you to think a little bit earlier than being a youth and taking a tent and sleeping bag to explore Frontenac Park. Think way back to the time of the Greek historian Herodotus. Then, if people wanted to travel to another place they simply walked or acquired a boat, travelled to their destination and began living off of the land. Cool eh. Yet even he noted during his travels that most of the prime landfalls were already occupied so colonization wasn't an option. Consider two more recent travellers. We all know that Christopher Columbus wanted a trade route and talked valiantly until he received a fleet of 3 rickety boats and 90 crew members to go find it. Maybe we can think of him as the epitome of the entrepreneur as he promised that everyone who contributed would receive a windfall from his new sea route to the orient. Could this be like Elon Musk of today promising a trade route to Mars? Another example is Admiral Zheng He the Chinese explorer who travelled great distances over sea in times well before Columbus. He had the solid backing of the Chinese government who supplied the massive fleet and crew. He sailed seven expeditions through the Indian Ocean and beyond. We can think of his adventures as an earlier version of the Apollo Moon missions. These three travels provide two important insights. One is that transporting a human is common place even if the method might be fraught with risk. Two is that humans are everywhere on Earth so that finding a fresh place to live off the land is extremely unlikely. Like some aggressive bacteria spreading over an unwashed dinner plate, humans have travelled and spread their abodes across this jam-packed Earth. We've come a long way and that is a good starting point for a conversation.

Now most conversations about projects will at one time or another turn to the subject of cost so let's look at it. What's a lunar habitat going to cost? No one's built one so no one really knows though literature provides many estimates. I want to use the International Space Station (ISS) as a relevant corollary. Its build cost is about 150B<sup>1</sup> \$US to date. More components are wanted! So consider it to be a work in progress. Wonderfully, it's been occupied non-stop since 2000 but that occupation also comes at a cost. What is this cost? Consider that its inhabitants have needs; air, food, water, guitars, Youtube access. For these, 8 supply vessels a year deliver about 30000 kilograms. A contract for this costs \$1.4B<sup>2</sup> annually. That is, for the space station, there has been substantial initial cost, \$150B, to emplace the infrastructure and then some appreciable carrying costs, \$1.4B annually. The ISS is good as a corollary but it isn't perfect. It still orbits

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<sup>1</sup> According to Wikipedia in 2010 \$US

<sup>2</sup> (8flights times \$175M per flight)

within the protection of Earth's atmosphere. And it's nearby; we can travel to it from the Earth's surface in less than 6 hours. Nevertheless, let's use it and apply a reasonable scaling factor of 10 for a similar habitat upon the Moon. This equates to an initial cost of 1.5T \$US and a carrying cost of 14B \$US annually to emplace and maintain our habitat on the Moon. I think you can agree with me that this cost is pretty fun to talk about but it also underlines the single greatest challenge; getting the funds to pay for a lunar habitat.

So think about building on your conversation about costs. Let's find comparisons. One of the most expensive private projects to date is the Ichthys liquid natural gas project off the coast of Australia. Its development cost is likely more than 40B \$ once finished. Initial funds were raised by a public share offering. That is, people believed that the project would be a good investment because it is to extract and deliver energy resources. And to lower the risk, the extract is already sold. That's a darn nice project. In the public domain, things are similarly large scale. Some claim that the most expensive singular public project is one we've already looked at, the International Space Station<sup>3</sup>. But did you know that the interstate highway system in the United States cost about [\\$425B](#) in CY funds, nearly three times more! And it requires about \$25B ever year to maintain it. For those who drive down to Florida in the winter, it's a marvel! Some claim that it resulted from Eisenhower seeing the European road systems at the end of the Second World War and this drove him to personally see to the projects inception. In any case, we see two main avenues for funding; one as a financial investment strategy and the other as a civic betterment issue; an infrastructure investment strategy. See how funding can expand your conversation!

But, I want you to expand even further and talk about projects. Let's start by answering the question, "What is a project?" There are two main characteristics for a project. One is the requirement for a definable undertaking. That is, a project must know exactly what it wants and it must be achievable. For instance, creating a project for world peace would not fit. Two is that the project must have an end-state. Trying to find the last digit of Pi would not be a project. With these two characteristics, then project work can be costed and allocated (contracted out). For example, the London Olympics infrastructure project of £9.3B was a definable undertaking and had an end state; all venues ready for competition. Creating a lunar habitat via a project and using standard project management tools enables us to emplacing a lunar habitat. Your conversation can advertise this practicality.

If you want to have a bit more fun in talking, you can try to drill down these two characteristics. Defining the undertaking is probably pretty simple. We want a habitat on the Moon where humans can safely live; working and enjoying life. More on this later. But what is its end state? Is it just making and delivering the structure? Does it include transporting occupants to and from the Earth and the Moon? Does it enable some people to live their indefinitely? I say it is when people live there in a **self-sufficient** state. Consider self-sufficiency. It is a survival condition. For survival's

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<sup>3</sup> Though given changes to valuation, others may be more such as the US interstate

sake, the people on the Moon must be able to maintain their air supply, have continual access to potable water and have a source of nutritious food. Without these they must either return to Earth or perish. Self-sufficiency also addresses another concern. Imagine if people on the Moon relied upon Earth funds for supplies. Should the people of Earth become unhappy with this arrangement then they stop funding the supplies. The people on the Moon would have to return to Earth and their lunar facility would be empty and thus not fulfill its objective. To avoid this, the people on the Moon must generate enough revenue to pay for essential supplies and possibly for the carrying costs of any outstanding money borrowed to replace the infrastructure. From this we can argue in our conversations that self-sufficiency is a necessary end state for a lunar habitat.

So we have ourselves a project. And we see that our lunar habitat cost is greater than most other projects so far undertaken. Let's do one more calculation to put our lunar into a mode for proper conversation. Compare our cost to the global Gross Domestic Product. Assume that the infrastructure build-out and emplacement was to occur all in one year. Then its cost would represent 2% of the 77 Trillion dollar global GDP effort. Do you think that this is a lot? That is, 2% of every person's work, like yours, and every corporation's work, like Invista Canada here in Kingston, would be directed to a lunar habitat. How likely do you think we'd obtain 2% of one year's productivity of everything for this one project?! And don't forget the carrying costs on top. For it every person would have to shell out annually just to maintain the habitat; like the US does for the interstate. This part of any conversation might be a little more challenging but hang in there. I've got solutions for you.

Now that we have a good grasp upon the expected cost, let's return to talking of the ways and means of funding sources. Can we expect people to invest as with Ichthy's project? Imagine a lunar habitat as an investment. The mechanics are simple; people invest their disposable income into this project in the expectation of seeing a profitable return sometime later, not like my Canadian stocks today. The fundamental problem with this is the lack of direct return to any investor. What would provide a return? Well the Moon is made of atoms and minerals that we find on Earth. So is every other solid body orbiting in our solar system according to standard theory on the creation of our universe. So resource extraction is an unlikely revenue generator. The Moon could be a source of energy which can be delivered to and sold on Earth. But solar collectors on Earth would likely be a whole lot less expensive. So I expect that anything on the Moon would not be of interest to an investor; especially with most North American investors typical expecting a return within the first year if not sooner. This makes talking about investing in a lunar habitat challenging; don't you agree?

Now imagine this effort as being publicly funded as like Admiral He. In effect, governments allocate a portion of their tax base to funding a lunar habitat. Well, first consider that the most progressive type of government is the representative democracy. That is, the individual tax payer indicates, through voting, which person and political party will represent

them. Now guess. How many votes would a political party gain by saying that they will spend a huge amount of tax dollars upon a lunar colony? If you guess less than a few votes then you guessed the same as me. Why? To answer, simply look from the perspective of the average person. They have a road that needs improving, health care that needs upgrading, schools that need supplies and a myriad of other concerns. So, even while voters don't necessarily make a direct choice between civic improvements and a lunar habitat, that is what a representative government must do. And this is what eventually happened with the Apollo missions. Therefore, with the average person simply interested in watching science fiction opera then a real habitat lunar habitat that needs \$1.5T, we're going to have a challenging time talking about public funds.

So, we've run out of ways of funding. I say not so fast. We have one more we can talk about. First I'll give you a reference. After this presentation I want you to go out and learn of a gentleman by the name of E.O. Wilson<sup>4</sup> (Edward). Is he an astronaut? No. Is he a rocket scientist? No. Rather, he is a bug-guy. A bug-guy you say! What's that got to do with travelling in space you ask. Bugs aren't supposed to be in the space vehicles that's why we sterilize spacecraft! Let's not digress. Edward Wilson has spent a very long career devoted to the study of little bugs; mostly ants. Now you may not think much of ants but they are actually quite incredible. For one, they live in communities. Their communities can number into the millions, a bit like humans. These communities of millions are cohesive; the residents live and work together; again a bit like us. For another, they are incredibly capable technicians. See the similarities? En masse<sup>5</sup>; they hunt, they farm, they construct dwellings, they build highways and for about 100 million years they have lived almost everywhere that people now live. And perhaps most telling of all, if one were to collect all the ants on Earth, they have about the same volume as all humans. So tread lightly! These social creatures are powerful.

While I could talk about ants for a lot longer; let's move on. The most important take-away is the ant's communal life style. Here's what I mean, and it's best described in a book. One by Edward Wilson. It's entitled Social Conquest of Earth. In it, he considers both individual altruism (freely giving) and communal cohesion (togetherness) as distinct and favourable traits of both ants and humans. He argues in his book that communities go through a form of natural selection as much as individuals. He says that groups with a high degree of altruism are more successful than ones without. That is, group dynamics are as much a factor in the success of a species as the individual; hence his title a social conquest of Earth. In particular, he notes that successful groups, whether of humans or ants, have removed tendencies that reward individuality. Instead they have strengthened tendencies that empower the group. For humans we see this as universal suffrage, freely available education at least up to universities, and health care. Given that altruism is such a strong element of successful groups and that I consider our group of first world countries to be one of the most

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<sup>4</sup> The Social conquest of Earth

<sup>5</sup> build towering nests that incorporate [air conditioning](#)

successful, then as a space enthusiasts, I know I must learn to capitalize upon altruism and cohesion to get a lunar habitat in place.

Altruism. We've all heard about it. Let's look at it a bit more. How many people here volunteer for something? Perhaps you donate blood. You may tutor younger students. You may reach out to the community to raise funds. Did you know that at Queen's last year your Shinerama campaign raised over \$13 thousand dollars? Yes, altruism builds our society as a group and gives individuals a very warm feeling inside. Look around and you may be surprised at how altruism and the web are progressing community cohesion. For example, the International Red Cross / Red Crescent Movement receives over \$3.6B with a B annually. The Agha Khan Fund for Economic Development gets almost the same. From another perspective, for the year 2014 there was over [\\$260B](#) of donations made in the US alone. And this is just the dollar contribution. According to the World Giving Index a fifth of the people in the world has volunteered, a third has donated to charities and about a half has helped a stranger. These altruistic actors neither ask for receipts nor expect compensation. They enable and ensure the survival of our species; all without a pay cheque. So yes, we are talking about something that is already in place and has been providing wonderful benefit for many years.

With this, we've got some background for good conversations. But can we speed up the talking? I say we can! First, we must change the perspective of scientists and explorers and that doesn't mean cancelling the Big Bang Theory. Instead let's get inspiration from a very successful partnership. Do you know of the collaboration of Dr Wehrner van Braun and Walt Disney's<sup>6</sup>? I think they were as much a part of the success of the Apollo Moon mission as anything. Through theme parks, magazines and movies they presented an immediacy of space to the average person in the United States. They showed that space travel was possible and indeed profitable to everyone. From them, a whole generation got used to the idea of outer space, aliens landing on Earth, people visiting other planets and extreme adventures throughout. Through these two evangelists, the US society came to accept space as a part of their existence. This was no mean feat considering that at their time, airplane flights were still a rare commodity. Yet, through their actions, the Apollo effort continued through three presidents and all the world politics of the 1960s. Yes, those two certainly led the charge for their social group on some heady times. Where are the space evangelists today? Who is championing space fact? Now it's not like space has been neglected. Our mechanical surrogates continue to travel through space and have spent years exploring alien worlds. But, this is not the future imagined by Wehrner and Disney. They envisioned a time when people could casually travel throughout the solar system. We need to re-awaken this spirit and broaden the audience to include everyone on the planet.

Now having conversations is fun but I know that you want to get a bit into the dirt so to speak. To do this, let's put ourselves already on the Moon's surface. Here's a great image from 50 years ago, the first from the Moon Luna 9. There

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<sup>6</sup> [Wernher van Braun and Walt Disney](#)

is a good reason for you being on the Moon. This is to fill the leisure time of people on Earth! Does this sound odd? I say "No". Let's look. As we know, over half the 7 billion people on Earth live in cities. Another phrase for a city is a 'concrete jungle'. This concrete jungle has been prescribed to permit as many people to do work. People must make their leisure on their own. Most city dwellers don't have access to a real jungle or indeed any nature at all. Instead, many resort to leisure in front of electronic media. For example, in the United States an average person will watch over 5 hours of video every day. Is it possible that people will get bored with video? I say, "yes"; Fast and Furious can have only so many franchises. But, the Moon can counter this boredom. Use it as inspiration for video. Imagine, the many decades of emplacing infrastructure on the Moon. We'd witness trials and tribulations as we push the limits of our capabilities. Capturing this on video would allow everyone on Earth to share in the experience. Developing a whole new world would equally develop a whole new perspective to occupy leisure time of people on Earth. Given that the number of people on Earth will be surpassing 10 billion in probably less time than emplacing infrastructure on the Moon then providing leisure entertainment for all these people does constitute a good reason for a lunar habitat. Still not convinced? Note that the entertainment industry is about \$2T of the \$77T global economy. There's value to be had in a new inspiration. This entertainment value is something we can sell to people on Earth as value in having people on the Moon.

Ultimately though, there's one single best reason for you living in a habitat on the Moon. This is to continue advancing our species much as Herodotus, He and Columbus did. We continue extending our species to far off places as we've done for thousands of years. We can provide a whole other world to extend to. And the Moon is a natural stepping stone to the next world. This is a really catchy way to begin a conversation, as in "Say did you hear about the species that didn't become extinct because it moved to another world...". This is **why** we will put people on the Moon to live as I promised I'd tell you.

And I'll recap for the **how**. We have defined a specific project. The project features an achievable undertaking and an end state. Because of this we can estimate a cost to complete the project and establish a schedule. Knowing the cost, we start conversations that lead to a monetary stream to fund this project. We can use the globe-spanning Internet to reach out to extend our conversation to nearly every one of our species. Knowing that altruism is alive and well then, our social group will support this effort. A simple fait accompli, right?!

Before I conclude, let me tell you of myself. Did I say how old I am? I'll give you a hint. As a youngster, I sat in front of a black and white television as I watched the live broadcast of people stepping onto the Moon's surface. I have not found others building a habitat so I dabbled in crowd sourcing. Here's one campaign that I contributed to, a publicly funded space telescope that everyone can use. Here's another campaign I supported. It's for proving the concept of an interplanetary probe powered by a sail. Most importantly, I've put in place this process, the Lunar Colony Fund, which is the best chance of success. This is the focal point people can rally around to build a space faring future. I have started it.

But it is not for me. It is for you, the next generation. It has the best chance of success and it can get you there if you are willing to talk to it. Are you ready to speak for the future and take up this cause?

Thank you.