

Monday, April 23, 2018

Physics Lecture Series - Heath Mills

>>DR. GARRISON: Before we get started. Couple quick announcements. First off, if you haven't picked up your paper, please do and give me your papers from last week. Also, if the you have not emailed me the title for your presentation next week, you need to do it as soon as possible so I have all of those. With those presentations tonight, I'm going to go over after Dr. Mill's talk. I will actually go over your instructions for next week, so we are all on the same page on what you guys need to do and also when you do email me your title, I'm going the email you back with any information, any missing reports that you got. So that way, you know if you have everything in, that you think you have in. If you are missing presentation, that is part of your grade, so you do want to get those in to me. They are already late now but it is worth something.

Any questions? Also, when I go over the instructions I will show you guys the self-evaluation. Next Monday is going to be a long day so get ready the night before. Ready?

So start recording. All right. I want to introduce our speaker today. This is Dr. Heath Mills, former faculty member here at UH Clear Lake and now director of science for this STaARS organization. One reason why we invited him, and you can tell this is not -- he was not the original speaker planned. His partner was going to be here. One reason why -- tell you a little bit about what they do, they do interesting work, and this is one of these things that you -- like when I talk to a speaker about afterwards, something you might want to get involved with. So he's going to be around so please I will turn it over to Heath.

>>DR. MILLS: Thank you. All right. Well, thank you, sir, for allowing me to come in and do this and filling in for Craig today will be fun. It is also good to come in and give a talk at the spur of the moment, but this is a subject that is now very much dear to my heart in that it is involving the space industry and how the space industry is evolving and changing. Many of us were involved in or excited about and paid attention to NASA before we knew what NASA was and could do.

It is very unique now to be in a position now where I get phone calls about activities on the space station and the crew and the astronauts have questions and I get phone calls and I get to go to Russia and visit the space programs in Russia and Europe. It is something that is a unique way of getting involved in what is our neighbor right across the bayou here.

Getting involved in an emerging and new market and my research and what I did here at UHCL and before that, Texas A&M, literally into space and I would like to talk about that today. I would like to talk -- my research was bio tech and bio biology. Not going to have a quiz today. I want to talk about how the commercial market has evolved and changed and is currently changing right now.

So who in here knows what that is? Sputnik. So space age started 1957 with the launch of Sputnik. With this small satellite that was but in by the Russians, now everybody started looking up and wondering what could happen? What a could happen with this ultimate high ground. A lot of issues came in play with defense. Defense initiatives were put into play and since 1957, what was one singular, small, basketball-sized satellite has evolved into this mess. Yeah.

So as of a couple years ago and this is actually a really crazy website if you want to go to it. It is down at the bottom corner down here if you Google stuff in space. There is a website that allows you to -- giving a space talk with a laser. But this app allows you to go in and look at all of the space stuff in what is called lower orbit, LEO. It is less than 2,000 kilometers above earth's surface. There are over 21,000 objects now that are 10CM or larger. A lot of objects to track. Back up further and now you go to GEO which is GEO Synchronous Orbit. Now we are talking about 37,000 kilometers out. Now more objects.

So we went from a singular object in 1957 to well over 20,000 objects now in space. NASA is tracking those, defense systems are tracking those, but we are also utilizing a lot of those. If you have a cell phone on you right now which I guarantee everybody in those are, you are utilizing those. So what's happened?

Since those launches back in 1957, you have had a growing number of launches up until a point right about 1990 and 1990 was the what? History lesson. Fall of the Soviet Union. Now we saw a steep decline in -- past few years even less launches. Space has changed.

It went from being a high ground and military process and military advantage, still and still military interest involved, and a lot of defense initiatives involved in space, but it is evolving and changing but you still have all of these different countries and what the colored lines are here is when the different countries got involved and started launching their own rockets. Over the last 60 years different countries have gotten into the space race.

They have all been countries. They have all been government led initiatives until recently. Now there is a new space race. It is not led by the US or the Russians or Chinese. It

is starting to be led by commercial industry. The reigns are being turned over. SpaceX first launch 2008. Shortly after that then Orbital ATK launched, 2013. Blue Origin launched 2015. There is was very historic out in West Texas. They landed the rocket which now SpaceX does routinely except for one section that nearly blew up the drone ship. You can Google that and that was one heck of an impact. They landed both boosters simultaneously which is impressive. I have gotten the pleasure of watch watching SpaceX launches and everyone pauses and waits and comes back down and lands. It is awesome.

So you have SpaceX, Orbital and blue origin and online this the year is Sierra Nevada and end of this year or helpfully next year is Fire Fly; also a Texas company. There are a handful of other ones out there. Many more out there coming online, some of them we don't know about until they are ready to launch. They keep it very secret, but they are all commercial industry and that's where everything is now changing.

The point of this change and the driver of this change has been the commercial markets. In 2008 there was a NASA report that was put out that in 2008, same year that SpaceX did their first launch, it cost \$10,000 per pound to get something to orbit. Understanding that and that's a reduction from previous years, they were happy to report \$10,000. But understanding that to get the commercial markets involved, that price tag had to come down. Inside that report, buried within the report, their target was to reduce the commercial cost to get to orbit by 100-fold by 2025.

Last year, the price tag to put a payload on SpaceX was \$1,240 per pound. So in less than ten years since that announcement, SpaceX dropped it by an order of magnitude. Not bad.

Going in the right direction. Wait until you see what happens when all of those other companies get in line and start launching.

Everybody is trying to figure out a low-cost mechanism to get objects to space. Where are they trying to go? Well, one of the big destination and the destination of this presentation today will be the International Space Station. It goes over top of our heads or around the earth every 90 minutes. That's a heck of a speed. 17,000 miles per hour. That's the International Space Station and I'm sure being here in Houston you have seen this.

The space station is about the size of a football field end zone to end zone and about a 5-bedroom house. You have 6 people floating around, maximum right now about 6 people. Not too bad. That's the idea. Now it is made up of many different parts and each one of these parts got to orbit. They started delivering key components of the station back in 1998.

It took over 40 missions combined between the US and Russians to get all of the pieces up to the station and attach it and assemble. It is still being added on and new ideas adding onto it. That's the bulk of what is the station.

For my company and most of what the commercial market is for the US, they are targeting the -- STaARS, my company, has right now current an experiment in and permanently within that module but that is the components. That's the different countries that are involved in it. It is Japanese, Russians and US through NASA. That's where everybody is targeting. Big, big problem though.

If you are interested in commercial space within the US, you have mostly two options to get to space. They don't rhyme with NASA. They are either SpaceX or Orbital. NASA

currently does not have a vehicle going to the station. Hopefully (inaudible). Run into that in different places.

With that, there is only about 4 to 6 launches, depending on the sequence and delays and delays are always fun P about 4 to 6 a week but Orbital, two commercial companies are what provides payloads to the station. The other problem is only SpaceX comes back in one piece. Orbital is a trash can after it has been utilized. Carries payloads to station. After everybody has been removed from Orbital, then -- from the vehicle, then they load it with trash and they scatter it over the Pacific so if you want to bring something back from station, you have to go on SpaceX. Sierra Nevada will help that problem. It will go up and come back down. Vehicle called dream chaser that should launch at the end of this year will provide additional assets to bring some of the payload back down to earth in one piece.

Another problem. How many people have heard about this challenge? Yeah. The date floats around a little bit. Previously it was 2024. Different countries came together and agencies and extended it out to 2028 but there is a finite life time for the station. Charlie Bolden said in 2016, that it is inevitable that the station will be retired at some point. All of this momentum and energy and all of this work that I'm about to talk about, finite life span within the station.

So what do we do. The commercial market, receptors tire before then if things go well or we come up with an alternative. So because of that discussion, because of that announcement in the years prior to that people saw this coming and have been planning for this, now the challenge becomes what does commercial space do with the lack of station? Is

there a mechanism to commercialize the International Space Station? The Trump administration has said that funding for LEO, he wants to get the government out of funding this by 2025. Turn it over to commercial industry. Turn it over to commercial space.

NASA agrees that the transition of LEO should go to commercial space because NASA should be going further out. Going to cis lunar or gateway project. Go out to Mars. Go further. Do what NASA does well. Go explore.

We have shown we can get to space. Now let's do something there. Let's commercialize that side. The problem I should say -- the problem with turning over station to commercial is the ultimate cost of it. Right now the cost to maintain station annually is about 3 to \$4 billion estimate per year. STaARS is not going to buy the station yet. We have to find something bigger before we do that.

Whoopies do we have? One of the options that are growing and taking hold is instead of the International Space Station, what if there were commercial space stations? What if individual companies started flying their own stations? Not a bad idea. Bigelow has had a beam on the station for the last assert years. Inflatable habitat. Low cost, works mostly. We have had some issues with it but it's a great concept. Axion, also they have concepts and concepts with it. They are getting funding and requiring hardware and doing the designs. Lots of momentum. There are other companies out there that are buying for their own station. The idea on that one is similar to what SpaceX and orbital is doing with providing launch services. Private companies could provide orbital services.

So NASA or other partner companies and lease space on the privately-owned stations,

the same way that NASA goes and leases space on the (inaudible) vehicle, SpaceX and Orbital.

NASA has seen this challenge and has offered \$150 million to this problem, this challenge. Let's say over in the next 5 years they will put in \$900 million over the next five years and with any government program you don't know how long that will last but that's where the earmarks are for that project. That's one solution.

Now there is -- with that price tag, no matter who owns it, there is still that challenge of who is paying for it? How are you going to pay to get there and maintain it?

This was a funny article that came out two days ago. Last week in Colorado Springs there was a 34th space symposium. A lot of space companies, NASA, different agencies came together for the space symposium out in Colorado Springs. They had a panelist there and one of the sessions was led by a couple of the groups on the panel and Erin MacDonald came with the statement they don't want to see a Taco Bell station. I know they are not serving tacos on the International Space Station, but it is selling advertisements. Corporate buy willing. Being a private company and going into this and trying to put payload on the stations and trying to reduce the cost to my customers, we have talked about selling advertisement space and NASA is not for this. There are sticker requirements and label requirements. You don't put a sticker on there. We put an -- Astros won the championship last year and that got us into big trouble. They earned history and we put it on the station. This happens to be the configuration of how it stirred. Instead of subtle, when they opened it, it was sitting right there. Oops.

But, this is serious, and this is real and part of it is -- what Erin said was this is -- I think it goes against what the public perceives the page station is supposed to be like. How many



people know where Cowboy Stadium. It is not called that. It is AT&T stadium. Something cherished to Texans is Cowboy Stadium but now AT&T stadium. I don't think Taco Bell will sponsor a stadium, but what if it was Merck or Shell?

This is a screen caption and I left it on the side and I thought it was interesting and for fortuitous. This was an advertisement on here. They say space is not a place to go. Space is a place to do. The idea of changing over the lower orbit space over to commercial and industry as they are making a joke about it here, here is lock key Martin saying let's go.

Things to think about. Let's go back to here, crazy GEO. All of these objects in space. Let's move it down to the corner and let's add back in the International Space Station and put in Axiom because it's a cooler picture and then ask why? Everything has been going up since 1957. We have own over 20,000 objects flowing around in space in LEO and GEO. We have all of these plans to build new stations and commercialize space. Why? Why go there? Other than just go float around and --

There is a commercial side to this but why go? I will make you do a little homework, little well-thought experiments here. Why? Think about it in your head and think right now and think to yourselves, think of reasons to go to space? Why spend \$1,000, \$10,000 or why spend \$3 to \$4 billion dollars a year? Why go to space? Everyone has at least 1, 2, 3, couple ideas? All right.

Well, I'm going to have a little fun with it. Ten reasons why space exploration matters to you. Number 10 -- I went through multiple websites and saw multiple things and they have slight variations, but I thought this was a coolest. Protection from catastrophic asteroids.

Think of that one? Number 9, it leads to more great inventions. Not just great inventions but more great inventions. It will be good for your health. Maybe not if you talk to Scott Kelly a little bit. Maybe not the astronauts but may translate to your health on earth which we will talk about in a little bit. Creepy.

Space exploration is inspirational. Right. Number 7. Number 6, support for national security. Anybody thought of that? Yep. Defense initiatives. Initially going to space, defense initiatives. We need raw materials from space. Very true. A lot of people have heard of about asteroids capture aspects and mining from the moon and raw materials from space. Nations can work together peacefully. This is an interesting thing with the Crimea incident. There was a lot of talk around NASA about what to do. We shut down talks with Russia. For the most part, that is something that has been left alone and stays out of that political issue and communication and activity still continues on the station between Russians and Americans. Working together peacefully, number 4.

Can answer really big questions. Anybody get to see this in the open house a couple weeks or month back. James Webb, going into space, where did we come from and are we alone? Some of the big questions that plague humanity. Humans need to explore. Urges. Also a human issue. Can we go out and go out further and see what's out there and then colonize to survive? Same as the first one but we will go with it.

Let's put the 10 back on the board. How many have a few of these. Couple of them? We are all thinking about it. We are all thinking about the reasons to go. This is now what commercial space has to identify. This is your market drivers. Why do you go to space?

Why a burger stand? Transportation company? Make money.

Part of the abstract was going and talking about the past. I will edit this slide. I will take away ten. Knocking out space. Knocking out you and editing and saying, reasons why age of exploration matter. Age of exploration, 1400's, 1500's, back when Europe started to expand. Hop on boats and going through the seas and very dangerous and lots of lives lost. Going out and trying to explore and for the most part. Instead of ten reasons, it all boils down to about three reasons. Gold, God, and glory.

I am not going to talk about number 2 or number 3. I am leaving that to someone else in a different classroom. Not doing it. Not going there.

But this is about commercial space and so I am going to focus on the gold side because that is commercial. You changed the minds of kings and queens when you said we can bring back gold, spices and resources and all of a sudden, you got a fleet of ships and you are going to the Caribbean. Not on a Carnival ship. (inaudible). You went there to bring back payloads, cargo. Now it is payloads.

All right. Cargo then and payloads now and if you put the gold onto each one of the line items there -- question mark on couple of those and you can twist the question mark on those but undoubtedly you can get at least half of those linked to gold in the commercial industry. So you start putting and finding and identifying how you can turn the raw materials into money, what happens to the ships? Everybody starts taking off. Everybody starts coming back loaded up just like they did in the 1400's and 1500's. So now you are starting to drive commercial space.

So to do that -- everybody has heard of research and development, right? Well the key is that we have gone to space to do research. It is time to put the "and" in that research and development because it is time to start development in that commercial side of space.

To do that, many companies and many agencies and many people are seeing that the best way to put the "and" in the research and development on station is to make sure whatever processes that industry is doing down here on earth, you can reproduce those up there, up here.

So match it and put it up there now and the question is: Are we ready to do? We have commercial vehicles going up and multiple commercial vehicles coming online. We have the idea, and everybody has got their top ten list and most of those come out to be commercial any ways so are we ready to take that leap and sail from Portugal or Spain and come to the new world? Are we ready to take that leap? Not going to go slide by slide on this I promise.

Investment group of frost and Sullivan came out with this list. Now my company is based on bio tech and life sign science. There are many companies out there in solved in earth observation. Flip side of it. Engineering and different aspects and focal points with their company vary. For our company, what we are doing is we are focused in on the bio technology and life science side of commercial space. So what we are looking at and how we want to look at how do we take advantage of the environment of micro gravity? Micro gravity is an environment and hopefully someone in here has taken at least one biology class.

So with that environment, whether it is temperature, salinity, nutrients, PH, pressure, whatever, each one of those variables affect how life operates. Reason I live in Texas and not Michigan. Temperature is important to me. Just like the rest of biology. Guess what? Gravity

is also important to biology. It changes the way biology operates. In any bio tech lab, you know that if you change the temperature on your samples, they respond. Well now we're learning that if you change gravity, there is a response.

How do we harness that and what do we learn from it? If you are going to change the station into a viable, in our case a viable commercial bio tech facility, there are certain aspects you have to consider, and this is how we are personally going in and developing and trying to identify this. This article was about how to identify a bio tech cluster? What is necessary to identify and establish a bio tech environment in a new area? They used Los Angeles and Chicago. They talked about Philadelphia and Texas as emerging bio tech centers and they pointed out some of the strengths and weaknesses as to why they are not Los Angeles and Boston yet. So what's on the board right now and I will flip through several of these and explain where my company is. Where we are looking at and where we're developing? Where the field of law is in vowel and how the marketing is involved.

Yes, I was faculty here and A&M and I was grading a lot and you will see a grade in here.

So expand the company base. Can this new area expand with new companies? Who has heard of center for advancement of science and space? CASIS, another acronym was charged several years ago, 6 or 7 years ago, by Congress to help commercialize space and pull in commercial entities and provide them access to the International Space Station. To do that what they have done is to invite and name implementation partners, companies that are involved in sending payloads to the International Space Station. STaARS, our company, is an

implementation partner to CASIS. With a funding reserve from Congress, that is their charge.

Can you get new companies to go to the station? Yes you can. We are an example of it. There is a wonderful mission statement whereas you see in here with STaARS and tars our acronym there, you see life sciences, bio tech, a front material to benefit all manned kind. We are a bio tech space company. There are other companies out there and implementation partners here. (inaudible) is another one and they were one of the first to come into play. They have launched many different payloads and projects for satellite development.

Olivia who is here tonight, (inaudible) scientific is involved with standardization of the commercial process to enhance what the projects are that are going to the station, enhance their commercial capabilities, their ability to be commercialized. So looking at the process of getting payloads to station and getting research back so that big industries are interested in them. Provide a unique service to the overall industry.

So you have payload providers and developers and those that enhance what the payloads are worth. That's where we are. My statement on this is, this market, this section, or the space station is growing.

Now one of those bullet points was skilled workers. Now when you see here is shift required. There is no doubt that astronauts are skilled workers. They are extremely skilled workers and extremely talented in what they do. They are not all micro biologists or bio tech. Some have been, and some have been good at it and some have been less talented at it, but astronauts are extremely important in the whole process. I am not talking about them. I am talking about all involved with the process. Bio tech life science industry, mostly out there are

engineers and operators. Where we developed and where we're building part of the community is that we are focused in on the science side of this, to find that sweet spot niche in the middle where we can operate, where I can talk to the engineers and the engineers talk to the operator and they talk to me late at night since we are off time sequence and what's best for the payload and experiments going up?

There is a shift required because there is not enough focus on this for it to be a beneficial place to do bio tech right now, but it is going in the right direction. So the other one on that is science based. Is there a science base? Is there a scientific reason to be in that area? Well, in this area here and the next couple slides I promise I will not give a quiz on this unless you fall asleep or are on Facebook, is some of the projects that we're currently working on. Now this is one of the projects that we flew last year. The main focal point I want you to focus on is this top here, drug discovery project. The results may lead to new advances. *Staphylococcus aureus* and so it is drug discovery. Major global market.

Stem cell, research from UCLA suggest that stem cells grow faster and differentiate faster in micro gravity. Preliminary results suggest that tissues that take 3 Moss to grow on earth may grow as fast as three weeks on station. What happens when the gold spike was put in a ground in Utah and connected the transcontinental railroad? Get to west real fast. You understand what happens there. This is a golden spike. Now all of a sudden, the shortage of organs are being cut drastically, significantly. That's an industry all because of the effects of micro gravity.

Tissue engineering, we are flying two projects and I am fortunate to be the co-PI's on

this with NIH. They are putting organs on a chip and they wanted to do humans on a chip. So instead of animal testing and testing to see what happens to the mouse liver, now you grow liver cells on a plate and you run the new drug compound past the liver cells and you see what happens. Pancreas is amazing and looking at insulin, that is a huge market right now and understanding insulin production and how different drug compounds are affected by the pancreas. The goal is human on a chip and it gets passed through the digestive tract and you test whatever is happening on it, without going to an animal and it is cheaper, easier and quicker.

We are flying 2 of the 5 projects going to the station in the next 12 months and one is a bone and lung on a chip and the other is a vascular system on a chip. Pretty cool stuff. The one that's the bone and lung is looking at lung infections, pseudomonas and how can micro gravity solve that problem.

Last one, because we are in Texas you have to talk about energy in every talk you give. We are working and flying here in the next month that's a bio fuel project. The preliminary data suggests in this one that this E Coli that a University of Alaska Anchorage professor is looking at how a more efficient production -- basic level genetics, once you identify that a cell can do something new, you can reproduce it. Identify what the genetic markers, what the genetic codes and operons were that changed in that new environment. You can induce that behavior back on earth. So it opens up a new and fun market.

So then -- with that one -- go back on that slide there. It is maturing. Now and my one other key points on this is that -- great projects. We're sitting on a ton of these projects. A lot



of the implementations are sitting on these projects. A lot of projects happened over the last 10 to 15 years. The issue right now to really get everybody excited and is if you have done an experiment you know and probably heard some of the faculty here say it; good in equals good out and crap in equals crap out. If you don't take care of the process of how the experiment goes up, you are not going to understand or appreciate what comes back down.

That's why matching up with the right experts and the right industry partners can help make what goes up and what comes back down actually valuable to big oil, big energy, big pharma, because for the first time we're moving away from and there is nothing wrong with engineering and those guys but moving away from that to the focal point of how science works on stations. Whether it is chemistry, biological, you have to maintain and constrain that experiment properly. The right language is starting to be said and it is not there yet, but the experiments are there.

So then becomes now the policy side. What type of policy is available? Can you get these projects to station? Can you get these resources to go up? You got the business. You've got the reason and got the experiments, but can you get it there and back? That's policy. I don't have the credits on there because I stole it from a partner company of course. They will be okay with it. What they promote is this time line. Now this time line here is contract negotiation takes a while but then 10 months roughly to develop the hardware. Then you go and fly and then you do post flight.

How many people in here want to go buy a year old I-Phone? Samsung? You want to latest technology, right? You want to have your research at the cutting edge? What if you

were stuck flying something 12 or 16 months old? Can you move at the speed of business? Can you get payloads up and down fast enough to make them relevant? In the biotech department there are companies that are founded and sold in 9 to 12 months. Completely out spaces this entire market.

So one thing that STaARS is doing is that STaARS is priding themselves off to the start that and we made a bold claim that we can get something up and back in 6 months. CASIS said, I dare you to do it in two. We have a project coming up on Orbital nine which is May 26th or 29th. It won't be our fault if that time line goes. It is not our fault.

Right now we are slated to two months. From kick off of the project to flight in less than two months. Problem is it took us 5 months to get it funded so we are cheating on those numbers a little bit, but this is trying to move in the direction of being at the speed of business. That's the whole point of this. It is improving.

Now premise and infrastructure. We talked about the station and longevity and vehicles but what happens when you get to station? This is the STaARS experiment facility and we launched on SpaceX 12 back in August of last year. This is our home on orbit. This is where it goes and sits, and we talk to it up there.

The infrastructure on this is key for big picture. We can provide temperature and we can provide centrifuge. What is that good for? You go higher gravity. So you start off from 0G and you spin the centrifuge and we can test different levels of gravity, we can do lunar, and higher gravity. 1.5G. So you have your controls right beside the experiment.

Until this summer, when tech shot flies their new experiment facility, we will be the --

right now we are currently the only operating US centrifuge in orbit. Something different like having a control right next to your experiment was new. So infrastructure is improving but needs to get better.

Temperature control very important. How do you regulate temperature? Is it to the levels of pharmacopeia standards? Working on it? Some things are good, and something is not but we are working on those. With this also becomes collaboration. Are there enough companies that can work together to get ahead faster than developing your own? This is one of the things that we jump in the on and other companies are working on, space tango and Austin and couple other companies are utilizing hardware from the past. Somebody spent \$1 million and 3 years to develop it and we are just reflaying it. So we are building collaboration. Air bus located out of Germany but also in multiple European countries and right across the street here in Texas. SpacePharma is a Swiss company and different companies that have hardware that allow us to do things faster and cheaper. We are using what they have. That helps build this mixed collaboration.

I say mixed because what happens when gold -- not everybody was collaborating out in California in 1849. You see stories and movies. What happens when the industry goes faster? Still yet to be determined.

Support services. This needs improvement. Too many ideas, too many projects whether physics, bio chemistry, it is left with translational issue. How do you translate what you do in your lab to go to station? Are there the right experts that you can speak with, that you can talk to, to be able to get your project to fit into a 10 by 10 cube ordeal with the

constraints of it has to be -- 5 days before any activity can happen to it. Go tell a skin cell biologist that they have to go more than 10 feet away from their incubator and they lose their mind. Now 5 days and it is going this the fast and it is a translational problem.

So the business support services needs improvement. We have a lot of projects. My background with oceanography and I was very used to going out to sea and working in crazy environments here that had ridiculous constraints. For me the space station is just another ship. I would love to take my samples with it and (inaudible) it is something that is developing, and this is that business support side.

It all comes down to this. Finances. You have the greatest project and great company to work with and you have translated it perfectly and you have taken care of all of the standard operating procedures and have everything lined up, who is paying for it? In any area it is finances.

So whether it is grant writing, and we have written a ton of grants and we have been successful with those which is great for us. Writing a lot of grants or the investing side of it. Can you get investors excited about it? So with a lot of the areas here, you develop the research project and you start developing and asking those complex questions. Can we solve the organ shortage? Can we help the environment by producing better, cleaner fuels? Major challenges. Can you develop the protocols necessary to make those investors feel comfortable about where your samples are going and those can be translated back to what has been done before? Can you do that?

In the end, what happens is you develop that space manufacturing, or you bring the

samples back and you develop a new industry here based on the data and experiments you collected while in orbit. If you can do all of this, now the king and queen of Spain will pay for your ships and you and the three other ships -- you got it. Right?

That's the difference. Can you get that investor, and can you do that side? The first slide has been altered by going to IBM and Mac. I put them all together and then gave the grades and you are not going to see those, so I got hosed but it's okay. The whole point is I was going through and trying to grade each of those and I had it color coded at the top of the slide with greens and red and you follow it through. This is not what you want to see your classroom have or you personally have, and this makes you not want to come back to school. If turn up with bad grades -- are we ready to open the station as a bio cluster? Not yet. Is it worth it? Yes. Is it going in the right direction? Absolutely. Is it something that me and other companies are trying to do? This is new space. This is the reason why we had all of this. So now we've shown that we can go. It is now time to do.

Actually had an interesting talk we heard in Russia by -- what was the name? The first (inaudible) that did the space walk. Alexia (inaudible) and now he is in his 70's. He gets up in stage in Moscow and speaking in Russian and I had an ear phone that allowed me to hear what was going on with it and he starts pounding the podium and turning around to all of the leaders of the different space industries behind him. We have proven we can go there and risked our lives to go there. Now let's make it worth it. Start opening up to commercial and start doing commercial industry. He was pounding the podium and in Russian it sounded awesome and cooler when it was in Russian but pounding the table and saying let's go, let's do it and go up

there.

With it, there are good signs and there are good metrics involved. CASIS has put this out last year, proposals generated 102 different proposals. This got to the phase of writing the proposals. Not all proposals are always funded as we know. There were 43 different projects that were funded by CASIS last year. Just last year to go to station, to develop and do new research. The question on those is, how many of those had standard operating procedures? How many were vetted throughout the commercial process? How many of those were to a level that pharmacopeia, that big pharma and big oil would be interested in. That's what we are trying to drive.

There's a dollar figure involved in this. \$22 million were paid out to go to space and CASIS paid about \$6 million of this. Let's go up there and make it valuable. That's the I.

One more quick pitch and I will close this out. (inaudible) sits on the space station safety foundation. Since we are talking about money and those not graduating in a couple of weeks and come back and write proposals to get funded. They fund a wide range of projects to go to station, go to space with support terrestrial research with space-based work.

The website is listed on here and this is an email link to get -- to answer -- if you have questions on it or you can see here after this. That is the presentation for today and I appreciate you guys listening to all of that and everything. I will leave that up on the board. Thank you for having me here and if you have any questions, I will be glad to answer them.

>> (inaudible).

>>DR. MILLS: So right now, if you have a very good project and you have a good

idea, your fastest route is station being --

>> (inaudible).

>>DR. MILLS: The rats fly, and mice fly, and they fly a lot of rats and it takes up screw space and time. If I understand what you are saying is that you are exactly right. All of these projects going up and what's coming back down? What is the value of what's coming back down?

>> (inaudible).

>>DR. MILLS: There are projects right now from multi-generation rats. There is also projects right now -- one big one we are working with, multi generation plants and so with the exact same idea in mind. If you took rice out here in Galveston and try to plant it in El Paso, doesn't have a chance in hell of surviving but if you slowly climatize it. Same thing here. What if you had multigenerational rats and plants? It is not done. It should be done and funded, and we have the capacity to do it now. Can we turn a module into a verbarian? Tough but can be done.

You find the cure for cancer in one of those trans genet mice and it is maintained at the station and how much does it cost to do maintain an oil rig. You get the right drug compound and find the right drug discovery, all of a sudden, the price tags go to orbit and don't mean much.

>> (inaudible).

>>DR. MILLS: Absolutely. Not only are you looking at what can benefit here, but benefit when we go to Mars, benefit when we go to the moon. That's one of the drivers, we

can't put a mouse inside of the centrifuge, but we can put plant seeds and so why not test lunar gravity? Why not test Martian gravity? One of the fundamental questions and if you do enzyme kinetics and bio physiology classes, enzymes work off of 10° Celsius and you change the order of magnitude back based on continuum of temperature. Is there a continuum of gravity or threshold? Do cells sense gravity at a point or change over the range of gravity? No one has done the study. Can you climatize a generation so that mouse is only going to be able to work in space? You bring that poor dude back and he is going to be flat?

>> (inaudible).

>>DR. MILLS: Exactly.

>> (inaudible).

>>DR. MILLS: Exactly. That's that threshold. Is there one that turns on and off?

What's so much -- my personal research was deep subsurface. We were in areas where life was barely alive and the whole question is what is life and how is it living and was on the edge? And we were able to ask very, very basic questions. How does the cell divide? How? Some basic biology questions. Same up here, basic questions can be revisited. Answers will be fun if the constraints are managed properly. Get the trans genet mice and see what it is like to be up there and have multiple generations and what happens to the fifth generation? There is a fertility experiment that's going up shortly. It is actually on SpaceX 14 or maybe on Orbital 9. One of the two. They are looking at how sperm swim in space. Basic questions. Other questions?

>> (inaudible).



>>DR. MILLS: Currently they are funded by an act of Congress. They have an allotment from Congress and separate from NASA. Not part of NASA budget. Separate line item and directly report straight to Congress. What they are and what they do is they match and look for -- that's the reason they invested 6 but their value was worth \$22 million. A lot of industry partnerships and some investors to go in and increase the amount of money they are able to spend on science. They are an act of Congress. (inaudible).

>> (inaudible).

>>DR. MILLS: They are really -- the next I think for SpaceX will have the rodent rats flying again and the Japanese is doing a rat module they will be flying to increase rat students on board. Fruit flies are a good one and they provide a lot of good genetic information and there may be a zebra fish project that went up on 13. Another genetic workhorse.

So there's a lot of projects like that and a lot of plant stuff going up as well. Interesting questions. A lot of things -- very simple, especially with the plants, what direction do the roots grow? Project that we're working right now and funded via National Science Foundation between UNLV and Ohio State, for me, microbiology, it's a microbiological project with a bacteria that produces magnetite.

Anybody take geology? Magnetic points to the north pole. There is a population of these in the north pole and south pole and they point to the poles. What in the hell happens when this poor dude goes around the earth every 90 minutes? Does it spin and go crazy? But the implication, commercial aspect is now these microbes point to and attract magnetic fields and this is used in the drug delivery where if you provide the right genes or a drug compound

that these bacteria produce and you are able to localize it by a magnet on your body, you can focus it on say a cancer cell on are a tumor and draw the medication only to that one specific area as opposed to going around your entire cells.

It's a fun project and it is cool to see what happens but there is a huge market implication to this as well. Other questions? You guys let me get out of here easy. Dang. All right.

(Applause).

Thank you, sir.

>>DR. GARRISON: All right. I do have final instructions and I want to go over what it is you have to do next week. So you can have a 5-minute break. This is not a break so don't go home. If you are taking a class for credit (inaudible) or 5838, you need to come back here. Okay. Otherwise get a little break and come back.

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