Conversation between Julia Christensen and Dr. Anthony Freeman
Live in front of an audience at the LACMA Art + Tech Lab
October 28, 2018

Dr. Anthony Freeman: So, here we sit, left brain and right brain - I'm not sure which is supposed to be which - but the conversation actually helps. As engineers, it really helps us to get a different perspective on missions, to look at them in a different way, and think outside the box. It's a bit of a cliché, but it really does help us to reimagine missions by having ways to interpret them in ways that are different…

Julia Christensen: Yeah, and I think one thing that we've talked about is that I'm an artist with what can be described as a "research-based practice." I get into these long-term research projects, really, that wind up spinning off into art projects in a number of disciplines. And as you can see here, I've been doing this research about upgrade culture for all of these years that has taken me through these phases of looking at how the "upgrade" impacts our lives. So for me, a lot of times the binary between art and science winds up breaking down quite a bit—and I'm really interested in that. I mean, for me, even the A-Team day, rather than just seeing it as research, I really see it as part of the art project. I see the whole platform as an artwork.

Dr. Anthony Freeman: I was going to ask you, do you see upgrades becoming more and more frequent, and for us working in the space program, does that mean that we have to continually refresh, setting this mission aside, to get people engaged? Do we have to continually update?

Julia Christensen: Yeah, it's a really great question. I think that, yeah, the upgrade cycles are getting shorter and shorter. And that is tied to the economy, the market, consumerism. And so, it's really exciting to imagine this mission, a 40-year mission—we can think of it even as a 200-year mission, really—to think about technology that transcends that trap of a market-driven upgrade cycle, to imagine technology that does what we need it to do beyond that [time scale]. I think that those design decisions about the upgrade are so ingrained in our thinking that it really takes sort of an expansive, imaginative moment to get outside of that. I don't know - what do you think?

Dr. Anthony Freeman: I do worry that missions we design that are still working 40 years from now will not be very appealing to young scientists and engineers to work on, because they'll be too limited, compared to where they could be.

Julia Christensen: Yeah, and on the other end of things, I know that it's also hard for scientists to commit to a long-term project like this, knowing that they might not see the end of it. That's also probably tied somewhere to funding, and I imagine it is increasingly difficult to get long-term, say, hundred-year funding for a project when administrations and Congresses, et cetera, turn over so quickly. Funding for a two-year project is much more likely.

Dr. Anthony Freeman: We do design missions with a 25-year lifetime, and they actually have a succession plan built in. There's usually a senior scientist who's in charge, and then they'll have a young doctoral student, a graduate student who'll be the sort of logical heir to all of that when we finally get a sample back from a comet - that takes a

long time - or when we get to a Kuiper Belt object way out there in the solar system. So, there's usually a succession plan built in, but 40 years is usually considered the working lifetime of a scientist - not necessarily the useful working life of a scientist, but 40 years is the time frame. So, you sort of plan for that horizon, because for anything longer is really hard to hand it off.

Julia Christensen: Yeah, we were talking earlier about how, with a project like this, we might have to engage a lot of 5 year-olds right now, because they'll be the scientists that one day will take over this project.

So, why do you think it's important to embed an art project, or creative thinking, in the development of this mission? What role do you think the art can play for the development of the larger mission and the spacecraft?

Dr. Anthony Freeman: We can make the spacecraft any shape we want, and as it transforms itself, we could also add [aesthetic] value to it - and it doesn't cost anything to add an aesthetic appeal to it, if we can do that. So, I think we're sort of trying to think ahead for future uses of the spacecraft, as it shifts and transforms; I think we're trying to appeal to a broader audience—you know, it would be a major undertaking to [launch this mission]. And I think all of humanity would like to be represented, not just our engineers.

Julia Christensen: Yeah. The day of the A Team meeting—we had this day-long brainstorming project, the A-Team meeting [at JPL]—and during that day, a number of exercises were planned for us that helped us look at ideas about art on the spacecraft from a number of different angles. And one thing that we spent a lot of time on was talking about who might be interested in this project over the long term. And it was interesting to think about audiences that are here on Earth now, and people who will be around in 2069 when the craft would take off, and then when it lands at its destination––or "lands!"—I should say, *flies by* its destination in 2109, there's yet another, future audience here on Earth. And then, anybody who might intercept the craft during that time frame, or hundreds of years later, including our as-of-yet-unknown cosmic neighbors—[anyone] who could intercept the craft, even another human civilization 2000 years from now–-they could find this relic out in space, sent by our civilization.

Dr. Anthony Freeman: I remember we talked about the recent asteroid from another solar system that begins with an O, and is something like Umami [Oumuamua]—some of you will have heard of it—and it was really long and thin, sort of rectangular, but not exactly, and it passed by so quickly, we barely had time to measure anything about it. We certainly had no time to send a spacecraft to it for a close-up fly-by. And now, it's gone, and we hope that others like it will follow so we can learn more about them. But was it of alien origin, built by somebody else? Probably not—but how would we know? How would we know? It went by so fast, we really couldn't get a good snapshot of it. They had a rough shape, and the pictures you saw were artists' impressions, not the actual picture of what it looked like.

So, how would we announce that our spacecraft, as it arrives at Proxima B, is not natural? What's the sort of universal telegraphing that says, "I come from outer space, and I am friendly." I don't know what the answer is, but is it some sort of radio signal?

Is it some sort of message in its shape, and overall structure? Is it something about how it interacts with light? What is it that's the universal message? So, we talked about that, and Julia has this great thought that when somebody finds Voyager 20,000 years into the future, how will they know that the Golden Record is the art part, and the Voyager spacecraft is not? That's the engineering, but how will they know? And I have no idea, no answer to that one.

Julia Christensen: Yeah—so just to put this in perspective, when this craft does actually arrive at Proxima B, it'll be a pretty small window when it actually flies by the planet. I mean, you know, we're going to fly there at a tenth of the speed of light, for decades, and then for just a few minutes, really, it'll be in Proxima b's proximity.

Dr. Anthony Freeman: Yeah. It's about as long as an ad break at the Super Bowl.

Julia Christensen: Yeah.

Dr. Anthony Freeman: That's the observation window—unless we learn how to slow it down, and to slow it down, well, we don't know how to do that yet. So, the challenges…

Julia Christensen: Right. So, just to kind of put it into perspective, the Umami—or whatever it's called—that flew through here, with us not having enough time to really assess what it is, we will be presenting a similar situation on the other end.

Another thing that you just brought up that is really informing my thinking right now is this idea that, why would a document like the Golden Record be the only "artwork" in the design endeavor of the spacecraft? How can we think of the whole spacecraft on the creative platform of an "art project?" How can we view the whole thing as veritable Golden Record, and encode our cultural stories, or our essential human characteristics, perhaps, into the design of the craft. If it were intercepted and taken apart and looked at, everything that we design tells a story about who we are. So, how can we make that a primary focus of our design? Rather than our story being inferred, how can we actually keep that in the focus of how we design?

And then, also this idea of radio frequencies or light frequencies being involved - I think another thing about this upgrade cycle that we're all living on right now is so tied to material. We're so tied to these objects. And if we could just kind of shift our imagination outside of material objects and think about developing technology that operates on light frequencies or ratio frequencies, maybe there's a way to think about this spacecraft and the artwork, and the message that it sends that isn't material at all. Maybe [the art] can be experienced in a different way.

Dr. Anthony Freeman: Should we open it up to questions?

Julia Christensen: Sure, yeah.

Dr. Anthony Freeman: Who would like to ask us questions? Sure - go ahead.

Audience Member 1: First of all, thanks for doing this. It's fascinating. I don't know if

you guys read this on Friday, but NPR ran a story about how the Cloud's actually being backed up to old-fashioned tape machines.

Dr. Anthony Freeman: Yeah, I did hear it, yeah.

Audience Member 1: There's concern because the technology may become obsolete. Well, I started thinking about that as you were speaking about these very forward-thinking ways of communication, is there any value to going back a step as well?

Dr. Anthony Freeman: Back to sort of retro communication approaches? Yes, there's an aspect to this that is important too, which is compatibility: the idea that a single technology is compatible across lots of different platforms, and stable, and has a connection. But there's also [the question of if] the spacecraft [will be] compatible with future-current technology. We want it to be at least backwards-compatible so that you can talk back to previous versions of the same software, or versions of the same hardware in some cases. So, I think there's [the need for] both—yeah, you might want to think back to something that's very traditional and very sort of old-fashioned, perhaps, but reliable and repeatable and stable over long time frames. But you also might want to think: how do I change it, upgrade it, so that it's compatible with my current systems, so that we can talk to it?

Julia Christensen: Yeah, considering the Golden Record, one thing that's so great about it is that, if the laws of physics are the same across the universe, as we believe they are, then you actually can play a record anywhere. I mean, you can drag a needle through the groove and produce a frequency. So, having that analog copy has a lot of value, as is true with the iCloud/magnetic tape situation [you mention]. I think that one of the lessons that we're learning now from this frequent upgrade cycle that we're in is that we need to be flexible in both directions. And as we develop technology in the future, especially for a piece of technology that is going to last over lifetimes, yes—we need to be thinking about flexibility, in terms of communication structures, and moving backwards and forwards.

Audience Member 2: Well, it seems like if you go to all the trouble to go to this planet, that you ought to stay there.

Dr. Anthony Freeman: Yeah.

Audience Member 2: So, have you thought about crashing into it, an object, I mean? Thinking back to the Carl Sagan days, he would say that chances are, whoever's there [on Proxima b] is way far advanced from us, and they would probably catch the object. Would that change what we would put on the spacecraft—if your assumption was that they're going to catch it, versus they're only going to see it for a second or two?

Dr. Anthony Freeman: It probably would, if we knew there was somebody on the other end, or suspected they had that capability. You might change the form considerably. We thought about how to slow it down—there are solar sails you may be familiar with, the photons from the other star slow it down. There's something called the e-sail which interacts with protons off the other star to slow it down. That might take some speed of it off, but we really don't currently know how to slow down enough to get captured.

That would be great, if we could do that.

Audience Member 2: So, you don't know how to speed it up?

Dr. Anthony Freeman: We don't know how to speed it up either. So, lots of unknowns in this problem.

Audience Member 3: How many engineers on the JPL staff really see this [collaboration] as a fruitful interaction, where discussing these issues and actually incorporating them [into the mission] can lead to greater success and accomplishment, versus how many think, "OK, this is super fun to talk about over a drink for 10 minutes at a cocktail party, but actually, we have important work to do, and this is just a sideshow."

Dr. Anthony Freeman: Yeah, that's a fair enough question. I would say we have quite a few engineers who just want to say, "Just give me the requirements, tell me what it is, and I'll go design something, and then we'll go build it, and it will happen." But I think a lot of us who work in the front-end understand that being able to communicate our ideas is really important, because essentially we have to sell them. So, in that [aspect], we're no different than someone making cars. In the end, someone has to buy this—you the taxpayer, end up paying for what we do, and that means we have to persuade someone that it's worth doing. And, you know, if they think it's cool, as well as scientifically interesting and technically challenging, those are three factors that tend to sway people. I mentioned Don Draper earlier—we're in the creative end of things, and the creative end of things is not just finding the technology to do the job, it's finding the solution that appeals to the greatest number of people.

Audience Member 4: When I learned about the Golden Record, it seemed problematic that we were attempting to create a message, a language not based on any preconditions so if aliens find this, they can read it. But it was fascinating. And I am hearing from you now that it may have also had a secondary marketing image for how the public might get involved. Did the Golden Record really serve a bit of a marketing, branding function for JPL?

Dr. Anthony Freeman: It does, yeah. I mean, NASA brought back the "Meatball" [icon] a few years ago. They had what was called the "Worm" [icon] for a long time, which is the squiggle that read "NASA", but they brought back the "Meatball" because that's what people associate with NASA, and that keeps it in the public attention. Yeah, part of it is the branding and the marketing, so yeah. We like to be well known. I remember when I first started JPL - you would tell people you worked at JPL, and they'd go, "What's that?" Even in Pasadena, "What's that?" They didn't know. And so, the branding and the marketing has, over the years, really accelerated the profile. And I don't mind that - that's great. When I go around the world now, I tell people I work at JPL, they go, "yeah, that's great, fantastic." So, they know about [our work].

Julia Christensen: I'd also like to reiterate that people think of this dichotomy between art and science, like the science is happening, and then the art is just this thing that we slap on that makes it pretty, or does this other thing. And I'm interested in breaking down that dichotomy as much as possible so that the artwork isn't necessarily separate,

but also can perform scientific function in a different way. I mean, one example that we've been talking about is this idea that holograms can be used to change the shape of a spacecraft so that it can interact differently with lasers or other environmental forces—I mean, light can physically alter how the spacecraft [functions], in a sense, so the craft can perform differently. And that could be a space for art making, too. So, it can perform this dual function of art and science. So, from the artistic side, I'm not as interested in sort of painting a mural slapped on to the spacecraft as I am in figuring out how we can develop an artistic gesture that can enhance the mission and the science itself, which is a different way of getting at this question.

Dr. Anthony Freeman: Some more questions? All right, Jobea, go for it.

Audience Member 5: I was curious about how you spoke of the Golden Record—I remember when the Golden Record came out, for me, it showed so many parts of our planet. What bothers you about it? Where do you see the missing parts are, and what makes you uncomfortable about the way it's presented?

Julia Christensen: Sure—this is really important, that's a great question. You know, so often when I talk about the Golden Record with people, one of the things that comes up over and over again is that even when the selection of sounds might potentially represent people from around the world from different cultures, the designers [of the project] were still primarily white, educated, from a certain demographic. And so, then that world view is filtered through the experience of those people. Unfortunately, among iterations of the Golden Record project—and even if we were to devise some system where everybody can upload something from Earth in the hopes of broadening the representative population—it still comes back to the [notion that the] people who have access to the tools [are the ones] who will be represented. So, the idea of generating this sort of sound and image database that can represent the whole Earth, or the whole of our civilization, just kind of runs into that [representation] issue over and over again. I am absolutely willing to keep brainstorming on that thread, and continue opening that up, but I'm also interested in thinking about this art project as something different altogether. I mean, how can we create a different kind of design and art piece that can represent humanity, that doesn't follow into this sort of mindset of selecting some things to represent us?

Dr. Anthony Freeman: I want to add a little bit about the Golden Record - the Golden Record was added really late in the project life cycle, and it was added against the wishes of most of the engineering team, from what I've read—I wasn't there at the time, so I don't know that for sure. But it's probably the one thing most people know about Voyager. So, you have to remember that—that even though it was reluctantly added, it was very memorable, and most people have an opinion on it. And if we don't do that, we miss a lot of opportunities.

We have two spacecraft on the way to Mars at the moment - they're CubeSats called Marco—Marco A and Marco B. And they're the size of a cereal box, each one of them. And we had lots of engineers who didn't want those CubeSats on the launch vehicle—they would be a risk, they would be a problem, et cetera. And they have an engineering function. But their real function is to let the rest of the world, young engineers to-be, or scientists to-be, imagine that they could do the same thing. Because these were really

tiny spacecraft that are going to take a great picture of Mars. It's not going to be the best scientific picture we ever got, but it's going to be a really cheap one. It's going to be the cheapest one we ever got. And so you can imagine the next version will be more sophisticated, more involved, et cetera. But lots of people could be involved in that, and that sort of opened it up, so that it's not just our four-star engineers that can work on it, but anyone can imagine being part of it.

Julia Christensen: And I'll also say, I do love the Golden Record. I mean, I'm not - you know, "anti-Golden Record." I think it's a wonderful thing. And it would be made differently now. I mean, it's very of the 1977 moment. The medium is the message, as McLuhan said, and the record itself [tells a story]—We can't write over it, there it is. I think that it's a beautiful sort of time capsule that tells a story about that moment.

Dr. Anthony Freeman: So, I give you another [example of a mission enhancement that might have non-quantifiable cultural value]: how many of you own a smartphone? All right, all of you. How many of you have a microphone in that smartphone? All of you, right? We never put a microphone on a Mars lander, because to the engineers, it doesn't serve a function! But if we'd had a microphone on any of the Mars missions, all of you would know what Mars sounds like. All of you. And you'd never forget that. But we haven't been able to do that because it didn't meet a requirement. But you could see why, as a species, we want to hear that sound. Other questions?

[Note: The Insight lander does have a microphone and has since relayed the sounds of winds on Mars back to Earth.]

Audience Member 6: I was curious, considering how this "upgrade culture" you speak of has sort of enabled missions like this to become even possible, to go to these other planets, do you think there's sort of an irony in criticizing it?

Julia Christensen: Yeah, absolutely. I mean, that is the irony, right? We've even discussed, "What if we could upgrade the Voyager right now?" We all want to be able to expand our possibilities and our knowledge, and we know we can do that through technology. So, yeah, I mean, it's really important that we're able to continue to do that, to upgrade and expand our capabilities. But we have to figure out how to square that with the critical environmental and social issues [posed by] technology. We need to be able to think critically about this; yes, we can design technology that will fly to an exoplanet in another solar system. But that doesn't mean that we should be wrecking our own planet. So it's a matter of thinking critically about design issues so that we can square the importance of the upgrade, of future upgrades, with the fact that this is our dream planet, Earth. There's nothing like it in our wildest imagination that we know of, anywhere right now. And so, this idea that it's okay to bury all of this technology within our planet? Yeah, I am critical of that. But I'm not critical of advancing technology. So, we have to figure out a way to square those things.

Dr. Anthony Freeman: I'm glad you think that upgrade culture is embedded in the space program, because it's not, really. It's really difficult to get people to change. So, Space X did that with the launch vehicle, the rocket industry, but it had been static for like 30 years before that. We're currently trying to get our engineers to switch processor units, because the core processor on most of our spacecraft since 2000 has been a

PowerPC from 1999. And that hasn't changed, so we're not fast. I'd like us to be much faster so that we're constantly taking advantage of the incredible changes that are going on Earth. But I don't think we're the fastest up-takers, to be honest.

Julia Christensen: So interesting, because [JPL's] choice not to upgrade quickly is about compatibility on a cosmic level. I mean, to upgrade the machines at JPL [here on Earth], they would also have to upgrade a multi-planetary system of technology that would be a huge under-taking. I mean, even here at LACMA, doing something like that takes a long time. [Upgrading at the scale of the institution, or universe] is different than buying a new iPhone.

Dr. Anthony Freeman: One more over here, maybe? Yeah.

Audience Member 7: It's such an ambitious mission, and it takes so long to get there, and it's probably—maybe I'm wrong—I'm guessing it's quite expensive. My question is, how do you know when technology is advanced enough to make it worth all the effort. Like, of course, this is the design time, it's probably not so expensive right now, but is there a protocol to know when we can do this now for $100 billion, or for $50 billion in two years, but we can do a lot more. How do you figure out when the launch window is that jives with finances?

Dr. Anthony Freeman: So, there's a futuristic physicist called Freeman Dyson, who wrote a lot about this in the '50s and '60s. And he talked about interstellar spacecraft. He said, yeah, it's going to be about 200 times the Gross Domestic Product of the planet, but don't worry, in 200 years, that'll be nothing. So, that's a kind of flippant answer to what you're saying, but if the technology makes it so that it's doable within a NASA budget, we probably go for it. We are nowhere near that right now. The costs have not gone down far enough. But we have seen dramatic falls in the cost of missions lately, so maybe they're falling fast enough. I don't know yet. The science community will tell us quite clearly when there's a real need to do this mission. They won't spell it out in the National Academy reports that we get, which basically are our marching orders. But as soon as the cost is at the right level, and when the need for discovery is the right level, they'll start yelling for it. And in this case, the discovery means an Earth-like planet.

Julia Christensen: This is yet another reason that the technology embedded in this craft must be as flexible as possible. We need to build the potential for upgrades into whatever technology is launched in the first place. I mean, building a system that's flexible enough to be useful now, and more useful potentially in 10 years or 20 years, is crucial—especially since we'll be doing research about the destination throughout its entire flight, so, the mission will certainly change once the craft is on its way. So, it's just another reason to invest in thinking about a flexible, adaptable system from the start.