WE ARE ETH – Episode 33

With Olivier de Weck, ETH Alumni and Apollo Program Professor of Astronautics and Engineering Systems at MIT

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[00:00:00] **Olivier de Weck:** **I hope that I will see the first human landing on Mars, I think there's a good chance for that. But to really establish a foothold there and a permanent presence, it's going to take many decades.**

[00:00:17] **Susan Kish:** In this episode, I'm talking with Olivier de Weck, the ETH alumni, Apollo Program Professor of Astronautics and Engineering Systems at MIT, and the Editor in Chief of the Journal of Spacecraft and Rockets. This is the We Are ETH podcast, and I am Susan Kish.

Olivier, good morning and welcome. Delighted to have you here today.

[00:00:48] **Olivier de Weck:** Good morning or good afternoon, Susan, I should say, right? We have six hours of time difference.

[00:00:53] **Susan Kish:** Exactly. Many people describe MIT as the ETH of the United States, or in reverse, they'll say the ETH is the MIT of Europe. Now you've been at both institutions. Are we, is that on track or is that just

[00:01:08] **Olivier de Weck:** I think

[00:01:09] **Susan Kish:** somebody teasing?

[00:01:10] **Olivier de Weck:** No, I think there's a lot of truth to it. First, if we start looking at when those two universities were founded, right? ETH was founded in 1851, MIT in 1861, and you know the mid, middle of the 19th century was an exciting time when really technology, what technology could do for society at scale really became clear, and so I think a lot of the original motivations for the founding of ETH and MIT were quite similar.

[00:01:40] **Susan Kish:** I think that sounds exactly right. And they're both now global institutions with lots of companies who believe in their research and work with them forming their clusters. I keep reading about you as a specialist and leader in systems engineering research. All three individual words I understand combined, I'm not quite sure what exactly systems engineering research means. Can you give us a definition and maybe an example?

[00:02:09] **Olivier de Weck:** Sure. Systems engineering really started not as a research direction, but as a field of practice. And we can argue how old systems engineering is if you think about, for example, the pyramids in antiquity. They had to be designed, they had to be built, the production of the stones and the logistics, everything had to be coordinated for those pyramids to come together. And that required decomposing the whole project into many different pieces, reintegrating them, understanding the requirements. And formally, systems engineering really started in the 1940s. Generally, it's Bell Labs that's credited with formalizing the notion of system engineering. This is when the old PSTN, the Public Switch Telephone Network, was created and we started having the ability to call each other across the globe, pre internet. And that required the electronics and the signal quality and the base stations and all the elements to come together in a way that when it all worked together in harmony, the functions, the level of performance would be achieved that you couldn't have from any of the pieces alone.

So systems engineering really grew out of that and then in the Cold War, the Apollo program, the Moon program, but also many of the defense systems in the Cold War we're so complex that traditional engineering monodisciplinary thinking wouldn't get you to the goal. So systems engineering is really the art and science of building, implementing and operating complex systems.

[00:03:45] **Susan Kish:** So, Olivier, you have an incredibly wide range of interests, right? When I went to Google Scholar and was downloading your papers of like 25 plus just this year, the number of topics it encompassed was breathtakingly broad from finance to space to promote sensing of forests. What's the common, I've always thought that professors were very specialized, focused on a particular area.

So how do you get to work so broadly?

[00:04:17] **Olivier de Weck:** That´s a great question. And first of all, even growing up in Switzerland as a kid, I had so many interests, languages, obviously, you know, Switzerland is a very, so I love languages. I.

[00:04:27] **Susan Kish:** How many do you speak?

[00:04:29] **Olivier de Weck:** It depends where you draw the line, but I would say maybe five that I could reasonably claim to speak reasonably well. I have a post doc in my lab right now at MIT who speaks seven languages, so I, he's Norwegian originally. So, uh, it's fun. Languages are amazing. My mother was actually a PhD in philology. My mother was a linguist, and she studied how languages, how languages migrated, for example, along the Silk Road and I think my love of languages I definitely inherited from my mom. And I did my military service in Switzerland, so I've always been fascinated by airplanes, rockets, satellites, but I think of myself as a specialist too, but a specialist in connecting disciplines. So if you think of traditional traditionally, we think you're right we think of professors and academics as being very narrow and very deep and specialized in one silo, of science. he real, I think the real exciting, the advances in science in the, in the next Century and beyond are going to be at the interfaces of the disciplines, for example, strategy and technology, remote sensing and planetary science, and actually properly connecting the disciplines and making them talk to each other interface and integrate them in a way that can lead to new insights.

That's actually a specialty, and that is, in a sense, system science. While the applications are very varied, the common denominator is multidisciplinary analysis, modeling, simulation, and optimization across disciplinary boundaries to yield new insights. That's really the common denominator here, Susan.

[00:06:12] **Susan Kish:** I think that's very cool. I have to tell you I majored in history and science, so I am a huge believer in this concept of cross disciplinary, looking at where the points of intersection are, or they aren't, right? So one of the things you have a lot of work in, and you mentioned in the discussion around projects are these ilities, which is the second time I've heard that expression.

Can you tell us what the ilities are and why on earth we should be interested in the ilities?

[00:06:43] **Olivier de Weck:** Absolutely. Uh, so the ilities, it's an awkward word or expression, but it comes from the fact that many, many of the life cycle properties of systems, that only really manifest themselves over time, you know, once a system has been built and fielded and starts operating, then you discover over time whether it possesses these life cycle properties, these ilities that we're seeking.

And I'll give you an example and I have it right here I have a model of this is the main reason I came to the United States, this airplane here that you're seeing is actually

(Susan: What is it?) the Swiss. Well, it's the F 18, it's a model of the F 18 aircraft. This is flown by the Swiss Air Force you see it's got the Swiss emblem here.

So this is, uh, this is the F 18 and I worked on this airplane as a, as an engineer, as a liaison engineer in the 1990s, when this airplane was first acquired and then assembled in Switzerland for the Swiss Air Force. And I really, my, my love of systems and systems engineering started as a young Soldier and then officer in the Swiss Air Force, when we were tasked with maintaining building and operating these airplanes. And when it comes to airplanes, the first thing you care about is are they safe? Can they fly? Can they take off? Can they do their mission? Can they land? But that's really only part of the story. The other properties that these airplanes have to have, they have to be reliable and reliability. And notice reliability ends in ility, right? And then we have maintainability. There was a time when, um, not anymore, but I could tell you every little door and every little cover of this airplane, what's behind it, a hydraulic pump, an electric generator, the engines, the anti G suit, all the different parts, and parts are not perfect.

You know, like our human bodies, they wear and tear, they fail sometimes, they need to be at different speeds, they need to be replaced, they need to be repaired, if you want to maintain the system at a level of performance and safety that it should be at, you need to maintain it and so the ease of maintaining a system, we call it maintainability. And notice, that word also ends in ility. And then I'll give you one more, I'll give you one more. This airplane, like many other systems, was designed for a lifetime of about 30 years. And we are, at this point, getting close to the, not quite the end yet, but maybe we're two thirds through the lifetime of that system.

So, over those 30 years, the system needs to evolve.

The software needs to be upgraded, perhaps new equipment needs to be added to it and that's what we call flexibility. The flexibility to change and evolve the system over time and notice, flexibility also ends in ility. So the ilities is essentially a collection of these life cycle properties that capture how well does the system age, how well does the system perform over long periods of time, years, decades, sometimes even centuries.

[00:10:00] **Susan Kish:** How did you get interested in planes. Did you, when you joined the Swiss army, did you say, that's what I want to do or had you studied this at the ETH and therefore that was a logical place for you to go?

[00:10:12] **Olivier de Weck:** I wish ETH at the time had a aerospace engineering curriculum or department, it didn't. When I joined ETH, I did my best to create my own version of that. But it, it wasn't, I think the students today at ETH are very lucky because there's a lot more options in that space but the story of how I fell in love with flight, whether it's airplanes, helicopters, satellites, is a very simple story.

It's, I used to spend a lot of time in the mountains, in the Alps, and in, specifically in the Valais, in Zermatt. So my family had an apartment in Zermatt, and I spent a lot of time up there as a kid. And when you're in the mountains, especially at night, in the

winter, the nights are crystal clear. You look up to the night sky and you see the Milky Way galaxy.

You see the stars, you see the planets. So I just fell in love with the night sky in the Swiss Alps and, of course, you have the helicopters, so our apartment in Zermatt was you know, 300 meters away from the helicopter pad of Air -Zermatt. And they're probably the best helicopter pilots in the world up there but seeing all the amazing missions that these helicopters would do, mountain rescue, resupplying of the huts, so I just fell in love with looking up to the sky and seeing what's up there. And uh, and that was the root of it.

[00:11:37] **Susan Kish:** That is a wonderful story. So let's talk about space for a second, right? I was reading some of the work that you were doing around projects like pale red dot and the Artemis Accords, new metrics to measure performance of missions. What is most exciting about space right now? Because it sure seems like it's a much more interesting field than it was even 10 years ago.

[00:12:03] **Olivier de Weck:** That's very true. Space is really seeing a, I don't know if revival is the right word, but the interest in space is enormous, and we're seeing that with our students here at MIT. The number of students that are interested in working in the space field, whether it's science, space exploration, space science, space based astronomy.

I have three of my former students who are astronauts, one of them is actually on the International Space Station. Her name is Jasmin Moghbeli, I had her as a student in Unified Engineering. She's on the space station as we speak.

And

[00:12:37] **Susan Kish:** Does one WhatsApp with the space station, or how does this work?

[00:12:41] **Olivier de Weck:** You have to have special, you have to know the back channels, but we had a really cool live session with her a couple of weeks ago. And then one of my colleagues here on the faculty just got back from the ISS as well, so the ability to work in the space field is very strong here and it's become very attractive for, so for science, for commerce, for exploration.

And we have to be honest as well for defense, defense and intelligence, this is an area where, you know, we've been trying to keep space as a demilitarized zone, so to speak, but the realities of life and what's happening on our planet are catching up with space as well. But, uh, it is a very fascinating domain and there's the near earth space, so low earth orbit, medium earth orbit, and then geosynchronous orbit.

[00:13:29] **Susan Kish:** Okay.

[00:13:29] **Olivier de Weck:** That's where we have built large satellite constellations, for example, like Star link but now beyond that, uh, so in what we call cislunar space, this is the Earth Moon system, which includes the famous Lagrange points, which we

[00:13:44] **Susan Kish:** I have no idea what that is.

[00:13:46] **Olivier de Weck:** The Lagrange points, there's five of them. They're really interesting locations, and they're basically points where the gravity of the Earth and the Moon are offsetting each other.

So they're stable points, or semi stable points, in the Earth Moon system, where you can put a space station, or a space telescope, and it'll stay there with no or only minimal propellant. They're really interesting points.

[00:14:11] **Susan Kish:** That's cool. And there are five of these places?

[00:14:15] **Olivier de Weck:** And there are five Lagrange points in, uh, in every pair of planets. Earth Moon, or Earth Sun, has five Lagrange points, yeah. And, uh, these are named after the famous, uh, French mathematician, Lagrange, who really discovered these based on calculations alone, and we've now confirmed that these Lagrange points exist, and they're very significant for exploration.

[00:14:39] **Susan Kish:** So I'm going to have to ask you, when will we be putting colonies on Mars? And if I understood one of your papers, you were basically arguing, we can't do it small, you can't do it like with 10 people. You got to, if we're going to do it, we got to do it big. But can you talk to us about Mars?

[00:14:56] **Olivier de Weck:** Absolutely. Mars is, in some sense, the planet, we could, I guess we could call it the sister planet to Earth. It is the planet that's most similar to Earth in several ways, its gravity is 0.38, so 38 percent gravity compared to Earth Mars is smaller, it has an atmosphere, it's thin, it's about 1 percent the atmosphere of Earth and it's a lot of CO2, but it does have an atmosphere, so it has some protection. The day on Mars is just about 40 minutes longer than on Earth, so it's, it's a very similar day and so there are a lot of similarities, so Mars would be probably the best place to put a human settlement. I should also say, you mentioned the space colonies, and this is a really interesting thing that's happened is, we don't use that word anymore, space colony, I know a lot of people are still using it, but we started not using the word space colony anymore because colonization has this kind of negative connotation on earth. I think we're still reckoning or realizing the many negative things of colonization, so our goal is not to colonize Mars in this sort of imperial sense, but to settle it, to create a new multi, multi planetary society on Mars that will initially, of course, be fully dependent on earth, but eventually hopefully develop more earth independence.

And achieving that is a huge challenge, it's a technological challenge, it's a logistical challenge, and it's probably a cultural challenge, too.

[00:16:28] **Susan Kish:** Very cool. Do you think it will happen in our lifetimes?

[00:16:31] **Olivier de Weck:** I don't know for sure, honestly, and I used to really care about that a lot, but a human lifetime, what is the average life expectancy now? It's 80 years, something like that, 85.

Switzerland has a great life expectancy. I don't know, I hope so, I hope that I will see the first human landing on Mars. I think there's a good chance for that, but to really establish a foothold there and a permanent presence, it's going to take many decades. A human lifetime compared to the history of our planet, the history of our civilization, it's really just a blip.

So we need to think big here, we need to think multi generational.

[00:17:09] **Susan Kish:** You use an expression in one of your interviews about a Sagrada Familia referring to the Cathedral in Barcelona, that it's got a, which started in 1882, it won't be done until whatever, two, three years from now. And used that as an analogy, which I thought was lovely, right? Human dimensioned, but very effective in terms of saying, you know, not everything gets done during our lives, sometimes it goes beyond and that's fine. That's fine.

[00:17:37] **Olivier de Weck:** That's right. Gaudi, I think Gaudi, the architect of the Sagrada Familia, I don't know if you, have you been to the Sagrada Familia, Susan?

[00:17:45] **Susan Kish:** It's wild.

[00:17:47] **Olivier de Weck:** It´s an incredible experience when you're in there, and it's almost like standing in a forest, but it's a, it's an artificial building. And Gaudi, I think when he set out to build that cathedral, knew that it wasn't going to be completed in his lifetime.

But I think he was okay with that.

[00:18:04] **Susan Kish:** There's a certain humility that comes with that, combined with a sense of grandeur. Let's talk about the ETH. You studied industrial engineering, and it sounds like you were trying to wiggle your way to studying the topics you're really fascinated by and then you went and worked in the Army on the F 18, and then you went to MIT?

Or how did you get to MIT? Because once you got to MIT, it looks like you stayed there.

[00:18:27] **Olivier de Weck:** Yes, I did. So my choice of ETH was really easy. I think I always knew when I was in high school, I got my Matura, as it's called, right? And I think it's changed a bit since then, but I did Matura type C, which was, you know, the mathematical scientific direction in Fribourg. That's my hometown, half German, half French speaking.

And I knew I wanted to study. Yeah, it's it's a very old town. You know, I knew I wanted to study engineering. There was a bit of a choice I had to make between either, I was going to study mechanical, you know, aerospace engineering, or biological engineering. That was the other direction that interested me, but I

[00:19:05] **Susan Kish:** That would have been cool.

[00:19:06] **Olivier de Weck:** Yes, and in fact, bioengineering is also a very interesting field. Anyway, so I chose more the mechanical engineering route, I did my military service in in, in Payerne, which is the headquarters of the Air Force, the ground Air Force, where airplanes are flown and maintained and all of that and I loved it, I loved my military service in Switzerland, it was really formative in many ways. I showed up at ETH in the fall of 1987.

[00:19:33] **Susan Kish:** Hmm.

[00:19:33] **Olivier de Weck:** And I was a little bit younger than most of my fellow students. I was 18 when I started ETH. I had skipped a year in high school for reasons that I can explain, but because I was actually in, it was actually in Graubünden, you know, in the Grison for a couple years in, in boarding school there while my parents were in Washington on sabbatical.

Anyway, the fact that the school year, I don't know if it's changed now in Switzerland, but at the time, the different cantons, the school years start and end in the different cantons in Switzerland was not the same.

[00:20:04] **Susan Kish:** No, I think it is still the same. It's, it allows a fair amount of cantonal independence.

[00:20:10] **Olivier de Weck:** Exactly. So I kind of exploited that, uh, in a sense and so I showed up at ETH as an 18 year

[00:20:16] **Susan Kish:** Are you saying you arbitrage the Swiss school system?

[00:20:19] **Olivier de Weck:** Absolutely. And so I showed up at ETH as an 18 year old, and I enrolled in Department 3A, which was 3A, Maschinenbau, which now, I think the ETH's been reorganized, but it would be MAF T, I think, the MAF T department.

And I did that for two years, and I really enjoyed it but, but then ETH created a new curriculum, which at the time was called 3E, Betriebs- und Produktionswissenschaften, which in English we would call Industrial Engineering. And I jumped on it right away, we were the first year, the curriculum was still very fluid, so we had a lot of freedom and what appealed to me was, it wasn't just about designing components or mechanical machines, but it was also understanding the production system, the logistic system that surrounds these machines and this kind

of systems thinking that we actually had a formal course in systems engineering, I took that, I loved it and that became, began my journey to, to where I am today.

[00:21:23] **Susan Kish:** So recently, I think ETH launched a space program that sounds extraordinarily interdisciplinary and multidisciplinary. This whole sort of range of work around it. Would you ever go back?

[00:21:37] **Olivier de Weck:** Well, I think it's a very exciting program, I know Thomas Zurbuchen, right, who came back from NASA to head that program. I think it's a very exciting time. I don't know if I'll come back, but if that program had existed when I was a student,

[00:21:50] **Susan Kish:** I was like, you would have signed

[00:21:52] **Olivier de Weck:** I might have signed up and not actually come to the United States, because the opportunities would have been so great in Switzerland, which at the time they, they weren't yet, so I'm really excited to hear about this new space program at ETH, and I'm, I'm happy to help out in any way.

[00:22:07] **Susan Kish:** Fantastic. Fantastic. Olivier, thank you so much. This has been a great conversation, I've got a few closing questions we'd love to ask. One of which I think you've already answered, which is when you were young and growing up in Zermatt, what did you want to be when you grew up?

[00:22:23] **Olivier de Weck:** Okay. There were really two professions that I had in mind, very different ones. One was to be an astronomer and I think I explained being at the night sky in the Alps, and I still to this day, I love astronomy. The one thing that held me back from astronomy, pure astronomy, was that when you're an astronomer, you're observing these very distant planets and galaxies, but you really can't change them. We can just observe and describe them and maybe discover them, but you can't really affect them directly and so I think the reason that I chose aerospace engineering as opposed to pure astronomy is that engineering is a very active profession.

[00:23:02] **Susan Kish:** You see the result of your work.

[00:23:04] **Olivier de Weck:** Exactly. Little did I know that there's a wonderful intersection between the two, which is actually the engineering of telescopes, whether they're ground telescopes or space telescopes and that's actually one of the, one of the areas that I'm working in is engineering, designing, optimizing telescopes, space telescopes, that was what my PhD was about. So astronomy was one and then the other one was being a chef, a professional chef. You

[00:23:31] **Susan Kish:** how cool.

[00:23:32] **Olivier de Weck:** I just love good food, you know, I guess you can call me a foodie. And, I will tell you this. I, I did not pursue that direction myself but my wife,

who I met in St. Louis, my wife's American, she's also Swiss now, she's a dual citizen, is in chef school right now, as we speak. Now that we're empty nesters.

[00:23:51] **Susan Kish:** Cool, isn't

[00:23:51] **Olivier de Weck:** training to become a professional chef. My wife is becoming a professional chef and I'm living that dream through her.

[00:23:59] **Susan Kish:** That is very cool. I bet dinner is a lovely occasion on your house.

[00:24:03] **Olivier de Weck:** It's amazing.

[00:24:06] **Susan Kish:** What is really capturing your curiosity right now? What do you think is the most compelling area of development?

[00:24:14] **Olivier de Weck:** I am Susan, you mentioned that you studied history, and I really love history as well, I think the history of technology, I published a book last year on technology planning and road mapping, and it's very future oriented but if you want to really understand the future, you have to understand history of humanity.

So I'm thinking what I'm fascinated by is the arc of human civilization and how it's evolved over the last let's say millennia. It's really millions of years but let's say a few centuries or a few millennia where technology really has started to play a major role in the evolution of our species, of our civilization.

And so what I'm fascinated by is extrapolating that into the future, not just five years or ten years, but decades, centuries or even millennia from now. What will Human civilization be like on our planet,

[00:25:12] **Susan Kish:** Mm hmm.

[00:25:12] **Olivier de Weck:** beyond our planet, and we don't really know. I don't know. I mean, I've studied this question a lot, and it could go really well, and it could go really poorly.

There's some really not good outcomes for us as a civilization, but there's some positive ones as well and my hope is that through research, through building, better technologies, more sustainable technologies, building better complex systems, you know, that, that operate better over their lifetime, that we can push the odds of a favorable outcome for our civilization in future centuries and even future millennia.

That's my hope.

[00:25:49] **Susan Kish:** Which leads logically to our next question, which is what are the books that you're reading or the podcast you're listening to? Because I have to say, do you actually read, do you read science fiction or the dystopian futures that

[00:26:03] **Olivier de Weck:** Oh

[00:26:03] **Susan Kish:** many authors read about?

[00:26:05] **Olivier de Weck:** Of course, I've read, uh, Asimov, you know, the Foundation series, Kurt Vonnegut, who may not be very well known in Switzerland, but maybe you know about him, uh, he's, he's really an interesting, a very funny author too, he used to live on Cape Cod and Sirens of Titan, for example, is a really interesting book that, that Kurt Vonnegut wrote.

And it's full of humor and it, yeah, I guess you could call it science fiction, but it's science fiction with some silliness and some humor in it that's just wonderful. I am just finishing up the biography of Elon Musk right now.

[00:26:38] **Susan Kish:** The Walter Isaacson book.

[00:26:39] **Olivier de Weck:** The Walter Isaacson book, I think very highly of Walter Isaacson as a biographer, you know, I've read the biographies of Jennifer Doudna, of course, Steve Jobs, John Adams, and others. I love reading biographies of people that have had a vision and influence in society, and, and I think there's a lot to learn still.

[00:26:57] **Susan Kish:** There is a lot to learn. And then finally, when you go back to Zurich, we, or if you go back to Zurich, what's your favorite place to go? Where do you like to hang out?

[00:27:07] **Olivier de Weck:** I know this is totally stereotypical, what I'm going to say now, but I just love the Mensa, you know. The Mensa in the main campus and then there's the Mensa downstairs, down the steps and then you have the cafe, where you can sit, if it's warm, you sit outside, you overlook the city of Zurich, the lake, the, the

[00:27:27] **Susan Kish:** Mm hmm. (Olivier: mountains)

[00:27:28] **Olivier de Weck:** I don't know that ETH students are aware how lucky they are. The quality of the food, the cafe, the togetherness, the amazing views, the location of ETH itself overlooking the city, MIT is great, we have the Charles River, we have downtown Boston, we have a lot of similar things they're a little different, but that's when I'm really happy, back in Zurich, is when I have a coffee and a little croissant, sitting on the terrace, uh, at the Mensa, looking out over the city and just reminiscing of my time there as a student.

[00:28:02] **Susan Kish:** Fantastic, fantastic. Olivier, thank you so much. Really appreciate your time today.

[00:28:07] **Olivier de Weck:** My pleasure, Susan.

[00:28:09] **Susan Kish:** I'm Susan Kish, host of the We Are ETH series, telling the story of the alumni and friends of the ETH Zurich, the Swiss Federal Institute of Technology. ETH regularly ranks amongst the world's leading universities with cutting edge research, science, and people.

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