SILICON VALLEY

PODCAST

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00:00:00,399 --> 00:00:06,029
Host (Matthew Buffington): Welcome to the
NISV podcast, this is episode 66. And sitting

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00:00:06,029 --> 00:00:09,480
with me again I have Abby. Abby, tell us about
our guest today.

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00:00:09,480 --> 00:00:14,139
Abby Tabor: Hey, Matt. Today we're talking
with Stevan Spremo. He works in the Chief

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00:00:14,139 --> 00:00:18,320
Engineers office here at Ames, and basically
his job is to guide other engineers through

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00:00:18,320 --> 00:00:22,929
the development of hardware that's going
to go into space, and carry life sciences

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00:00:22,929 --> 00:00:27,939
missions, for example. So Stevan started as
an electrical engineering student at San Jose

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00:00:27,939 --> 00:00:31,609
State [University], but he knew he wanted
to work with medical technologies or life

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00:00:31,609 --> 00:00:36,860
sciences, which is cool. And so he found the
perfect role for that here. And he's worked

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00:00:36,860 --> 00:00:41,290
on cancer research that's flown on the space
shuttle, and studying how plants grow in space,

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00:00:41,290 --> 00:00:46,780
and then coming right up in November, he has
a new mission launching, it's a small sat

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00:00:46,780 --> 00:00:51,260
called EcAMSat, which he’ll explain. But
this one’s very cool, it’s about studying

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00:00:51,260 --> 00:00:58,430
how bacteria are resistant to our antibiotics,
and whether that’s worse in space, and how

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00:00:58,430 --> 00:01:03,960
it all works to make things better for astronaut
health, and also for public health here on

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00:01:03,960 --> 00:01:04,960
Earth.

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00:01:04,960 --> 00:01:07,530
Host: It’s always the thing I get a kick
out of. Everybody thinks of NASA, they think

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00:01:07,530 --> 00:01:12,470
of rockets, they think of telescopes looking
out. But there’s a huge biology aspect.

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00:01:12,470 --> 00:01:16,640
And not just the astrobiology of looking out
into the stars and trying to find life…

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00:01:16,640 --> 00:01:17,640
Abby Tabor: No, but here.

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00:01:17,640 --> 00:01:21,440
Host: …but understanding biology. And it’s
like this really neat overlap. Before we go

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00:01:21,440 --> 00:01:28,250
too far into it, just a reminder, if you want
to give comments, participate, give any kind

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00:01:28,250 --> 00:01:34,830

of feedback, we have a phone number, it’s
650-604-1400. But if you want to do it the

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00:01:34,830 --> 00:01:41,270
new hip way, we’re using the hashtag #NASASiliconValley,
we’re on all the social media platforms

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00:01:41,300 --> 00:01:46,480
that you can think of. So without any further
delay, here is Stevan Spremo.

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00:01:49,380 --> 00:01:58,740
[Music]

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00:01:58,740 --> 00:02:03,020
Host: Welcome, Stevan. [Laughs] So we always
start this off the same way. Tell us a little

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00:02:03,020 --> 00:02:06,890
bit about yourself. How did you get to NASA?
How did you get to Silicon Valley?

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00:02:06,890 --> 00:02:15,769
Stevan Spremo: Thanks for having me. I got
to NASA – the story is when I was very young

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00:02:15,769 --> 00:02:22,329
in third grade, my brother and I were writing
to NASA to try to get like public outreach-type

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00:02:22,329 --> 00:02:27,139
photos of the space shuttle or the planets
and things like that. And we actually got

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00:02:27,139 --> 00:02:33,209
responses, which was really cool. So that
gained my interest when I was really young.

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00:02:33,209 --> 00:02:38,060
And then through high school I had more interest

as I learned chemistry and physics and went

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00:02:38,060 --> 00:02:43,999
through all my classes. And I just really
had this desire to come work for NASA. I really

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00:02:43,999 --> 00:02:50,389
wanted to be an astronaut and went through
college, and I got an internship in 1998 –

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00:02:50,389 --> 00:02:51,489
Host: Awesome. Yeah.

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00:02:51,489 --> 00:02:53,220
Stevan Spremo: – at NASA Ames here.

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00:02:53,220 --> 00:02:56,749
Host: Oh really. So were you already local
so you already knew about Ames, or did you

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00:02:56,749 --> 00:02:57,749
come from somewhere else?

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00:02:57,749 --> 00:03:01,879
Stevan Spremo: Yeah, I'm local from the Bay
Area here in the Silicon Valley. And I went

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00:03:01,879 --> 00:03:08,230
to San Jose State and was an electrical engineering
student. And in 1998 I joined a group called

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00:03:08,230 --> 00:03:15,400
Sensors 2000. I was doing life sciences, biological
sensors. So I was an electrical engineer,

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00:03:15,400 --> 00:03:20,780
and I had this focus that I wanted to combine
electrical engineering with medical technology

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00:03:20,780 --> 00:03:26,769
or life sciences experiments. And I thought
there was a real future to that. And it was

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00:03:26,769 --> 00:03:32,959
my future. And I started working on space
experiments that included biological sensors,

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00:03:32,959 --> 00:03:33,959
so –

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00:03:33,959 --> 00:03:37,209
Host: Okay. So it was like – so as a kid
you were like, this is NASA. This is what

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00:03:37,209 --> 00:03:40,639
I want to do. And then that kind of helped
shape like what you studied.

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00:03:40,639 --> 00:03:46,269
Stevan Spremo: Yeah. I mean, I had this very
specific focus of what I thought I needed

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00:03:46,269 --> 00:03:50,939
to study. So like in college I had the electrical
engineering courses, but I took classes like

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00:03:50,939 --> 00:03:56,670
zoology and extra chemistry that biologists
would take. So I really kind of started learning

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00:03:56,670 --> 00:04:03,159
the language of scientists as well. And basically
my career has been listening to requirements

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00:04:03,159 --> 00:04:08,489
of scientists on what they need to study in
space, and then I help design it.

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00:04:08,489 --> 00:04:13,769

Host: One of the things that Ames – bioscience
studies, it's like the experiments, the science

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00:04:13,769 --> 00:04:17,330
experiments that actually go up into the International
Space Station or went on the shuttle. So did

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00:04:17,330 --> 00:04:21,299
you already know that that was a thing that
Ames was already doing, or is it just happened

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00:04:21,299 --> 00:04:24,360
to be that what you were interested in matched
with what was already here?

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00:04:24,360 --> 00:04:34,009
Stevan Spremo: I had some knowledge that Ames
was involved in life sciences. We had a friend

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00:04:34,009 --> 00:04:38,270
of the family that had been working on experiments
at NASA. And so I did have some knowledge.

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00:04:38,270 --> 00:04:41,710
Host: You had the inside track. You knew what
people were already doing, a little bit.

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00:04:41,710 --> 00:04:43,180
Stevan Spremo: A little bit, yeah.

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00:04:43,180 --> 00:04:47,520
Host: And then when you did internship, did
you just like go online? Did you know somebody?

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00:04:47,520 --> 00:04:49,180
How did that work out for you?

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00:04:49,180 --> 00:04:55,889
Stevan Spremo: When I joined here, I did have
someone who introduced me to the whole internship

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00:04:55,889 --> 00:05:02,210
program. But it wasn't like a direct in. So
I interviewed with I think it was – I don't

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00:05:02,210 --> 00:05:05,020
have a count – but maybe like 15 managers.

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00:05:05,020 --> 00:05:06,540
Host: Really. That's –

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00:05:06,540 --> 00:05:11,860
Stevan Spremo: And so what happened is I kind
of had this very specific goal or dream of

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00:05:11,860 --> 00:05:15,620
what I wanted to do. And they said, "Well,
you really need to meet with this one specific

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00:05:15,620 --> 00:05:19,909
manager." And he was out on medical leave
for a number of months. So what they kind

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00:05:19,909 --> 00:05:24,229
of did was interview me and see if there were
a number of different positions onsite that

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00:05:24,229 --> 00:05:30,530
I would fit with. But then they kept saying,
"You belong in the Sensors 2000 group." And

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00:05:30,530 --> 00:05:36,490
fortunately, they decided to take me on as
an intern. And then they converted me to a

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00:05:36,490 --> 00:05:40,300
full-time civil servant later. And then I
got my position.

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00:05:40,300 --> 00:05:46,270
So I was a co-op student, which is a civil
servant student, while I was going to school

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00:05:46,270 --> 00:05:47,670
at San Jose State in electrical engineering.

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00:05:47,670 --> 00:05:51,889
Host: Yeah. Nowadays they've replaced it with
what's called the Pathways program. But before

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00:05:51,889 --> 00:05:55,930
it was like they had different variations
of co-op where people would be able to go

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00:05:55,930 --> 00:06:00,500
to school and also work at the same time,
or some mix of that, and then basically get

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00:06:00,500 --> 00:06:01,770
into the civil service afterwards.

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00:06:01,770 --> 00:06:05,950
Stevan Spremo: Yeah. That's – I started
out as a civil servant from day one as a student.

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00:06:05,950 --> 00:06:08,050
So all that time counted towards my –

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00:06:08,050 --> 00:06:09,050
Host: Oh that's awesome.

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00:06:09,050 --> 00:06:11,729
Stevan Spremo: – retirement and all those
things. So we were getting those benefits

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00:06:11,729 --> 00:06:12,729
first – civil service.

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00:06:12,729 --> 00:06:18,020
Host: So when you come on while you're working
in this group, what is some of the stuff that

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00:06:18,020 --> 00:06:19,449
you're working on initially?

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00:06:19,449 --> 00:06:25,439
Stevan Spremo: So I worked on these electrochemical
sensors. When I came to NASA, I was actually

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00:06:25,439 --> 00:06:30,880
starting to run a wet chemistry lab, which
was a little unusual being an electrical engineering

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00:06:30,880 --> 00:06:31,880
student.

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00:06:31,880 --> 00:06:32,880
Host: I was going say, yeah.

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00:06:32,880 --> 00:06:37,620
Stevan Spremo: And so what I was building
was electrochemical sensors to measure metabolic

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00:06:37,620 --> 00:06:44,810
changes for cancer cells that are growing.
So we look at pH changes in cancer cells.

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00:06:44,810 --> 00:06:50,659
And the whole system that we were working
on was an automated system that would sustain

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00:06:50,659 --> 00:06:53,969
life for C6 neuroblastoma cells, brain cancer
cells.

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00:06:53,969 --> 00:06:56,550
Host: Okay [laughs]. I was like thank you
for clarifying [laughs].

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00:06:56,550 --> 00:07:01,889
Stevan Spremo: And so we were – the idea
is to fly this up on the space shuttle on

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00:07:01,889 --> 00:07:10,189
STS-93, which was a Columbia mission. In 1999
it launched. And we worked with the Army,

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Walter Reed Army Institute of Research. And
the sensors were direct inline measurements

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00:07:15,400 --> 00:07:20,449
with the cells. And so, as in microgravity
environment changed, we were looking to see

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00:07:20,449 --> 00:07:25,900
if cancer grew differently in space. And so
the sensors I developed, I built like 150

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00:07:25,900 --> 00:07:29,280
sensors, and I think 16 of them flew to space
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00:07:29,280 --> 00:07:30,280
Host: Oh wow.

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00:07:30,280 --> 00:07:34,770
Stevan Spremo: – and made these detections.
So we had spares and extras in selecting the

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00:07:34,770 --> 00:07:39,050
best of the group. But they were from scratch.
We literally built them a hundred percent

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00:07:39,050 --> 00:07:44,570
in the lab and then interfaced them with an
electrical system that read it out, stored

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00:07:44,570 --> 00:07:47,490
it, and then we retrieved the data when it
came back from space.

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00:07:47,490 --> 00:07:52,310
Host: Crazy. Because like oftentimes when
you think of like, cancer research, NASA isn't

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00:07:52,310 --> 00:07:56,520
the first thing that pops into your brain.
So – but in the end, it's like understanding

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00:07:56,520 --> 00:08:03,159
how things grow with little to no gravity
helps you to better understand how those things

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00:08:03,159 --> 00:08:08,460
operate. And as you can understand them, you
can better fight them or cure them or move

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00:08:08,460 --> 00:08:09,460
them along.

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00:08:09,460 --> 00:08:13,360
Stevan Spremo: Right. Yeah. It was kind of
an amazing opportunity to merge technologies

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00:08:13,360 --> 00:08:16,599
and then benefit this cancer research, so
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00:08:16,599 --> 00:08:20,659
Host: And so even thinking about those sensors,
I'm trying to think. So what does that exactly

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00:08:20,659 --> 00:08:26,069
look like? Is it like a petri dish or some
thing with the actual cells in it, and then

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00:08:26,069 --> 00:08:30,159
you have your sensors that like kind of read
it? What kind of changes are you looking at?

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00:08:30,159 --> 00:08:36,710
Stevan Spremo: So there were fluidic loops,
so it was called Biona-C. And there'd be hollow

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00:08:36,710 --> 00:08:41,770
fiber bioreactors that would grow the cells.
And then there were media that was fed to

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00:08:41,770 --> 00:08:47,880
the cells so it sustained life. And that would
circulate through with a pump. And then from

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00:08:47,880 --> 00:08:54,190
time to time we would take measurements or
draws of fluid off from the sample where the

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00:08:54,190 --> 00:09:02,770
bioreactor was, measure the H+ ion content
or pH, and then read that out to a circuit

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00:09:02,770 --> 00:09:04,640
card, and then store the data.

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00:09:04,640 --> 00:09:08,950
And then we'd see trends to see how things
were growing in space versus on the ground.

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00:09:08,950 --> 00:09:13,481
So we had the identical system on the ground
as we did in space, looking for a difference

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00:09:13,481 --> 00:09:18,710
in any kind of metabolic activity. Do the
cells do something different in space or not?

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00:09:18,710 --> 00:09:25,270

And so that was the experiment. And it was
kind of a technology demonstration. The Army

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00:09:25,270 --> 00:09:28,190
was also interested for their own aspects
of research, too.

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00:09:28,190 --> 00:09:33,390
Host: So moving along from your work, then
what did that eventually move into, what other

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00:09:33,390 --> 00:09:35,750
things did you work on until you landed where
you are now?

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00:09:35,750 --> 00:09:40,530
Stevan Spremo: Right. So the next experiment
I worked on was a space station experiment.

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00:09:40,530 --> 00:09:43,040
It was called European Modular Cultivation
System.

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00:09:43,040 --> 00:09:47,950
Host: Okay, and [laughs]. You can – yes,
tell me about that [laughs].

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00:09:47,950 --> 00:09:53,470
Stevan Spremo: So that EMCS was a – it's
a centrifuge system that's up on space station

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00:09:53,470 --> 00:10:00,010
right now. And we designed some cartridges
that basically plug into that system. And

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00:10:00,010 --> 00:10:03,331
we were growing plants – plant seedlings
– in space, so

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00:10:03,331 --> 00:10:04,331

Host: Okay.

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00:10:04,331 --> 00:10:09,410
Stevan Spremo: – we were studying Arabidopsis
thaliana seedlings, in which we were doing

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00:10:09,410 --> 00:10:10,980
a phototropic response.

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00:10:10,980 --> 00:10:11,980
Host: Okay.

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00:10:11,980 --> 00:10:16,870
Stevan Spremo: And so basically, we would
induce light and shine light on these while

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00:10:16,870 --> 00:10:21,920
we were rotating it one-third gravity levels,
which is the equivalent of Mars – would

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00:10:21,920 --> 00:10:28,750
be the equivalent of Mars, one-sixth g which
is equivalent of the Moon. And then microgravity

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levels, basically looking at how plants grow
in space. There're basically photoreceptors

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00:10:34,360 --> 00:10:40,750
on plants that activate different responses.
And because in microgravity the plants grow

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00:10:40,750 --> 00:10:43,160
more in a tangled ball or confused state.

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00:10:43,160 --> 00:10:44,160
Host: Yeah.

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00:10:44,160 --> 00:10:49,670

Stevan Spremo: They don't grow as well. So
we were studying how do we, engineering-wise,

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00:10:49,670 --> 00:10:56,360
alter that by having light affect these photoreceptors.
And actually we can change how the roots actually

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00:10:56,360 --> 00:10:57,360
grow –

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00:10:57,360 --> 00:10:58,360
Host: Okay.

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00:10:58,360 --> 00:11:03,810
Stevan Spremo: – and how the green, leafy
portion or cotyledon portion would also grow.

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00:11:03,810 --> 00:11:08,090
And with the altered state, we look at the
RNA analysis for the genetic aspects, of what

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00:11:08,090 --> 00:11:15,060
was going on, to study how to go to the Moon
and Mars eventually. So that was another experiment

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00:11:15,060 --> 00:11:20,770
I worked on. I specifically worked on the
optics to make sure that the light was basically

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00:11:20,770 --> 00:11:22,760
equally being distributed across –

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00:11:22,760 --> 00:11:23,760
Host: Yeah.

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00:11:23,760 --> 00:11:28,690
Stevan Spremo: – all the plants, and a number
of other circuit-based designs that were supporting

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00:11:28,690 --> 00:11:33,270
that. And then also making sure it's biocompatible,
because when you lock everything in a chamber

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00:11:33,270 --> 00:11:37,710
there're other gasses or volatiles that come
off from the circuit boards or other things.

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00:11:37,710 --> 00:11:38,710
Host: All variations.

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00:11:38,710 --> 00:11:41,210
Stevan Spremo: And it can cause the biology
to die.

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00:11:41,210 --> 00:11:42,210
Host: To – oh.

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00:11:42,210 --> 00:11:47,120
Stevan Spremo: And so we had to do other things
to actually make sure that the air inside

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00:11:47,120 --> 00:11:53,020
the chamber was basically clean enough that
it wouldn't extend the life of these systems.

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00:11:53,020 --> 00:11:57,130
Host: And I guess that makes sense because
if you think of plants, which have evolved

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00:11:57,130 --> 00:12:03,790
over millions of years with gravity pulling
down on them, and then just seeing how once

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00:12:03,790 --> 00:12:08,880
you remove that gravity, you change it to
the Earth or Moon, different levels, I mean,

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00:12:08,880 --> 00:12:13,040
it helps us to understand if we're planning

on eventually going to Mars and doing things

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00:12:13,040 --> 00:12:16,610
that – to understand how those plants react.
But that's smart of thinking, like you've

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00:12:16,610 --> 00:12:23,100
seen plants move to get closer to the sunlight.
They kind of grow in those ways. So using

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00:12:23,100 --> 00:12:26,440
that to manipulate it to change the way it
grows is pretty neat.

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00:12:26,440 --> 00:12:30,800
Stevan Spremo: Yeah. So there're two responses
that we were studying: There's gravitropic

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00:12:30,800 --> 00:12:31,800
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00:12:31,800 --> 00:12:32,800
Host: Yeah.

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00:12:32,800 --> 00:12:35,670
Stevan Spremo: – and phototropic. So the
light, I guess, from what the botanists are

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00:12:35,670 --> 00:12:40,170
telling me, there's a photoreceptor. And we
were studying putting blue light and red light

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00:12:40,170 --> 00:12:44,490
on the roots. And actually you can make them
go away or toward those lights.

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00:12:44,490 --> 00:12:45,880
Host: Really. You can help control them.

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00:12:45,880 --> 00:12:49,880
Stevan Spremo: Yeah. So that – in addition
to the white light that's –

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00:12:49,880 --> 00:12:50,880
Host: Yeah.

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00:12:50,880 --> 00:12:54,330
Stevan Spremo: – kind of making the green,
leafy portion, assimilating the sun. And also

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00:12:54,330 --> 00:12:57,970
the roots actually do very specific things
with light as well.

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00:12:57,970 --> 00:13:02,190
Host: No, I get a kick out of it because typically
when people think of NASA, you think of rockets

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00:13:02,190 --> 00:13:05,760
and astronauts. But at the same time, it's
like, yay, you're in space, or you're on the

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00:13:05,760 --> 00:13:09,310
Moon, or you're on Mars. At the end of the
day, what are you going to do there?

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00:13:09,310 --> 00:13:10,310
Stevan Spremo: Yeah.

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00:13:10,310 --> 00:13:13,800
Host: So this is what these science experiments
– there're questions, there're hypotheses

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00:13:13,800 --> 00:13:18,290
to figure out, okay, what can we learn by
being in these places that we can't learn

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00:13:18,290 --> 00:13:23,960
from Earth, and kind of working out those

theories. So what are you working on now?

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00:13:23,960 --> 00:13:25,820
What's kind of like your day job?

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00:13:25,820 --> 00:13:28,910
Stevan Spremo: So I'm in the Chief Engineer's
office here –

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00:13:28,910 --> 00:13:29,910
Host: Okay.

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00:13:29,910 --> 00:13:35,830
Stevan Spremo: – at NASA Ames, which there's
a number of things I do in that role. I've

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00:13:35,830 --> 00:13:41,460
been at NASA 18 years now, and I get called
in if there's maybe a problem on –

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00:13:41,460 --> 00:13:42,460
Host: Mm-hmm.

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00:13:42,460 --> 00:13:46,490
Stevan Spremo: – hardware development that
can't be figured out, or there was a mishap,

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00:13:46,490 --> 00:13:50,720
something went wrong. I'm trying to figure
out lessons learned, like why did we have

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00:13:50,720 --> 00:13:56,440
something go wrong in the first place and
identifying root cause. So also there's a

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00:13:56,440 --> 00:14:02,450
number of standards and procedures, like it's
almost like a prescription. Before you start

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00:14:02,450 --> 00:14:08,110
a project, like how do you formulate it to,
I don't know, it's not to guarantee success,

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00:14:08,110 --> 00:14:10,150
but to increase chances of success.

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00:14:10,150 --> 00:14:11,150
Host: Yeah.

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00:14:11,150 --> 00:14:15,880
Stevan Spremo: So that's kind of my role is
to work with engineers and guide them and

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00:14:15,880 --> 00:14:19,770
put some, I guess, milestones or gates to
do checks.

204
00:14:19,770 --> 00:14:21,040
Host: A checklist, of sorts.

205
00:14:21,040 --> 00:14:25,050
Stevan Spremo: Yeah, it's like the equivalent
of a checklist to make sure that you've completed

206
00:14:25,050 --> 00:14:29,200
a number of tasks that would help in the reliability
of a system.

207
00:14:29,200 --> 00:14:33,510
Host: Well, you figure if something's going
to go wrong, you'd rather it go wrong here

208
00:14:33,510 --> 00:14:38,780
at Ames where you're like – you're working
on experiments. Like [you'd] rather that it

209
00:14:38,780 --> 00:14:43,350
go wrong here while we're practicing as opposed
to while it's in space. So it's kind of, learn

210
00:14:43,350 --> 00:14:44,570
some of those lessons.

211
00:14:44,570 --> 00:14:51,510
Stevan Spremo: Right. Absolutely. So we take
things to the test chambers here - the vacuum

212
00:14:51,510 --> 00:14:57,300
chamber or the vibration shake table. And
we simulate all the things that might go on

213
00:14:57,300 --> 00:15:04,330
in space to try to basically mitigate – or
make sure that doesn't happen in space, so

214
00:15:04,330 --> 00:15:10,790
an astronaut is not experiencing a piece of
gear that is failing for any reason. So yes,

215
00:15:10,790 --> 00:15:11,790
that's kind of what –

216
00:15:11,790 --> 00:15:14,370
Host: [Laughs] Tested in advance. "That's
kind of what I do."

217
00:15:14,370 --> 00:15:15,370
Stevan Spremo: Yeah.

218
00:15:15,370 --> 00:15:20,180
Host: Because I always think about it of not
only being in space or surviving like the

219
00:15:20,180 --> 00:15:25,400
vacuum or harsh conditions, but it's like
you've also got to survive a rocket launch

220
00:15:25,400 --> 00:15:30,900

so that with the very intense moments where
you don't want your science experiment to

221
00:15:30,900 --> 00:15:33,420
fall apart [laughs] on its way up.

222
00:15:33,420 --> 00:15:38,530
Stevan Spremo: Right. There're basically 10
to 15 minutes that it's a pretty harsh environment

223
00:15:38,530 --> 00:15:43,660
going up and through different stages of the
mission of firing a rocket engine. There're

224
00:15:43,660 --> 00:15:45,850
vibrations and there're other environmental
effects.

225
00:15:45,850 --> 00:15:46,850
Host: Acoustics.

226
00:15:46,850 --> 00:15:52,320
Stevan Spremo: Acoustics, and absolutely.
And just the change to vacuum as well once

227
00:15:52,320 --> 00:15:57,270
you get in the vacuum of space and the thermal
extremes, and so after you're past that launch

228
00:15:57,270 --> 00:16:02,460
phase. But yeah, there're a number of environments
we test for, yes. So –

229
00:16:02,460 --> 00:16:08,070
Host: So okay. So now I've heard of one of
the things that you're working on called EcAMSat.

230
00:16:08,070 --> 00:16:10,170
So that sounds like a fancy acronym.

231
00:16:10,170 --> 00:16:11,280
Stevan Spremo: Yeah.

232
00:16:11,280 --> 00:16:12,980
Host: Tell us a little bit about what that
is.

233
00:16:12,980 --> 00:16:17,690
Stevan Spremo: So it's – EcAMSat stands
for E-coli Antimicrobial Satellite.

234
00:16:17,690 --> 00:16:18,690
Host: Okay.

235
00:16:18,690 --> 00:16:26,080
Stevan Spremo: And so what we're studying
on this -- it's a CubeSat. So it's a 6U spacecraft.

236
00:16:26,080 --> 00:16:31,650
6U is like a standard – it's basically roughly
a shoebox size –

237
00:16:31,650 --> 00:16:32,650
Host: Yeah.

238
00:16:32,650 --> 00:16:33,650
Stevan Spremo: – like a large shoebox.

239
00:16:33,650 --> 00:16:34,840
Host: Or a loaf of bread or something. It
kind of –

240
00:16:34,840 --> 00:16:38,590
Stevan Spremo: Yeah, this particular one is
kind of like two loaves of bread –

241
00:16:38,590 --> 00:16:39,590
Host: Okay.

242
00:16:39,590 --> 00:16:44,790
Stevan Spremo: – in size as a good comparison.
And we're studying antibiotic resistance in

243
00:16:44,790 --> 00:16:45,930
space, which is –

244
00:16:45,930 --> 00:16:46,930
Host: Okay.

245
00:16:46,930 --> 00:16:51,180
Stevan Spremo: – a really big problem on
the ground, as well as may impact future travel

246
00:16:51,180 --> 00:16:55,740
for astronauts in the future. And what we
are finding out through a number of other

247
00:16:55,740 --> 00:17:01,000
experiments that have gone up – and this
will help validate what we're learning – is

248
00:17:01,000 --> 00:17:08,089
that E. coli or yeast or a number of bacteria
are more virulent in space. They actually

249
00:17:08,089 --> 00:17:09,650
grow at a rapid pace.

250
00:17:09,650 --> 00:17:11,110
Host: Oh really. They're like stronger in
space.

251
00:17:11,110 --> 00:17:12,110
Stevan Spremo: They're stronger.

252
00:17:12,110 --> 00:17:13,110
Host: Oh wow.

253
00:17:13,110 --> 00:17:16,030
Stevan Spremo: And the effects are – this
was an unexpected –

254
00:17:16,030 --> 00:17:17,030
Host: Yeah.

255
00:17:17,030 --> 00:17:21,270
Stevan Spremo: – outcome. And so there's
a parallel between the ground and what we

256
00:17:21,270 --> 00:17:24,820
live – are experiencing on the Earth, antibiotic
resistance, and trying to figure out what

257
00:17:24,820 --> 00:17:26,290
mechanism's causing that in space.

258
00:17:26,290 --> 00:17:27,290
Host: Okay.

259
00:17:27,290 --> 00:17:33,600
Stevan Spremo: So EcAMSat is going into a
microgravity environment, taking a 48-well

260
00:17:33,600 --> 00:17:37,340
plate microfluidics array. Basically each
one of those –

261
00:17:37,340 --> 00:17:38,340
Host: Okay, yeah.

262
00:17:38,340 --> 00:17:43,560
Stevan Spremo: So it's a fluidics card that
has milliliters in scale –

263
00:17:43,560 --> 00:17:44,560
Host: Okay.

264
00:17:44,560 --> 00:17:47,780
Stevan Spremo: – of fluid going through
it. So imagine – the best way I've been

265
00:17:47,780 --> 00:17:52,000
able to explain the volume of each one of
these little cells is like an eraser head.

266
00:17:52,000 --> 00:18:00,380
So imagine 48 eraser head, like a pencil eraser,
worth of volume on a card. And we flow through

267
00:18:00,380 --> 00:18:04,620
different antibiotic strains. So we grow up
the cells. So we put it in hibernation before

268
00:18:04,620 --> 00:18:05,620
launch.

269
00:18:05,620 --> 00:18:06,620
Host: Okay.

270
00:18:06,620 --> 00:18:09,510
Stevan Spremo: And it sits on the pad. It's
in hibernation. We get up to space –

271
00:18:09,510 --> 00:18:11,310
Host: It launches. It goes to the space station.

272
00:18:11,310 --> 00:18:15,540
Stevan Spremo: And then when it gets up to
space, it has a deployer, a dispenser.

273
00:18:15,540 --> 00:18:16,540
Host: Okay.

274
00:18:16,540 --> 00:18:21,370
Stevan Spremo: And then a door opens. There's
a container it rides up in. And after the

275
00:18:21,370 --> 00:18:28,060
primary satellite is gone and we can do no
harm to it, the doors open and we eject this

276
00:18:28,060 --> 00:18:29,620
out with a spring pusher foot.

277
00:18:29,620 --> 00:18:30,620
Host: Okay.

278
00:18:30,620 --> 00:18:32,870
Stevan Spremo: And then it kind of has a tumbling
effect.

279
00:18:32,870 --> 00:18:33,870
Host: Yeah.

280
00:18:33,870 --> 00:18:38,970
Stevan Spremo: And it has – it's got a passive
system to align with a magnetic field and

281
00:18:38,970 --> 00:18:41,410
knoll out this and stabilize.

282
00:18:41,410 --> 00:18:43,030
Host: Figure out where it is

283
00:18:43,030 --> 00:18:48,320
Stevan Spremo: And that takes about four days.
After we're stable and the microgravity environment

284
00:18:48,320 --> 00:18:56,650
is the best that it can be, the experiment
starts. And for 150 hours we go through a

285
00:18:56,650 --> 00:19:05,150
number of events. And we feed the cells. They
grow up to what we say stationary phase. And

286
00:19:05,150 --> 00:19:07,080
they've eaten all the sugars that we feed
them –

287
00:19:07,080 --> 00:19:08,080
Host: Okay.

288
00:19:08,080 --> 00:19:12,140
Stevan Spremo: – is basically what happens.
And then we have an optical detector that

289
00:19:12,140 --> 00:19:19,860
shines light through – red, green, blue.
And the absorbance pattern is noticed on a

290
00:19:19,860 --> 00:19:21,130
photodetector below it.

291
00:19:21,130 --> 00:19:22,130
Host: Okay.

292
00:19:22,130 --> 00:19:25,620
Stevan Spremo: So we shine through the card
and are able to look at how things are growing

293
00:19:25,620 --> 00:19:26,620
and see trends.

294
00:19:26,620 --> 00:19:27,620
Host: Okay. So that's how you know.

295
00:19:27,620 --> 00:19:31,040
Stevan Spremo: And between the different color
metric measurements, we can tell trends. And

296
00:19:31,040 --> 00:19:33,160
there're things that happen in red, maybe
not in blue.

297
00:19:33,160 --> 00:19:34,160
Host: Okay.

298
00:19:34,160 --> 00:19:39,610
Stevan Spremo: And so we calibrate that way.
The other thing we do then is we administer

299
00:19:39,610 --> 00:19:40,951
antibiotic and stress the cells out.

300
00:19:40,951 --> 00:19:41,951
Host: Okay.

301
00:19:41,951 --> 00:19:45,030
Stevan Spremo: So different concentrations,
there's a response, okay? So you're building

302
00:19:45,030 --> 00:19:51,460
the antibiotic resistance response. And in
microgravity, there's a wild type and a mutant

303
00:19:51,460 --> 00:19:56,100
we're studying. And the principal investigator
is looking at this – the scientist looking

304
00:19:56,100 --> 00:20:02,020
at this, Dr. A. C. Matin at Stanford [University],
his hypothesis is that the two – the wild

305
00:20:02,020 --> 00:20:05,850
type and the mutant strains will stress at
a different response rate.

306
00:20:05,850 --> 00:20:06,850
Host: Okay.

307
00:20:06,850 --> 00:20:12,490
Stevan Spremo: And then we can look at that

and try to get the genetic marker to kind

308
00:20:12,490 --> 00:20:17,540
of explain what's going on, why things are
becoming more resistant.

309
00:20:17,540 --> 00:20:18,540
Host: Okay.

310
00:20:18,540 --> 00:20:22,330
Stevan Spremo: And then we basically look
at the trend after that, administering something

311
00:20:22,330 --> 00:20:23,330
called alamarBlue.

312
00:20:23,330 --> 00:20:24,330
Host: Okay.

313
00:20:24,330 --> 00:20:30,290
Stevan Spremo: And alamarBlue is like a dye
that it kind of changes color as the cells

314
00:20:30,290 --> 00:20:36,010
metabolize. So we can look at trends and curves
of how the cells continue to live on and the

315
00:20:36,010 --> 00:20:42,920
way they intersect. And the graphs or the
curve fit of the trends will tell us if, in

316
00:20:42,920 --> 00:20:47,770
comparison with the same exact experiment
on the ground, if the space environment is

317
00:20:47,770 --> 00:20:49,870
responsible for doing something different
–

318

00:20:49,870 --> 00:20:50,870
Host: Okay.

319
00:20:50,870 --> 00:20:54,780
Stevan Spremo: – like microgravity or radiation
versus a 1 g environment on the ground.

320
00:20:54,780 --> 00:20:59,180
Host: Yeah. It's crazy because you think,
obviously, as we look at like human exploration

321
00:20:59,180 --> 00:21:05,000
or having people in the Space Station, it
behooves us to understand how [laughs] bacteria

322
00:21:05,000 --> 00:21:13,610
or E. coli, how things grow differently in
microgravity. And having all of this, just

323
00:21:13,610 --> 00:21:19,760
seeing all the differences and understanding
that better can then prevent or just – it's

324
00:21:19,760 --> 00:21:23,150
not like only could it have benefits for us
here on the Earth, but also help for that

325
00:21:23,150 --> 00:21:24,380
further exploration as well.

326
00:21:24,380 --> 00:21:28,470
Stevan Spremo: Yeah, the idea here is this
is decade – what we call decadal science.

327
00:21:28,470 --> 00:21:29,470
Host: Okay.

328
00:21:29,470 --> 00:21:33,160
Stevan Spremo: So it's a decadal survey of
what we need to do further space exploration.

329
00:21:33,160 --> 00:21:34,160
Host: Oh, okay.

330
00:21:34,160 --> 00:21:39,320
Stevan Spremo: So this supports astronaut
health for long-duration exploration missions.

331
00:21:39,320 --> 00:21:42,770
So we have to understand this as kind of a
keyway to the future.

332
00:21:42,770 --> 00:21:43,770
Host: Yes.

333
00:21:43,770 --> 00:21:47,890
Stevan Spremo: How would we administer antibiotics
to an astronaut is really what the question

334
00:21:47,890 --> 00:21:52,730
is here. But there's a secondary purpose on
the ground is, are we going to discover something

335
00:21:52,730 --> 00:21:58,610
in space that could help antibiotic resistance
issues on the ground. And that's becoming

336
00:21:58,610 --> 00:22:03,140
a really large problem for terrestrial or
Earth aspects of antibiotics.

337
00:22:03,140 --> 00:22:06,430
Host: I like whenever they're talking about
the International Space Station, they always

338
00:22:06,430 --> 00:22:12,340
say, "Working off of the Earth, for the Earth,"
because this all has benefits not only for

339

00:22:12,340 --> 00:22:16,260
going on the way to Mars – and this is – you're
talking about checklists before. This is one

340
00:22:16,260 --> 00:22:20,800
of those things you need to understand before
doing that journey to Mars. But then the side

341
00:22:20,800 --> 00:22:25,500
effects can be finding out how to solve other
problems here on Earth as well.

342
00:22:25,500 --> 00:22:30,350
Stevan Spremo: Yeah, absolutely. In this case,
we might need to have the astronauts having

343
00:22:30,350 --> 00:22:37,850
a dosing of like four, five, 10 times whatever
the amount is. But also if we find a pathway

344
00:22:37,850 --> 00:22:44,760
of how antibiotic resistance, what the mechanism
is, that's something that might be a game-changer.

345
00:22:44,760 --> 00:22:48,600
One thing I didn't mention is after the experiment's
done –

346
00:22:48,600 --> 00:22:49,600
Host: Yeah.

347
00:22:49,600 --> 00:22:52,400
Stevan Spremo: – we store all this data,
and then we telemeter that back down to Earth.

348
00:22:52,400 --> 00:22:56,990
Host: I was going to say. So the SmallSat
hitches a ride on a rocket where somebody

349
00:22:56,990 --> 00:23:01,450

else has paid more money to go [laughs]. Once
that goes off, it's safe, you launch yours

350
00:23:01,450 --> 00:23:06,520
– start that science experiment. And yeah,
is it just they – sends that data back to

351
00:23:06,520 --> 00:23:07,520
you guys here.

352
00:23:07,520 --> 00:23:12,690
Stevan Spremo: Yeah. So we have a great program
that basically we work with Santa Clara University,

353
00:23:12,690 --> 00:23:17,710
and they have a ground station. And we have
two antennas on our system. And what happens

354
00:23:17,710 --> 00:23:24,230
is the electronics store the data as we're
going through the experiment – all this

355
00:23:24,230 --> 00:23:25,440
light measurement and –

356
00:23:25,440 --> 00:23:29,020
Host: And you're controlling all that from
the ground. It's up there? Or is it automated

357
00:23:29,020 --> 00:23:30,020
now?

358
00:23:30,020 --> 00:23:31,020
Stevan Spremo: It's actually automated.

359
00:23:31,020 --> 00:23:32,020
Host: Oh wow.

360
00:23:32,020 --> 00:23:35,030

Stevan Spremo: It will run on its own. And
then we call it and ask for requests for the

361
00:23:35,030 --> 00:23:36,030
data through –

362
00:23:36,030 --> 00:23:37,030
Host: [Laughs] Okay.

363
00:23:37,030 --> 00:23:38,300
Stevan Spremo: – Santa Clara University.
And it's a great outreach thing because the

364
00:23:38,300 --> 00:23:40,790
students there are operating the satellite
for us.

365
00:23:40,790 --> 00:23:41,790
Host: Oh, that's awesome.

366
00:23:41,790 --> 00:23:46,220
Stevan Spremo: And they retrieve the data
and deliver it to NASA. So it's rough – it's

367
00:23:46,220 --> 00:23:48,340
not a lot of data. It's like a megabyte of
data –

368
00:23:48,340 --> 00:23:49,340
Host: Okay.

369
00:23:49,340 --> 00:23:52,500
Stevan Spremo: – for the whole mission.
It takes about two months through the orbits

370
00:23:52,500 --> 00:23:57,400
and everything that we do to get that small
amount of data. We don't have – this comparatively

371

00:23:57,400 --> 00:24:00,100
to the LADEE mission I worked on –

372
00:24:00,100 --> 00:24:01,100
Host: Yeah.

373
00:24:01,100 --> 00:24:02,230
Stevan Spremo: – we had major breakthrough
on laser communications.

374
00:24:02,230 --> 00:24:03,750
Host: And that went to the Moon.

375
00:24:03,750 --> 00:24:08,960
Stevan Spremo: That went to the Moon. And
that had 622 megabit-per-second download rate

376
00:24:08,960 --> 00:24:09,480
Host: Oh wow.

377
00:24:09,480 --> 00:24:11,230
Stevan Spremo: – from the Moon per second.

378
00:24:11,230 --> 00:24:12,230
Host: [Laughs]

379
00:24:12,230 --> 00:24:14,470
Stevan Spremo: So it was like a DVD a second
versus this.

380
00:24:14,470 --> 00:24:15,700
Host: It's smaller, but –

381
00:24:15,700 --> 00:24:20,250
Stevan Spremo: It's smaller, but you don't
need that much horsepower to this because

382
00:24:20,250 --> 00:24:21,430
the data file's not very big.

383
00:24:21,430 --> 00:24:22,430
Host: Okay.

384
00:24:22,430 --> 00:24:27,660
Stevan Spremo: So it's scalable. And what
a CubeSat does is pretty interesting because

385
00:24:27,660 --> 00:24:31,110
it only operates off three to 10 watts of
power.

386
00:24:31,110 --> 00:24:32,110
Host: Yeah.

387
00:24:32,110 --> 00:24:35,250
Stevan Spremo: If you think about your old
incandescent lightbulb that you grew up with

388
00:24:35,250 --> 00:24:39,160
in probably your house or – this is a fraction
of that –

389
00:24:39,160 --> 00:24:40,160
Host: Yeah.

390
00:24:40,160 --> 00:24:42,340
Stevan Spremo: – what it's consuming, and
doing all these tasks and reporting home and

391
00:24:42,340 --> 00:24:47,640
delivering a whole experiment that's been
automated. And I always find that aspect really

392
00:24:47,640 --> 00:24:48,640
amazing.

393
00:24:48,640 --> 00:24:55,330
Host: Like being more compact, being easier,

being like a small sat, using that CubeSat

394
00:24:55,330 --> 00:25:02,570
kind of like modules, it makes it cheaper.
It's easier to do. If something goes wrong,

395
00:25:02,570 --> 00:25:05,690
it's like I'm sure replacing it isn't the
end of the world.

396
00:25:05,690 --> 00:25:10,559
Stevan Spremo: The other thing that I didn't
mention earlier is the temperature requirements.

397
00:25:10,559 --> 00:25:11,720
We maintain –

398
00:25:11,720 --> 00:25:12,720
Host: Oh yeah.

399
00:25:12,720 --> 00:25:15,880
Stevan Spremo: – this – we have to simulate
the body's temperature. And so –

400
00:25:15,880 --> 00:25:17,080
Host: And you're doing that in space [laughs].

401
00:25:17,080 --> 00:25:21,110
Stevan Spremo: Doing it in space. So 37 degrees
Centigrade is normal human body temperature.

402
00:25:21,110 --> 00:25:22,110
Host: Okay.

403
00:25:22,110 --> 00:25:25,880
Stevan Spremo: So we're simulating that. If
we go above that, we'll simulate a fever and

404
00:25:25,880 --> 00:25:28,059

ruin the experiment and kill off the E. coli.

405
00:25:28,059 --> 00:25:32,660
Host: And how do you get that temperature
while on the satellite that's in space where

406
00:25:32,660 --> 00:25:34,780
it's pretty cold, as I understand?

407
00:25:34,780 --> 00:25:39,800
Stevan Spremo: Right. So we designed this
so orbit after orbit, it's capable of maintaining

408
00:25:39,800 --> 00:25:42,770
37 degrees plus or minus a half degree Centigrade.

409
00:25:42,770 --> 00:25:43,770
Host: That's crazy.

410
00:25:43,770 --> 00:25:49,900
Stevan Spremo: So we have looked at models,
and we model this to – basically dynamically

411
00:25:49,900 --> 00:25:57,730
every orbit – maintain its temperature.
We do models that are upwards of 650,000 calculations

412
00:25:57,730 --> 00:26:05,610
to look at all the situations that thermally
it's still stable. And so that's really an

413
00:26:05,610 --> 00:26:07,730
engineering feat that this system –

414
00:26:07,730 --> 00:26:08,730
Host: Oh, crazy.

415
00:26:08,730 --> 00:26:12,230
Stevan Spremo: – is maintaining. And as

a CubeSat, being low-cost, and we're still

416
00:26:12,230 --> 00:26:17,290
achieving this requirement is kind of amazing.
It's taking a lab up to space and –

417
00:26:17,290 --> 00:26:19,480
Host: Uh-huh. Like a mini-lab. Automated,
too.

418
00:26:19,480 --> 00:26:26,910
Stevan Spremo: Right. It's automated. I think
another thing I didn't mention is that we

419
00:26:26,910 --> 00:26:29,820
take a little canister that's got one atmosphere.
It's got lab air in it.

420
00:26:29,820 --> 00:26:30,820
Host: Okay.

421
00:26:30,820 --> 00:26:35,920
Stevan Spremo: So that's something the cells
also need to have to simulate the environment,

422
00:26:35,920 --> 00:26:36,920
so –

423
00:26:36,920 --> 00:26:40,500
Host: And after the experiment's run its course,
you've got all your data. Then it just burns

424
00:26:40,500 --> 00:26:43,260
up in the atmosphere? Or how does that work?

425
00:26:43,260 --> 00:26:50,490
Stevan Spremo: Yeah. Since it's a low-Earth
orbit system, we maintain orbits generally

426

00:26:50,490 --> 00:26:56,540
that are less than 25 years in life. And then
just natural decay of atmospheric drag around

427
00:26:56,540 --> 00:27:02,610
the Earth, it will eventually pull down into
the Earth's atmosphere and literally vaporize.

428
00:27:02,610 --> 00:27:03,610
Host: Vaporize.

429
00:27:03,610 --> 00:27:04,610
Stevan Spremo: Yeah.

430
00:27:04,610 --> 00:27:08,820
Host: So I can imagine somebody thinking,
"You're sending E. coli into space! What if

431
00:27:08,820 --> 00:27:13,140
this crashes on my house?" It's like, "No,
it's never to get even close to that. It'll

432
00:27:13,140 --> 00:27:17,620
get burned up and vaporized long before you
even know it."

433
00:27:17,620 --> 00:27:20,610
Stevan Spremo: Yeah, so we get that reaction
a lot.

434
00:27:20,610 --> 00:27:21,610
Host: [Laughs]

435
00:27:21,610 --> 00:27:25,890
Stevan Spremo: "What are you doing sending
E. coli up to space? Is this a dangerous thing?"

436
00:27:25,890 --> 00:27:26,890
And –

437
00:27:26,890 --> 00:27:31,740
Host: You probably have more in your bathroom
[laughs] or on the doorknobs than you do in

438
00:27:31,740 --> 00:27:32,740
this –

439
00:27:32,740 --> 00:27:38,460
Stevan Spremo: The particular strain we were
sending up, it's a common strain that actually

440
00:27:38,460 --> 00:27:39,679
people are treated for regularly.

441
00:27:39,679 --> 00:27:41,080
Host: Okay, okay.

442
00:27:41,080 --> 00:27:47,620
Stevan Spremo: So antibiotics and everything
are regularly given to patients on Earth for

443
00:27:47,620 --> 00:27:49,160
this particular strain we're studying.

444
00:27:49,160 --> 00:27:53,150
Host: This is pretty – it's a normal one.
People can calm down. Anyway, it's going to

445
00:27:53,150 --> 00:27:54,380
burn up in the atmosphere.

446
00:27:54,380 --> 00:27:57,440
Stevan Spremo: Yeah, it's going to – it's
never going to reach back down to the Earth,

447
00:27:57,440 --> 00:27:58,440
yeah.

448

00:27:58,440 --> 00:28:05,350
Host: Anybody who's got questions for Stevan,
we are using Twitter, so we're @NASAAmes,

449
00:28:05,350 --> 00:28:10,490
and we are using the hashtag #NASASiliconValley.
So if anybody has questions, we'll just push

450
00:28:10,490 --> 00:28:13,380
them on over to you [laughs] and he'll respond.

451
00:28:13,380 --> 00:28:15,220
Stevan Spremo: I'll be glad to respond to
anybody's questions.