William Gerstenmaier Video Interview

Space Hardware/Software Testing Philosophy

So I will talk a little bit about test philosophy and lessons learned. Again, if I look at station, when we first tried to power up the lab right and the lab wouldn't power up. I think every computer failed to a halt. We absolutely had to do the testing that we were going to do down at the Cape. So we had the original plan we were going to just launch all these modules, check them out on-orbit and then life would be good. They would never come together at all on the ground. We would do no integrated testing at all down at the Cape. We'd just essentially ship and shoot all these pieces up and then we determined, not only did we have to do this integrated testing, and it proved itself in being very good at ringing out problems, but then I think sometimes we go maybe a little bit overboard. For example, on the life support system, we did a whole bunch of testing on the water circulation system. On the ground we ran for multiple years, we tested things out, we found some problems, but then we get on-orbit and all of a sudden we find out we have biofilm growing on the inside, filters are clogging up, the system is shutting down, and we had not accurately figure out what was going on from a biocide standpoint, and what occurred to us there was we had essentially many feet of tygon tubing which is permutable to carbon dioxide and carbon dioxide was fairly high onboard space station during certain phases. That actually is a nutrient for this biofilm to grow in the tubing and that, essentially, contaminated our system. So, I don't think we could have ever done enough ground testing to tease out that problem. So there's a point where you've tested enough on the ground. It's better to take it to flight and then understand what you've really got in flight. So, as we think about going to Mars, we're going to have to have this spacecraft, this habitation module. It's going to have to operate for roughly a year, two years in space on the journey to Mars and on the way back. We could try to test all that on the ground, but I think there's some advantage to potentially take that, at some point, to space station, attach it to station, or just fly as a free flier and let it run for the extended period of time you expect and see what works and doesn't work because you can only test so much and at some point you need to go fly, and that's the tradeoff. Where is the testing on the ground really applicable? Where does it really buy down risk? And where is the testing kind of cluged? It's as good as we can do, but it's not really what you're going to see in flight. At that point, if the risk isn't too high, it's maybe better to just go to flight, tease out those problems while they're small, make sure you've got enough flexibility in the system on orbit that

you can then repair it on-orbit and then continue to keep operating. So there's a tradeoff. You can spend forever testing on the ground and really not learn what you need to really learn. So, what is that right balance? MEIT, maybe we went overboard a little bit and tested a little bit too much, but the results were really good. All the electrical interfaces pretty much worked. We didn't have any major misalignments or configurations. We had some things that were maybe problematic, from a bolt standpoint, but that all worked pretty good overall. So maybe that's about the right level, but then in some cases we may have spent too long on the ground testing for things that we would have discovered much quicker once we got to flight and, as long as we discover them quickly in flight and they're not a big consequence to you, that's perfectly fine. That's the art of our business where you have to look at what the right level of testing is versus where that testing should be done and it's much like an aircraft test pilot, same kind of thing. Is that test point really important to you? Or can I infer that? Is the analysis sound enough that I can get from the analysis? I don't need to put somebody's life at risk to go grab that test point, or maybe that test point isn't far enough out. Maybe we didn't push far enough on that envelope. It's not worth putting somebody in an aircraft to go fly because they're not going to learn anything from the previous test point they just did. So what is that right balance of testing? And that's truly an art. So, like I talked about before, even in the preparedness for anomalies and off-nominal situations, you can prepare so much you're over prepared, but then you need that right level of preparedness you can deal with what you get when it comes about.