Broad Matters Season 9 Episode 4

“Misson to Mars” with Dorothy Carter

Ken: Welcome to Broad Matters.

Quinetta: A podcast bringing you thought leadership, innovative perspectives and real-world impact from Michigan State University's Eli Broad College of Business.

Ken: I'm Ken Szymusiak, Managing Director for the Burgess Institute for Entrepreneurship and Innovation.

Quinetta: and I'm Quinetta Roberson, the John A. Hannah Distinguished Professor of Management and Psychology.

Ken: We're excited to introduce our guest, Dorothy Carter, associate professor in the Department of Management here at the Broad College of Business.

Quinetta: Dorothy is leading groundbreaking research that's helping NASA prepare for humanity's mission to Mars. At the core of her research is the concept of multi-team systems, such as astronaut crews and earth-based mission control teams. She and her collaborators look at how success depends not on just one team's performance, but on how multiple teams coordinate and communicate to achieve complex goals.

Part of her research even included experiments right here at Broad, where student teams acted as mission control for volunteer spaceflight crews at NASA's Human Exploration Research Analog Facility. Her work is helping NASA and all of us better understand how people can work together to achieve extraordinary goals. Thank you for joining us, Dorothy.

Dorothy: Thank you so much for having me.

Ken: What motivated you to explore teamwork and how did that curiosity evolve into this NASA funded project?

Dorothy: Yeah, so I've always been curious about why people don't collaborate as effectively as they could. So that motivated me to study teamwork in the first place. A long time ago, I was a retail manager, and I realized how difficult it is to get people to work together effectively.

That's driven my research on leadership and teamwork in general. But a while ago, NASA posted what's called a request for proposals that my team and I responded to their request for proposals was looking for expertise in teamwork and leadership research to help NASA understand kind of the barriers to effective collaboration during a human mission to Mars. And what I really like about working with NASA is that when they have a big grand goal like, “we would like to send a team of humans to a deep space destination

like Mars” they start working backwards and thinking about all of the things that could go potentially wrong, and they call those the risks of the mission.

There's many things that can go wrong logistically, you know, health wise, but one of the risks that they identified is what's called the team risk. And so, the team risk is the risk of behavioral and performance health decrements due inadequate coordination, collaboration, that sort of thing within the crew. But the team risk actually doesn't just stop within the crew.

The crew also has to collaborate effectively with many teams on Earth- Mission Control, but also organizations that partner with NASA, international space agencies, that sort of thing. So, it really forms what's called like a large multi-team system. And we really need that entire multi-team system to coordinate and collaborate effectively in terms of supporting this mission. But we also know that it's going to be challenging.

So that's what my team and I responded to. They were looking for proposals that would address this challenge. What's been really exciting for us with this project is it combines both fundamental research, like so basic science to advance understanding of how multi-team systems collaborate, as well as practical interventions. They don't expect us to just give them a report of what we found research wise. They actually want us to provide practical interventions to help support the collaboration going forward.

Ken: Oh, that's really cool.

Quinetta: Dorothy, can you walk us through how you approached this project and how your research is structured?

Dorothy: Yeah, okay. So, our research is guided by kind of three major questions. The first question is: “During this journey to Mars, what is likely to happen in terms of the patterns of collaboration within and across the groups that make up this spaceflight multi-team system?” So, given what we know about the demands of a long duration mission to Mars, what's likely to happen to the way that they collaborate? And then we also look at what patterns of collaboration are needed in order to support mission success.

Then, we kind of are looking at the disconnects between what patterns are likely versus what patterns are needed, and, when we find disconnects between those two patterns, the third question is, “how can we intervene to support the collaboration patterns that are needed, and avoid the ones that maybe are more likely to happen?” And in order to answer those three questions, we took a mixed method approach. It's an iterative cycle of research combining a variety of activities. So, within kind of what we call our field study

component of this project, we have done deep dives into decades of archival documents and interviews with astronauts over the course of the past 70 years.

We've also conducted over 30 interviews with current or former members of Mission Control to really understand how collaboration happens currently and also get their perspectives on what needs to happen to adapt to the demands of the future missions. We've also done controlled laboratory experiments here at Broad in the Kessler Team's Leadership laboratory, as well as down in Houston, Texas and Johnson Space Center.

There's a capsule, which probably talked about a little bit later, that's called the Human Exploration Research Analog Capsule. So, we've done some controlled laboratory experiments, both in the lab here as well as in that analog environment. And we've combined that with agent-based simulations to really dive deep into, like, how the processes of collaboration are likely to unfold in these long duration missions and what can we do about it to support performance?

Ken: This would be the longest duration humans ever been in space, right? Six to eight months is, like, max usually and, is it like 18 months just to get there at its best, right? So, what is the types of folks that we could actually, like, try to assemble like the right types of personalities even does that way into this too?

Dorothy: Yeah. So, our project is not specifically about that. But again, like I was saying, NASA has identified this big team risk issue and that has sparked quite a few projects that have been funded over the years, led by people in kind of similar fields- industrial organizational psychology or management or communications. And I know specifically 1 or 2 of those projects are addressing that exact question about what individual differences are we particularly needing to select for.

Some of that was coming out in our interviews with the subject matter experts, like that work in Mission Control right now. They were kind of speculating about what individual characteristics might we really want to prioritize in comparison to what we do right now? And one thing that stood out to me, as several of them were mentioning this need for essentially proactivity, but like a willingness to try things and fix things because they're not going to be able to rely as heavily on mission control’s suggestions in real time.

So, they're going to need to be kind of hands on wanting to fix the craft, that sort of thing, if needed.

Ken: Yeah.

Dorothy: So, we were really lucky to work with HERA, the Human Exploration Research Analog group, for three campaigns, and a campaign involves four missions. And so, each mission is 45 days. And before each mission, they go through a long selection process.

They select for individuals who are astronaut-like current or former military folks or people who have been involved in NASA or just, you know, interested in space in general. So, they have a passion for the context and they're willing to volunteer their time to live and work inside of this capsule for 45 days straight without seeing their family.

And they don't just participate in my study; they participate in many studies. So, it's kind of a large coordination effort on the part of HERA to work with researchers kind of around the country on a variety of different projects. It might be sleep deprivation projects, health issues, how do you make things on 3D printers and all sorts of questions.

But my research specifically was about how does that team up with teams outside of the capsule and so throughout the 45-day mission, the crew inside of the capsule teamed up with undergraduate students at the Kessler Lab four times. They played a simulation. They completed a complex problem-solving simulation, where they had to identify a location on the surface of Mars and, quote unquote, make a plan to build a well on the surface of Mars in this particular location.

There's 12 people in total involved in this simulation, and each one of them has their own area of expertise that's relevant to solving this complex problem. Four of those people happened to be inside the capsule, and the eight other ones happened to be here on Earth at Broad. So, the first time that they played this game was about a week or so into living inside the capsule.

They were able to communicate with each other in real time, meaning when somebody from HERA sent a chat message to somebody on Earth here at Broad, that message appeared in real time. But then the second and third time that they played the simulation, there was what's called a communication delay between space and Earth. First a minute and then it was three minutes.

And then the fourth time that they played the game, it was back to baseline of that kind of control condition. They were able to communicate in real time. So, one of the things that we know about a mission to Mars is that as the crew travels further from Earth towards this deep space destination, there is going to be unprecedented communication delay that, you know, astronauts have never dealt with previously.

And that's because of the time it takes for radio waves to travel through space. And so potentially, by the time they get to the surface of Mars, there might be upwards of 20 minutes. They say, “Houston, we have a problem.” And that statement takes 20 minutes to get to Earth. And then they say, “what is that problem?” and that takes another 20 minutes.

It might be, you know, too long to really solve the problem. If they're on the other side of Mars, communication can be cut off entirely. So, this is a real concern in terms of mission success and collaboration, particularly between Earth and space. So, our experiment was designed to evaluate the impact of that communication delay on multi-team system collaboration.

So again, they had no communication delay and then they yes, yes, yes. No. Overall, like obviously we find that that hurts their ability to problem solve effectively. These are the same eight undergraduate students who this is a kind of a repeated measures experimental design. So, we find that what is really supportive of problem solving in our task and consistent with what we discussed with our subject matter experts in the interviews, is this ability to maintain what we call collective attention.

So collective attention, meaning like Quinetta and I are focused on the same thing at the same. Time that supports effective problem solving. And the more that this collective attention happens, the better the problem is solved. And of course, if you break down the communication between people, it's harder to maintain collective attention. And so therefore it's harder to problem solve.

So that's what we find in that experiment.

Quinetta: So, how would you put those findings into practice? What did you learn about how teams can stay connected and aligned when you have those communication delays and it's not immediate?

Dorothy: If I didn't mention this before, it took us years to collect this data, right? Because each mission is 45 days and it's an intensive coordination effort.

We have a sample size of like 12, right, which is very small in terms of running effective statistics. Right? And in no universe are we able to collect a million “what if” scenarios, like what if we tried this or what if we tried this? Or what if we tried to intervene and try out a variety of theoretically relevant countermeasures to support multi-team system collaboration that would take my lifetime and many other people's lifetimes.

We want to send a team of humans to deep space destinations much sooner than that. So, what we did to remedy that, like kind of limitation of like, we can't try out a whole bunch of interventions and see what would help with actual human subjects is what we did is we took those human subjects, and we created a virtual test bed.

So, we took our observed human subjects’ data from this actual human experiment. And then we created an agent-based computational model., and in that agent-based computational model we have very similar-type people. Like, we have 12 agents. They are playing this game four times over the course of a 45-day mission. And we have created this kind of virtual testbed that then we can run what if scenarios.

“What if we tried to increase this? What if we decreased this?” and that way we're able to pinpoint points of intervention that can say, “NASA, this is what we think you should do” in terms of supporting collective attention, even under cases where that communication is delayed. And so, through that process, as well as our observed empirical data, we find at least three main points of intervention that seem to work to support collective attention, even in cases when communication is delayed.

So, the first one is relatively obvious, which is that practice effects are there. So, training together can be helpful in terms of supporting collective attention. We use our repeated measures design, and we see a practice effect both in our empirical data as well as in our agent-based modeling simulation. The next one is a little bit supported by prior research on countermeasures, which is that keeping communication simple between people is also very important.

So, some of the researchers have done interesting work to develop communication protocols that astronauts can use during communication delays. And so, potentially one of the reasons why those may have a positive effect is that they are keeping the communication streamlined and simple, so then people can keep their collective attention maintained and problem solve together. And then the third thing we found is that the degree to which, like, influence or like trust is there between people and distributed and kind of (unknown), so like a shared leadership type structure is also very supportive of collective attention, even when communication delay is there.

To us that one was that a little bit more novel and supports this idea that it's not just kind of the cold systems that are important to support collective attention, it's also the human kind of affective relationships that you have with people. So, the idea here is that if you and I have developed a strong influence bond, and then we get separated by space and time, we're still able to kind of get our minds together, even despite this distance.

And I thought that finding was interesting because it also resonated with what our subject matter experts were starting to tell us in terms of the way that they approached making sure the collaboration worked effectively. So, several of the flight directors that we talked to, mentioned that before the crew launch, they would take them out to get coffee or something. Really get to know them so that when they're out there, they still know that the flight directors have their best interests at heart, and they're willing to be influenced and, like, hear them if they're making specific suggestions.

That's kind of like part of our holistic kind of countermeasure intervention approach here is we think training, obviously, will do, keeping the communication simple and streamlined and using a protocol, but also really paying a little bit more attention to those social bonds in more of a systematic way, rather than just kind of a one-off. Some people do it and some people don't.

Ken: What parallels do you see between NASA's approach to tackling ambitious projects like long range spaceflight, and how organizations can effectively manage their own teams?

Dorothy: A lot of the reasons why I like working with NASA as a researcher, I think, could be translated to any organization. So, one of them is the fact that NASA does have these grand goals and then work backwards about all the things that could go wrong in pursuit of them.

So, I think any organization can use that and think about not just what could go wrong in terms of marketing a product, but also in terms of collaboration and leadership effectiveness. I also think NASA's ability to learn from prior mistakes, like a learning organization, is a emulate able goal for any organization. We learned that through our archival documents. There's pages and pages of debriefing every time something minor goes wrong and they're willing to adapt.

In fact, we have a paper published that shows the massive adaptations that NASA's multi-team systems engaged in over the decades.

Quinetta: So, not to ask you for any of NASA's secrets.

Dorothy: Yeah.

Quinetta: What's one thing that a business leader could do to build trust in their team drawn from your research?

Dorothy: What we kept hearing from some of these interviews, especially, is that they really appreciated when the leaders trusted them.

I think that's something that, like, every leader can reflect on. Right? So we talked to quite a few individuals who are on console. So, they might be simulating a particular part of the mission and there's so many pieces of this puzzle that go into this. Some flight directors may immediately just accept the response from folks, and then that kind of signals this trust. Whereas others may be asking a lot more questions.

So, I just think the lesson here is that building trust among the members of your team requires first that you trust your team.

Quinetta: Yeah, rocket science.

Dorothy: Yeah, exactly. Yeah.

Ken: The other that came to mind to me is how do you see this research evolving as AI becomes a bigger part of how teams communicate and work together?

Dorothy: AI obviously is becoming central in all organizational contexts, NASA included.

They certainly recognized that the crew on a mission to Mars is going to rely heavily on AI decision making systems. You know, one of the challenges that I think the mission planning is facing is like how much to rely on AI and how much should we engineer the system itself to be in charge of things, right? Versus how much do we want to train these already superhuman individuals on board to take some of the burden off of them?

There's obviously going to have to be engineering of the system itself to like, make its own smart decisions, but that can't be taken too far. The crew has to be involved in some of these processes as well. In general, the challenge right now is trying to figure out how to strike that right balance between how much should we rely on AI versus human expertise.

And I think that challenge is pervasive across organizations.

Quinetta: You discuss the benefits of your research for, you know, your work, what you learned, you articulated the benefits to NASA. What do you think students who participated in the experiment learned or took away from the experience?

Dorothy: Well, I've had students who are participants in that study over the years sell it on their resumes that they've helped -

Ken: I would!

Quinetta: Helped humanity.

Dorothy: Yeah, exactly. Just playing that game, the computer simulation that we built that is a complex problem-solving game, like I said, does give them some practice in doing these sorts of things with communication delay. So, there's the inherent benefit of practicing that type of really complicated, challenging simulation. You know, we have a pretty active team of undergraduate and graduate student researchers who help to fill out these research goals.

And so, I think with all of them, those are marketable skills. We had some alumni come back and talk to the Broad management first years, and they were all emphasizing that their number one, most important, like on the job development skill was, like, how to lead teams. We just don't know how to do it very well.

Quinetta: So, they may have gotten a competitive advantage, if you will.

Dorothy: Yeah, exactly.

Quinetta: Where do you see this research heading next?

Dorothy: First of all, we have a lot of publications to write based on these data. Within the data that we've collected. I'm particularly intrigued by some of the things that we were finding with regard to the subject matter expert interviews. Quite a bit of that was describing how this very large, multi-team system activated parts of it to address really critical incidents, you know, something like a fire aboard the ISS or like these challenges that must be addressed really quickly. We asked a lot of questions about how those are addressed in real time. And it seems to be this process of kind of activating a subset of individuals and teams, potentially across multiple organizations, across space and time, right? And so, I'm interested in finding out more about how that unfolds and like, what are the best practices to support that.

So, in general, we're wrapping up this project over the next year. So, stay tuned for publications and results. We've got to submit our final report by the end of the year that provides our practical interventions for NASA.

Quinetta: You obviously are passionate about this work, so I want to ask what drives you to do the work on multi-team systems?

Dorothy: I think it's just, like, all of the challenges that humanity is facing. The big ones require collaboration on a big scale. So, I'm interested in the phenomenon of people working together across boundaries. And that phenomenon shows up in health care, space exploration, the military, traditional corporations, etc. and I think people are people all the time in all of those situations.

For me, my passion is about understanding how people collaborate across disciplines and boundaries, but that just ends up being relevant to many places that are also interesting.

Quinetta: I have an interest in bettering humanity.

Dorothy Yeah, exactly. Who doesn't? Right, yeah?

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Quinetta: And remember, like, rate and subscribe to Broad Matters on Apple Podcasts and Spotify.

Ken: That does it for this episode. I'm Ken Szymusiak

Quinetta: ... and I'm Quinetta Roberson. Join us next time to hear faculty and staff weighing in on relevant issues and discussing how their work makes an impact, illuminating how and why Broad matters.