WM2017 Conference Panel Report

PANEL SESSION 62: Nuclearized Robotics Perspectives on Use and Need

Co-Chairs: **Philip Heermann,** *Sandia National Laboratory*
Richard Voyles, *Purdue University*

Panel Reporter: Genia McKinley, *US DOE*

Panelists (62A Panel):

1. **Carol Landry,** *International Vice President, United Steelworks*
2. **Jim Key,** *President, USW-AEWC*
3. **Marty Reibold,** *Director of Strategic Initiatives, Fluor-BWXT Portsmouth*
4. **Robert Ambrose,** *Principal Technologist, Johnson Space Center, NASA*
5. **Harris Edge,** *Team Leader for Advance Mobility and Manipulation Team, US Army*
6. **Kam Saidi,** *Mechanical Engineer, Intelligent System Division, NIST*

Panelists (62B Panel):

1. **William "Red" Whittaker,** *Professor, Carnegie Mellon University*
2. **Thomas Sugar,** *Professor, Arizona State University*
3. **Shinji Kawatsuma,** *Senior Engineer, Japan Atomic Energy Agency (Japan)*
4. **Robert Buckingham,** *RACE Director, UK Atomic Energy Authority (United Kingdom)*
5. **Philip Heermann,** *Senior Manager, Sandia National Laboratory*
6. **Steven Tibrea,** *Research & Development Director, Savannah River National Laboratory*

Between 105 and 140 people attended these panel sessions which discussed the aspects of robotics, including the state-of-the-art, trends, R&D, technology maturation and transfer, and relevance to nuclear applications. Expert roboticists shared perspectives on the use of robotics for: (1) the handling of high-hazard, high-consequence materials and waste; (2) assisting workers perform tasks that are dirty, dull, dangerous, and/or difficult; (3) easing the performance of tasks that are physically demanding, stressful, or ergonomically challenging; (4) performing tasks that are beyond human abilities; (5) improving the ability to respond to and recover from operational upsets, accidents and natural disasters; and (6) improving the worker and facility safety.

Summary of Presentations

Panel 62A:

Carol Landry discussed how some United Steel Workers Union's members that she represents working within the DOE complex that work around radioactive waste face risk. She discussed the issues of an aging workforce as well as physical demands that can take a toll on these workers and how sound methods and tools need to be develop to enhance allow work to be done safely. USW immediately recognized the benefit of the Science of Safety partnership and that robotics keeps workers in mind. She emphasized the importance of adopting robotics that won't

replace humans, but robotics that will assist human workers with the challenges in the workplace. He lastly expressed the need for a greater national discussion to share these benefits and how there is a lack of standards and guidelines to share how workers can benefit from these technologies and remain safe. **Carol** shared her excitement about being a part of this advancement in worker's health and safety.

Jim Key, as an extension to Carol's discussion, further explained that he represents all USW Union employed by DOE. He expressed that the DOE workforce is aging and that within the next 5-6 years there will be a huge vacuum because others chose construction over other trades. The mission is to improve safety, quality, efficiency and productivity of facility operations. Visited **Jim** encouraged robotics developers to work closely with USW.

Marty Riebold's perspective was based on what we see every day in the DOE community. During his background of the Portsmouth facility, he explained the cleanup to be a very complex, labor intensive process that lends itself to be assisted with robotics applications. Being the host site to the Science of Safety demonstrations made it much more valuable to the participants and feedback to the workers. The vendors did a good job of engaging the workforce all the way through the demonstrations. He stressed the importance of contamination control for Portsmouth and how this isn't something that roboticists are thinking of when developing/out of box. And that contamination control is something to look at for future use. Robotics can be effective at teleoperation by removing the worker from the workforce while still maintaining control. **Marty** was very pleased that the workers adapted quickly to the new technology and were proficient with a short time. Hands on use by workers was the best way of identifying potential applications. Can't emphasize enough to get robotics into worker's hand/workforce engagement.

Robert Ambrose focused on robots working with humans. Not about taking jobs away but allowing them to work longer, stronger, faster, and smarter. He expressed that NASA is not about taking people out of their jobs, but rather to help augment and give better capabilities. He discussed wearables (i.e. Roboglove, using robotics for exercise equipment in space), rovers (RVs assisting astronauts in space), athlete system (slow mover, carrying habitat), Robonot 2/Human –Safe arm development (safety architecture teamed with GM). In summary, **Marty** stated: "in space and on Earth, robots will be working with people."

Harris Edge presented an autonomous system overview for aerial research as it enables teaming of intelligent systems with humans. ARL wants them to be intelligently interact with soldiers which could be saving lives, logistics, etc. Technologies that ARL develops needs to be robust and the robots need to have some level of autonomy (high level). They need to be able to move quickly, perceive the environment, and be able to communicate: Intelligence, perception and good manipulation to be able to work with soldiers. Robotics collaborative technology alliance could be as large as 5-6 entities, spanning 5-10 years and handling human scale/backpack size robotics or larger. ARL has a very comprehensive plan and is now working to partner with DOE.

They're working with technology to enable teaming of soldiers and robots for small unit operations. Robots need to be able to survey surroundings, catalog all objects and be able to explain what was seen. Robots needs operational tempo, being able to move at similar swiftness of humans and coupling basic research areas together so that the robots respond in such a way that if the soldier were to teach a robot what to do that the robot is able to do it. The use of complex robots would take time for the soldier to know how to use. When moving to extensive robots it will take time, in which simulation is the best way to do this. Hopefully we can have the soldier and robots work the same way.

Kam Saidi explained that NIST doesn't invent technologies. He discussed their standard test methods (apparatus/procedure/metric). A comprehensive suite of 50 test methods for ground, aerial and aquatic systems. Tests are scalable, apparatuses scale to environments. Aquatic test methods tested in frac tanks, etc. Aerial tests methods for both indoors and outdoors. When doing a lot of these tests you can compare robots to one another. No one test tells you much about a robot. Just helps tell you if the robot is suitable for your mission. Tests help stakeholders (robot developers, robot users, program managers) understand better what missions are and helps refine design and what they're good at. Conducts validation exercises for robot developers helping them understand system weaknesses and needs and how to improve them. Also, helped other US government agencies purchase robots through this method, helping them run tests based on needs. Not done so that they can become testing facilities, but help push them out so that others can test further. Other facilities around world that does tests as well (some collaboration being done). Work is applicable because work is similar with nuclear facilities.

Panel 62B:

William "Red" Whittaker discussed university robotics from land, sea, air. He showed video…Robot operating in water, mud. Explained that they had 4 years of successful work. Light work consisted of tremendous wash down, applying fixatives, and things special to the industry. Heavy work, of concrete demolition, water jetting, etc. Utilized broc which eventually became pretty successful. He shared how robots are being used in tunnels, shafts, underground storage and inspection and event response, similar to that at WIPP. Showed air slots under double shell tanks, ambition is inspection and shared that there will be robotic solutions for these. Shared that robots are used underwater and for site mapping. Showed type of equipment that lit fire in WIPP. He concluded by stating that technical features are in good hands" now if you can dream it you can do it."

Thomas Sugar discussed wearable robots for worker assistance, providing an overview of wearable assistance that's out there. He explained why he thinks wearable robots will help people: to help workers lift heavy objects, palletize, etc. He proceeded to discussed what's fueling this growth: an older workforce and better robotic systems we're seeing.
Tom explained a wearable robotic system to be: a device that can be worn on body to assist user, device can be passive or active, device can assist a joint or transfer the load to the ground. **Tom**

walked through different devices examples (Assistive, manufacturing and construction -more bulky and costly systems that probably won't make it into the marketplace right now). He thinks the exoskeletons (passive) will get there first.

Shinji Kawatsuma discussed nuclearized robotics lessons learned and perspectives. He expressed that they're still responsible for technology team, but main role is supporting developers for Fukushima robots. He provided some background on earthquake/tsunami that led to Fukushima Daiichi NPPs incident. The plant lost power and became severely damaged from hydrogen explosion. A new technology had to be adopted. **Shinji** provided a review on the tasks with the robots explaining that more than 20 robots were deployed during emergency response, several tens operations conducted, 2 robots hadn't returned, robots wired and limited for mobility, with no accidents from radiation effects. Lessons learned included conformity (specialized organization required, system needed/not robot, unitization needed in case), reliability (radiation resistance), maintainability and decontaminability (robot must be maintained under radiation environment, contaminated robots were radiation source for operator).

Rob Buckingham runs fusion reactor that doesn't actually work, but they'll get there. All work has been comprised of getting that reactor to work. "Race to Zero"…that's where we're going. Purpose of getting to zero is that we need to get to Zero manual intervention. **Rob** explained that all work will need to be remote which will drive lots of research. He described the RACE 5 areas (RACE FRAME-getting design in place is imperative, RACE twin, RACE tools-process tools are very important, RACE to ARMS-autonomous remote systems, RACE TEST Facility-testing and supporting NIST work going on). All about people's response to the next age of robotics that's coming. **Rob** explained that all systems and regulations are built around people. Culture eats strategy for breakfast. "Cars are the first robots"-being the first time that millions/billions of people are getting inside of a robot but he believes that they will eventually become boring/the norm to them. Will have to figure out what to do next.

Philip Heerman discussed how national labs have been helping DOE assemble the SoS initiative. **Phil** continued to share that the lowest way to do safety is to say, "don't put your food under the metal blade", next…put a guard around it, but the very best thing you can do is to design the hazard out. He shares that DOE has been working on engineered safety, meaning can you move some of these things to the environment? There hasn't been a lot of work in applying these things to the worker. New R&D area exploring whether we can begin to design some of these things out. **Phil** shares that we can expand the space of Robotics and automation/humans with augmentation of human workers. Robotic PPE can also prevent internal injuries which is different from normal PPE which protects you from external hazards. It's technology to enhance worker safety and performance. In the past, we "wrapped people around the technology to do the work or manage machines, but now we can wrap the technology around the people. These are the things that can greatly increase safety in the workplace.

Thomas Nance discussed development of robotics and remote systems for difficult to access environments. His presentation was more interactive with a nice amount of figures/pictures/videos. He showed the large diameter pipe crawler…homemade robot for F-Canyon. Showed application example for DWPF Melt cell cleanup. Showed remote sampling of HLW Tank 18F-used tethered system with operator in the loop where they combined homemade components with off the shelf components to achieve goals. Often the conditions aren't what you expect once you get the robot into the system. He then showed the WIPP camera system that SRNL came up with which was a one-off battery operated camera to look into the system to see what conditions were before entering into the area. Next, he showed H-Canyon Air Tunnel Inspections Background which were deployed multiple times. **Tom** discussed H-Canyon inspection vehicle routes for which some crawlers were left behind. Although some were a partial success, the objective is to learn from the system. Lastly, he showed video of 2015 inspections, detailing some issues that the crawlers ran into.

Question and Answer

Panel 62A:
In response to a question of how can robots of future help do more, **Robert Ambrose** replied that if someone were to state in the future that they'll be walking around holding a robot they wouldn't believe it. He thinks workers walking around with robots assisting with work will become the norm. **Carol Landry** goes on to comment that she has her reservations on the statement "how to get workers to do more", but she's taking it as an opportunity to get workers to work better. Thinks it is a good thing for the workers for better awareness. Some applications will help workers get back into the workplace after being ill. At some sites this is the only workplace in the area with great benefits. She's hoping that as workers age, these applications can be used to help workers stay in the workplace longer. **Jim Key** added that with a lot of workplace injuries seen, the exoskeleton can assist and allow workers to be relaxed while still performing work. If we could take the top injuries/complexities and use workers to aid in improvement or robot can take ALARA concept it could get workers away from immediate hazards or injuries. Lastly, **Harris Edge** commented that robots coming to assist with common dangers will be one of the most cited things on the army side.

The panel was asked for their take on robots handling weapons in future. **Harris Edge** replied that since there is a moratorium on autonomous weapons, robots can be used to identify many things. It's up to all of us to figure out how to best handle autonomous systems. We're the ones in control right now and we need to figure out how to best handle these systems.

A comment was made to the panel that there are a lot of technologies out there with a need for workers in the workplace, maybe were on cusp of going from worker to industrial revolution. Then they were asked how do we get past the worker to acceptance in workplace for our contractors? Our contractors have to be incentivized to bring in these technologies to help the

workplace. How do we do that as an agency and nation and get the message out? **Marty Riebold** replied that getting the right application that's a good fit and need for the work that has worker engagement, one we all agree makes sense and where you can take a person out of harm's way, those things will present themselves. From the contractor's perspective, it needs to come back to whether we can make it cheaper, faster and safer and get the most value for our money. Once you get the worker engagement the business model will follow. **Jim Key** shared that one should be looking at it from not just the end user perspective. If it benefits the worker from repair of device being used. **Carol Landry** added that going back 6 months before getting involved, she wouldn't have been a proponent. But we need to be educating people about the technology and what it's about. We need to take the fear out of it that robots are going to replace workers. Compare costs vs. benefit of using technologies, At the end of the day the bottom dollar is what makes most decisions. **Jim Key** ended with the comment that we wouldn't want robots to make all the decisions.

Panel 62B:

A comment was offered that the first set of panelists did a good job about worker assist and the second panelists discussed going where no humans have gone before. A question was then asked to **Carol Landry** of how can one mesh those together? **Carol** responded that she could certainly see evidence in some of the applications, such as with WIPP. She went on to explain that had some of the applications not been there we'd certainly have put some workers at risk. This scenario comes to mind quickly on how we mesh those together. As we go further we might have to go further than using these enhanced robotics. I don't have a lot experience with going beyond where we are right now, but we'll have to explore these things.

The question was addressed to the panel, of the robots seen today which have been designed for safety and reliability? **Red Whittaker** commented that once system goes hot, it's hot. Previously it was all about reliability. On the safety side, consider the dose. You integrate those years and years of operation. The only way it works is to be safe and reliable. **Phil Heerman** shared that when you do operations like this you have to plan for the back up operations and you have to operate carefully. You must plan with that level of rigor. **Shinji Kawatsmuma** shared his experience by offering that by introducing the robot operators and developers, robot operators were exposed to those levels. Thus, stating that we need to understand the conformability of the robots themselves.

The panel is asked whether money ever an issue? **Red Whittaker** stated that the only way to get it done is economically. In the robotics service world, there's still a correlation between the money, how much it costs, and how much can get done.
Low costs dictates a lot. **Robert Buckingham** added that it's behooven for engineers to design things safely. These are all factors that go into engineering design. If you have enough time to invest in getting the design right then you have a good system. If you can get good tools in good hands you can do good work.

The Panel is asked when they're developing their systems, where are they seeing the largest costs? **Rob Buckingham** stated that 70% of costs in design and 30% in hardware. Labor costs are the most, but somehow, we need for it to be the other way around.

As the dialogue continues, a comment is made to the panel that problems haven't really changed, yet we've had 3 decades of advancements. Then the panel is asked, what is really going to pay off? **Red Whittaker** stated that "small is one of the next big things." Another breakthrough is the availability for high performance hard top electronics (FPGA, etc.). **Tom Sugar** shared that radiation hardening of process boards, miniaturization should be easily achievable in the next few years. **Rob Buckingham** stressed "Big data!" He shared that we only go in once a year or so to collect data which isn't good. If you could go collect data everyday then you'd have really detailed info about the state of the plant. Much better data for your risk case to support action. Somehow, we've got to get into the use of data more. **Phil Heerman** added that the technology is getting to a point to get a lot of things done. It's about getting the needs with what's needed to complete the task. Teaming with the humans to solve the problems. **Shinji Kawatsuma** shared his experience that most time spent testing to tailor robot system to the situation because they needed to optimize each case. Engineers should be trained to respond accordingly.
Thomas Sugar in-situ processing of the waste.

The panel was asked how these things are being taken into account. Haven't heard anything about remote on remote, effectively repairing the system in. **Rob Buckingham** shared that for him recovery is probably the most difficult thing of the design failure. It's about really good engineers that understand the whole problem. **Red Whittaker** added that it's not like the nuclear industry came looking for complex issues. Some of the charter has to be bottom up to infuse into these possible needs. **Phil Heerman** offered for anyone to talk to him afterwards about how to change the requirements.