INL/CON-12-24735
PREPRINT

Needs for Robotic Assessments of Nuclear Disasters

2012 ANS Annual Meeting

Victor Walker
Derek Wadsworth

June 2012

Needs for Robotic Assessments of Nuclear Disasters

Victor Walker, Derek Wadsworth
Idaho National Lab: P.O. Box 1625, Idaho Falls, ID 83415-2220, victor.walker@inl.gov

INTRODUCTION

The nuclear disaster at the Fukushima nuclear reactor plant in Japan underscored the need for remote systems that can assist in dynamic high-radiation environments. The INL participated in delivering robotic technologies to Japan and as a result has proposed new work and methods to improve assessments and reactions to such events in the future.

OBSERVATIONS FROM THE FUKUSHIMA REACTOR RESPONSE

On March 11, 2011 Japan experienced a series of disasters. After the terrible impacts of a major earthquake and tsunami, the resulting damage to the Fukushima Daichi nuclear plant threw much of the nation and world into turmoil.

In the days and weeks that followed there was a great need by the local responders and national decision-makers for information about plant damage and operational status as well as situation awareness with regard to radiation releases. The hazards represented by the radioactive environment made it hazardous for the staff to collect the necessary data. Automated recording devices were generally not functional or not relevant to the dynamic environment and their was need for more specific information. These conditions made it desireable to use remote systems technologies to gather relevant information but in observing the rollout, there appeared to be several barriers that made that difficult.

First, there was a lack of reliable information to quantify and map the radiation fields in and around the plants. This resulted in hesitation and uncertainty about deploying certain types of sensors and platforms to perform operations. Second, there were no systems ready to respond to collect this information. No dedicated robotic platforms that allowed radiological "hardened" reliability for use in an uncertain environment were readily available. Third, there was a lack of relevant sensors for the situations. And finally, there was a lack of expertise and trust for remote system use for immediate response and assessments.

Within two weeks, the government of Japan and the owner of the nuclear plant contacted the United States to start an ongoing dialog of support and assistance in their time of need. The Idaho National Lab worked with other national labs and industry partners to identify potential technologies and expertise for near-term characterization efforts and provided domain-expertise in radiation material impacts and robotic handling. As part of the support for the efforts, the US Department of Energy (DOE) provided needed tools to Japan and trained local resources on their use. The DOE sent a robotic platform equipped with radiation sensors and the ability to map radiation to outdoor GIS systems, 6 radiation-hardened cameras of different configurations, and a gamma-cam radiation detecting camera.

As a result of this interaction, the difficulty of deploying remote equipment in an unstructured, dynamic, and hazardous environment was made evident to all involved. Subsequently both the US and Japan are instigating methods to better respond to such events and perform remote recovery operations.

ROBOTIC NEEDS IN NUCLEAR DISASTER SITUATIONS.

The efforts associated with the Fukushima reactor response and observations from previous disasters such as the Three-Mile Island incident indicate that there are several phases associated with an incident response. First, the assessment activities; secondly, the remediation of immediate issues; and finally, the recovery and stabilization efforts.

Although there are robotic platforms which can be applied to each phase, there is particular interest in identifying issues and providing tools for addressing the initial assessment activities for immediate response following a disaster involving radiation.

This assessment would need to involve the collecting of information at both wide area and localized sites involved in the incident and would require a wide set of tools for effective use.

To gain an effective understanding of the situation, parameters of interest may include imagery, radiation levels, temperature, chemical signatures, and other environmental factors. These are key indicators for determining the extent and type of damage and the safety of the environment for further action.

Furthermore, a phased approach for the assessment activities would likely be necessary with each phase collecting specific information which would be needed for assessment and which would require special tools. Typical assessment phases would be: first, collection of environmental parameters; second, determination of conditions driving those environmental parameters; and third, physical sample collection and analysis.

Phase I: Environmental Parameter Monitoring involves evaluation of general conditions surrounding the reactors, facilities, and structures. These assessments can be accomplished by a multitude of sensors including cameras (still, video, infrared etc.), radiation detectors, temperature measurements, etc. A key to gathering this data would be deployment of the sensor, which is typically accomplished by a remotely operated ground and an aerial vehicle as applicable.

In addition, it is crucial that the tools provide effective characterization of the data in a way which results in a clear understanding of the situation. This initial information and understanding are essential, and will dictate subsequent decisions and actions.

Phase II: Contributing Condition Identification needs to provide visual and other qualitative information that can be used to plan mitigating activities. Assessment at this level requires gaining access to areas inside buildings and structures. This requires wireless data/control transmission, platforms that can place sensors at key locations, non-line of site operation, etc. During this phase equipment will be exposed to elevated radiation levels that may impact operation and longevity. Understanding these effects will be essential to determine the proper selection, use, and maintenance of the equipment.

Phase III: Physical Sample Collection will allow more detailed quantification of parameters that are present and lead to a greater understanding of extent of damage and required recovery actions that must be taken. The sampling activities are fairly unique and require general remote material handling capabilities. Sampling activities would include air and water sampling and potentially recovery of selected materials.

Each assessment phase would require a set of relevant tools and deployment methods targeted to the specific needs of that phase.

To be able to assemble and deploy effective tools for these assessment activities there appears to be several efforts needed. First, a greater understanding is needed of relevant sensors and capabilities of these sensors for deployment in each phase. Existing hazmat response robots have a broad scope of sensors for use but several of these have limited ranges and not be appropriate for potential readings in a highly radioactive hazard environment. This will also need to include the development of a set of intelligence-based tools to rapidly characterize the relevant information for use in determining potentially hazardous environments and possible causes. Situational awareness and characterization is critical in decision making.

Secondly, study of the impacts of a high radiation environment on the systems and their sensors will be critical. There is limited understanding of how systems respond and what degredation occurs in high-radiation environments. Tests in actual fields and building of modular systems to mitigate damage will be essential for ongoing reliability of the overall deployment. This may include change of materials and modular systems that can easily replace damaged components. And specific communications options need to be tested for a wide range of deployment possibilities.

And third, the development of actual tools and training protocols for quick deployment with experienced operators. The ability to comfortably deploy and gather information without delay will be crucial to the overall effectiveness of any response system.

The INL continues to provide guidance and leadership in the development of nuclear energy research and continues in the advocacy for safe deployment of nuclear energy. In this effort, the lab hopes to develop the protocols and infrastructure to identify, evaluate, integrate, and maintain a suite of equipment to carry out and support these rapid assessment activities.

We hope that through all of our efforts to learn from our nuclear past that we will be able to effectively prepare for and avoid further disasters in the future.

REFERENCES