Note of SAFESPUR Meeting

THE USE OF REMOTELY OPERATED VEHICLES AND ROBOTICS – NUCLEAR DECOMMISSIONING AND OTHER APPLICATIONS

SKM ENVIROS, SALFORD QUAYS, 20 MARCH 2013

Chair's Welcome

The meeting was chaired by Peter Booth (WSP). He said that the use of remotely operated vehicles (ROVs) and robotics was a new subject for SAFESPUR. He looked forward to the presentations, which included demonstrations of devices and videos of applications in the fields of nuclear decommissioning, characterisation and environmental remediation.

Peter thanked SKM Enviros for hosting the meeting. He then reminded participants that the SAFESPUR forum belonged to its members. He encouraged those present to think about topics, formats and venues for future events, and to let CIRIA have their views during or after the meeting.

ROV Technology: Horses for Courses – Matching Applications to Needs

Presentation

The first presentation was by Jon Montgomerie of AMEC. He began by considering some of the differences between the nuclear and defence sectors and other sectors as far as the use of ROV technology is concerned. One of these is that there is less potential for technology transfer because of the nature of the working environment. In particular, the need to be able to decontaminate ROVs means that the devices must not have parts where radioactive contamination can build up and be difficult to remove. Another difference is that it is possible to justify higher costs in the nuclear and defence sectors because safety requirements often make it essential to use ROVs. In contrast, in the construction industry ROVs are used only when they have significant advantages over hands-on methods, such as saving time or money or both. The result is that demolition ROVs are much more widely used in nuclear decommissioning than in the construction industry.

Whilst in other sectors designing an ROV for a particular application is the last resort, in the nuclear sector it is often the only option. However, it is important to make as much use as possible of previous designs and not to make unnecessary changes. It is also essential to consider the whole system, including the ROV, the tools, the controls, the means of viewing operations and the capabilities of operators. It is not just a question of whether the ROV is right for the application but rather whether the system as a whole will do the job well. Often what is needed when choosing a technology is a systems integrator, not a product vendor, and experience in remote operations is key.

Q&A

The first questioner asked for an example of the wrong choice of tools for a job. Jon gave the example of demolition ROVs, which are well-suited to destroying entire facilities but poor for demolishing only parts of facilities. However, in the latter case an ROV could be used as deployment machine for a robotic arm. The second questioner asked for further details of why ROVs were not much used in civil demolition. Jon said that, outside the nuclear sector, ROVs were only used for demolition where they were cheaper than a hands-on approach or where there was a particular need, such as when access was limited or when it was necessary to demolish the inside of a building, leaving the outside intact.

There was then a question about choosing materials with which to make ROVs so as to facilitate decontamination. Jon said the choice of materials depended on factors such as the quantities and nature of contaminants and the allowable decontamination techniques. A participant from Dounreay said that, for some applications, it was preferable not to carry out decontamination but to consign the whole ROV as waste. In such cases the costs of writing off the ROV and disposing of it as radioactive waste had to be built into the price for the job. Another questioner said that it was important to compare the costs of designing a bespoke ROV for a job with the costs of modifying a proprietary ROV. Jon agreed but noted that modifying an existing bespoke ROV was often an attractive half-way house.

The last question was whether, in Jon's experience, project managers tended to be risk averse about new ROV technologies. Jon said that there were some project managers who were cautious about new technologies because of the potential for exceeding budgets and timetables. There were others who recognised that considerable R&D would be needed to identify the capabilities required of ROVs for their applications and to design the ROVs, construct them and test them. For the latter he gave the example of an ROV that AMEC was developing for the ITER fusion reactor.

The Nature and Scale of the Robotics Challenges at Sellafield

Presentation

Alex Jenkins of Sellafield Ltd gave the second presentation. He began with a brief history of the use of ROVs and robotics on the Sellafield site, noting that there had been considerable advances in the sophistication and reliability of devices over the years. He went on to outline the scale of the decommissioning and other challenges at Sellafield. On the $3km^2$ site there are hundreds of facilities, including legacy ponds, wet and dry cells used for highly radioactive materials, stores for raw and packaged intermediate level waste (ILW) and alpha-contaminated glove boxes. There are also civil structures to be monitored. ROVs and robotic devices often have to operate in ageing facilities. Key attributes are that they should be robust, simple, recoverable, reliable, value for money, able to operate in difficult environments and maintainable. Relatively "agricultural" vehicles and devices are often the best.

Current applications of ROVs and robotics at Sellafield include:

- crane-mounted devices to remove fuels and ILW from old facilities
- characterisation of the contents of legacy ponds with submersibles
- decommissioning highly active cells (where the device gains access to the cell, dismantles the equipment inside, exits and then moves on to the next cell)
- repairs of various sorts.

Sellafield Ltd believes that there will be an increasing need for ROVs and robotics because of the pressure for reduction of doses, risks, costs and the time it takes to decommission facilities. It commissions R&D from universities, SMEs and larger engineering companies. Current projects include the development of a small remotely operated flying vehicle to monitor and characterise the inside and outside of buildings, and the development of crane and ceiling mounted devices with highly flexible arms (e.g. for water jetting).

Alex concluded his presentation by demonstrating a WallRover™ device. Various types of WallRover are being developed for Sellafield, with applications including creating 3D visual (point cloud) maps of the inside of active facilities, characterising beta/gamma contamination in buildings, sampling from concrete walls and inspecting ILW packages in stores.

Q&A

A questioner asked whether the WallRover technology was related to that in submersibles used for removing sludges from ponds. Alex replied that the unique feature of the WallRover suction technology was that it caused very little air disturbance and thus essentially no airborne contamination. There was then a question about the performance of the WallRover on different types of surfaces. Alex said that the devices worked well on painted surfaces, even where the paint was flaking off. They had not been tested on oily and greasy surfaces but had been trialled successfully on concrete, brick, wood and polished stainless steel. Future developments would include determining whether two devices linked together by an articulated arm could climb from a floor to a wall to a ceiling, or from the side of a stack of ILW drums to the top. Payloads range from under 1kg to over 5kg.

In answer to a question about post-processing of visual and other data collected by WallRovers, Alex said that there would be work on this in future. The final questions were about positioning and accuracy. The WallRover uses its starting point as the datum and employs infra red laser range finding. It is accurate to about 5cm at a distance of 8m, which makes it possible to monitor the behaviour of civil structures and is sufficient to provide the first 'as is' view so decommissioning philosophies can be developed.

ROVs and Robotics at Dounreay – Opportunities and Applications

Presentation

Charlie Fowler of Dounreay Site Restoration Ltd (DSRL) focused his presentation on the Shaft and Silo project. The Shaft was built as access for the construction of the tunnel to hold the Dounreay discharge pipeline but was then used as an ILW disposal facility. It is 65m deep and holds about $750m^3$ of waste, which is covered in water. The Silo is a concrete structure into which waste was tipped. It holds about $480m^3$ ILW. Both facilities contain a wide variety of wastes including drums, glove boxes, large vessels, poles and sludges. Radionuclides present include plutonium and natural, enriched and depleted uranium, as well as fission products.

Enabling work for the emptying and decommissioning of the Shaft and Silo was carried out prior to 2012. For the Shaft this included constructing a working platform above it, installing a grout curtain around it, and reinforcing the plug at its bottom. Various pieces of equipment were removed from the top of the Silo and a low activity drain was removed from the Shaft and Silo area. Conceptual designs were then developed for the facilities to remove wastes from the Shaft and the Silo and to treat and package these wastes. The work is now at the scheme design stage.

The Shaft headworks are being designed to operate completely remotely. Waste will be removed from the Shaft by crane and placed in a wet holding area (a "mini-pond"), where it will be sorted and size reduced by two ROVs and placed in a shredder. There will be an intervention platform that can be manoeuvred over the Shaft to remove difficult objects. Shredded waste and sludges will be grouted into WAGR boxes and TRU-Shield containers. Waste will be retrieved from the Silo using a crane and a Brock, then sorted, size reduced and grouted. The aim is to start waste retrieval in 2016 and complete it by the end of 2019. It is planned that the Shaft and Silo facilities will be demolished by the end of 2021.

Q&A

A questioner asked about the reaction of stakeholders such as the Nuclear Decommissioning Authority (NDA) and regulators to the proposal to make such extensive use of ROVs and robotics. Charlie said that the strategy for the Shaft and Silo had been submitted and agreed during the bid process for a new Parent Body Organisation (PBO) for Dounreay. The strategy is now being implemented, so far to the satisfaction of NDA and the regulators.

Another question was about maintenance of the ROVs. The reply was that the ROVs will be brought out of the facilities remotely but maintenance will be by hand (with staff in airline suits because of the high levels of alpha contamination). At the end of operations the ROVs will move themselves into WAGR boxes so they can be disposed of as waste.

Case Study: Dounreay Particle Clean Up

Steve Goodwin of Land & Marine described the project to find and remove radioactive particles from the seabed near Dounreay. Land & Marine, working with Nuvia and DSRL, had designed, built and used the subsea ROVs, the control room, the deployment system and the survey system. Challenges included the size of the particles (typically 1mm diameter, buried 6mm deep in an area about 4km long), the rough seas, the need for accurate tracking (so that the whole area was covered) and the need for 24 hour operations.

The ROV weighed about 8t and was deployed from a barge by pushing it through the air-water interface then lowering it to the seabed. It was controlled via GPS and acoustic monitoring to work within guide corridors; this involved reversing if the ROV became more than 300mm off line. The ROV had eight sodium iodide detectors: five on the front, one on each side and one on its sensor line. When a particle was detected its activity and depth were measured. The particle was then pumped into the ROV's reception tank. On the barge the particles were isolated and their size and activity measured. They were then placed in approved packages and moved to DSRL for analysis and disposal. The barge had a crew of 24 people and was moved into position by tug boat. It operated 24 hours each day while at sea, with a support vessel to transport people and supplies.

The contract was awarded to Land & Marine and Nuvia in February 2010 and work at sea began in August of that year. In the 2010 season 429 particles were found, of which 81 were significant in terms of their activity. In the 2011 season 351 particles were found of which 38 were significant; for the 2012 season the figures were 299 particles of which 16 were significant. At the beginning of the project there were on average 6.5 particles per hectare of seabed. The density now is less than 0.5 particles per hectare.

DSRL consider the project to have been highly successful. This view is shared by the Scottish Environment Protection Agency (SEPA), which has decided that it will be unnecessary to carry out reassurance monitoring of the seabed in 2014, as originally planned.

Future Developments – Autonomous Technologies

Presentation

Jeffrey Kuo of the National Nuclear Laboratory (NNL) gave a presentation on the work being carried out by the Autonomous and Intelligent Systems Partnership (AISP), of which NNL and Sellafield Ltd are members. AISP is led by BAE Systems; other industry members are Network Rail, DSTL, Schlumberger, SCISYS and the UK Space Agency. The Engineering and Physical Sciences Research Council (EPSRC) distributes the funding to university members. Following initial discussions with industry in 2010, EPSRC issued a call for research proposals in 2011. 73 proposals were submitted, of which 15 are now being funded. The total funding for research under the auspices of AISP is about £16 million.

Jeffrey explained that autonomous systems are one way to resolve the problems of tele-operation, that is the manual control of a robot by an operator. These problems typically include:

- the lack of a direct line of sight to the robot (with reliance on TV images, often in shades of grey)
- congested and hazardous environments (with significant potential for collisions)
- the non-linear motion of robotic arms (with a need for two joysticks to accomplish movement in a straight line)
- response time (i.e. the lag between operator actions and movements of the robot)
- the difficulty of repeating exactly the same movements several times.

Autonomous systems are those that can make decisions with some or no human intervention. They have some awareness of their situation, and can optimise their mission and produce commands to hardware to execute it, either in real time or off-line. They are expected to be particularly useful for dark, dull, dirty and dangerous applications, where they have the potential to be cheaper, faster and more reliable than robots controlled by operators.

As an example of work in progress under AISP, Jeffrey summarised the project on “reconfigurable autonomy” being carried out by a consortium led by the University of Liverpool and involving Sheffield University, Surrey University, NNL and Sellafield Ltd. The project will produce an open source library of software for the nuclear and other industries. The software will be able to be reconfigured for different missions and will have a level of “plug and play” capability. Its main application will be in simulators because the nuclear industry does not yet consider that autonomous systems are safe enough to use in actual nuclear facilities. For this reason, the current NNL simulator is used for operator training and to try out the designs of new robots. During the AISP project the NNL simulator will be modified so that it is no longer joystick controlled but instead uses a data stream from an autonomous system. Jeffrey ended by giving a video demonstration of what can be done now with a simulator using an Xbox controller, and hence what an autonomous system needs to achieve.

Q&A

Noting that autonomous systems were already used in other sectors (e.g. agriculture, the oil and gas industry), questioners asked how long it would be before they were accepted for use in nuclear decommissioning. Jeffrey’s view was that it would be more than ten years but that some partially autonomous systems might be deployed earlier (e.g. autonomous off-line planning of skip movements). Another questioner raised the issue of confidence that an autonomous system would not damage nuclear plant. Jeffrey said that this highlighted the importance of the system having an accurate representation of the environment in which work was to be carried out. It was suggested that non-nuclear applications could be used as a stepping stone and Jeffrey agreed that this was a possibility.

Transfer of Approaches and Technology from Defence to Nuclear

Presentation

The final presentation was given by Robert Suttling of QinetiQ. He began by outlining the concept of “integrated survivability” for armed forces personnel. This has as its components “don’t be there”, “don’t be hit”, “don’t be penetrated” and “don’t be killed”. ROVs and robots usually fulfil the “don’t be there” function; examples are devices for detecting and disarming explosive ordnance.

A key current objective in the defence sector is to improve the management of defence capability. Any capability erodes with time and has to be updated. Typically such updating is carried out infrequently (e.g. every ten years) and involves major changes to software and/or hardware. The objective is to design new capability so that it can be updated more frequently, incrementally and cheaply. This involves moving to open, rather than bespoke, architecture for systems.

Open architecture has the advantages of modular safety and dependability cases, and of multi-level security. Industry has access to the architecture and can plan its investment accordingly. The cost of a change is then linked to the complexity of the change, not the complexity of the system itself. In addition, strategic planning is improved. Robert gave as an example the defence standard for generic vehicle architecture. This sets out for industry the components that exist and those yet to be developed, with data available on an open website. He suggested that this approach would be transferrable to the nuclear industry.

Another potential area for transfer of approach is in links to the gaming and entertainment industry. The defence sector has strong links to gaming technology, which has applications in areas such as gunnery and pre-deployment training, and the development of unmanned flying vehicles. Other defence uses of ROVs and robotics that may of interest to the nuclear sector include devices to deliver cameras and sensors, to gain entry to buildings and to remotely hose down an area. There is also a simulator for training personnel to use the Dragon device for dealing with explosive ordnance.

Q&A

A questioner asked how long it had taken to change the defence approach to one of open standards. Robert replied that the first vehicle complying with the generic architecture was now in use and that this had taken ten years. The key to making progress was in choosing the standards that would be made open.

Conclusion

Peter Booth concluded the meeting by thanking the speakers and participants. He said that the six presentations had all been very different and hoped participants would consider which aspects could be most useful to their organisations. He suggested that it would be appropriate for SAFESPUR to revisit the topic of ROVs and robotics in about two years' time.

Peter also reminded participants to provide CIRIA with feedback on the event by replying to the questionnaire that would be emailed to them. This included a question about future SAFESPUR events. Owen Jenkins of CIRIA explained that an event on long-term monitoring of groundwater was being planned for June 2013. It was suggested that this should involve the regulators, as well as NDA, site operators and contractors, and that the Soil and Groundwater Technology Association (SAGTA) could be invited to take part. Potential topics for later events included waste minimisation and re-use, an update on legislation and regulatory frameworks, and stakeholder consultation. Expressions of interest in these topics and suggestions for others would be welcome.