Integrating Commercially Available Remote Systems to Address Current D&D Challenges – 15399

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ABSTRACT

Many current D&D challenges across the DOE complex require some form of remote handling expertise and equipment. For example, high visibility projects such as Building 324 D&D and the recovery of wastes from the Alpha-Caissons and the 618 10-11 caissons at Hanford all require the development and application of advanced remote systems. Additionally although alternate solutions and options are being sought, robotic/remote systems will likely be required for completion of D&D at Savannah River Site's Building 235-F, at the West Valley Demonstration Project and many other DOE facilities that are scheduled for D&D. Similar systems are also needed to support the UK cleanup program on projects such as the decommissioning of the Pile Fuel Cladding Silo. As a result, there are a significant number of R&D and Technology Development projects underway in order to address the growing need for remote systems in D&D.

In addition to these significant R&D efforts, there are also numerous remote systems in use in multiple applications in both nuclear and non-nuclear industries and the use of remote systems at the Fukushima Daiichi plant has been extensive in the past 12-24 months. In many cases, the systems developed are customized for their given application but there are also multiple systems in use which could be applied to the worldwide D&D challenge either directly or with some minor adaptation.

During FY14, the Office of D&D and Facility Engineering (EM13) funded a review/assessment of the current state-of-the-art of robotics and remote technologies in order to generate a baseline of what is available, what has been used where and for what applications and what has been successful and what hasn't. Where possible, the assessment was extended to identify remote systems that have been used in non-nuclear industries but which, with limited modification, may have application in the nuclear industry.

The work also included a review of the most recent publicly available TBuRD (Technical Baseline and Underpinning R&D) activities being undertaken by the UK NDA and their Site Licensed Companies (SLCs) in the area of remote systems in order to compile a searchable database of both available, commercial-off-the-shelf (COTS) remote systems and developing technologies. Other suitably qualified organizations in the US and the UK (such as UK National Nuclear Laboratory, SRNL, PNNL ORNL, OC Robotics and others) were also engaged to identify other ongoing

technology development efforts which may be of interest and benefit to the decommissioning community.

In all, of the order of 500 remote systems were identified and cataloged in both hard copy and as a searchable database. These systems were categorized in terms of their main application e.g. manipulator, wheeled land-based platform, track land-based platform, water-based platform, air-based platform, end effectors , sensor, crawler etc to clearly demonstrate the depth and breadth of available systems in each category. In addition, single page summaries of each system were produced and used, in a workshop setting, to dentify technologies which, when integrated with other currently-available technologies, could provide a workable system to address existing needs. An initial workshop was held with CH2 Washington Idaho (CWI) and DOE Idaho in August 2014 to explore how the available systems could be integrated to address current and future D&D needs at that site.

INTRODUCTION

Many current D&D challenges across the DOE complex require some form of remote handling expertise and equipment including high visibility projects at the Hanford, Savannah River, West Valley, Portsmouth and Paducah sites. In addition, D&D activities at Sellafield and Dounreay in the UK and Chalk River and Whiteshell in Canada also require remote systems to address challenges where it is unsafe for human entry and activity. As a result, there are a significant number of R&D and Technology Development projects underway in order to address the growing need for remote systems in D&D.

Although remote systems have been used in D&D projects, there is no single source of information on the systems themselves, what the systems were used for or how they performed. This project focused on gathering and assimilating available information about systems which have either been used or which are being developed across all industries to provide a reference ‘catalog’ for D&D managers. The catalog was then used in a facilitated meeting to identify potential solutions to current and future site challenges at the DOE Idaho site.

APPROACH ADOPTED

The project involved the following tasks.

Task 1: Desk-Based Review of the State-of-the-Art of Remote Systems in D&D: In this task a desk-based review of the state-of-the-art application of remote systems in D&D was conducted. The review included literature surveys, conference proceedings, website research and telephone discussion with end-users of remote systems and identified the system used, where it was used, what it was used for and any comments on how it performed. The remote applications were then codified in a common format (ie manipulator arm, land-based platform, water-based platform, air-based platform, sensor, end effector etc) to enable the construction and interrogation of a database.

Information sources included, but were not limited to, the following;

General
Gizmag, Institute of Electrical and Electronics Engineers, World Nuclear News, International Federation of Robotics, Robotics Business Review

Universities/Research
National Centre of Competence in Research (NCCR) Robotics, MIT Field and Space Laboratory, Harvard Robotics Laboratory, Stanford Robotics, Carnegie-Mellon Robotics Institute

Other Media

- Magazines (Wired)
- newspapers (major US, UK and European newspapers)
- websites from the major US/UK nuclear sites (Hanford, Savannah River, Sellafield, Dounreay)
- National Labs websites (Sandia, PNNL, SRNL, ORNL, NNL).
- DOE Tokyo Daily News and Fukushima Robotics Lab for Fukushima-related updates.
- IAEA publications and news alerts.
- DOE reports

Face-to-face Discussions
Where possible, interviews were arranged with key personnel at organizations such as Sellafield Ltd and National Nuclear Laboratory to solicit their input and experience into the availability and suitability of information and data.

In each case, links and additional data were pursued in an effort to ensure as comprehensive data collection as possible was achieved.

Task 2: Desk-Based Review of D&D TBuRD data from UK NDA/SLCs: As part of the UK NDA and its Site License Companies' Technology Development efforts, annual tasks known as TBuRDs (Technical Baseline underpinning R&D tasks) are developed which detail the technology need, the SLC plans for addressing that need and the insertion point of the technology developed into the overall baseline cleanup schedule. In Task 2 of the work completed, NuVision reviewed the latest set of publicly available TBuRDs which involve the development or applications engineering of remote systems to identify areas where the UK NDA and its contractors are allocating funding to develop and engineer remote systems. This dataset complemented that from task 1 in that it illustrated the planned level of development for new systems in the UK. The data generated was also codified in the same manner as the information from Task 1 and added to the database in Task 3.

Task 3: Database Development and Data Input: In this task a searchable database based on the output from tasks 1 & 2 was constructed to provide a list of the technologies and systems

identified. The database was placed on a web-based platform and subsequently provided to DOE-EM.

Task 4: Review of DOE Remote D&D Needs: In this task, available lists of DOE remote D&D needs generated during previous and current work on the DOE Technology Development program were interrogated to identify remote systems needs. In addition, a "Needs Identification" workshop was held in June 2014 which involved DOE and their prime contractors from all major sites (Richland, Oak Ridge, West Valley, PPPO, Savannah River, Idaho) as well as Sellafield from the UK.

For remote systems the primary issues are:

- delivery systems/platforms for;
  - decontamination agents
  - fixatives
  - sensors
  - characterization systems
- disposable/low cost but radiation tolerant equipment
- duct inspection and decontamination equipment
- improved visual and sound systems
- cheap, quick, fast characterization systems
- sensors for high radiation areas
- 3D visualizations.
- size reduction
- manual handling

Task 5: Data Analysis and Workshops In this task the data generated was analyzed and organized/managed in a workshop setting to identify;

a) COTS remote systems which may meet a DOE need
b) COTS remote systems which, with some minor modification, may meet a DOE need
c) Current or planned UK TBuRD activity which may be developing a remote system which will meet a DOE need

THE DATABASE

The database developed is a comprehensive compendium of the current state-of-the-art of remote systems technology. During the project, it was hosted by the NuVision Engineering/Cogentus team and is now being transitioned to be hosted by Florida International University as part of its KMIT suite of D&D databases. At the present time there are no plans to expand the database owing to funding limitations.

Screen shots from the database are shown below.

Going forward it is envisioned that the database will be a tool for D&D planners and practitioners alike. However, its long term value will be dependent upon how much funding is made available to maintain and expand it. Certainly the database is a mine of useful information and data on remote systems and could become a widely used and routine tool in the D&D world.

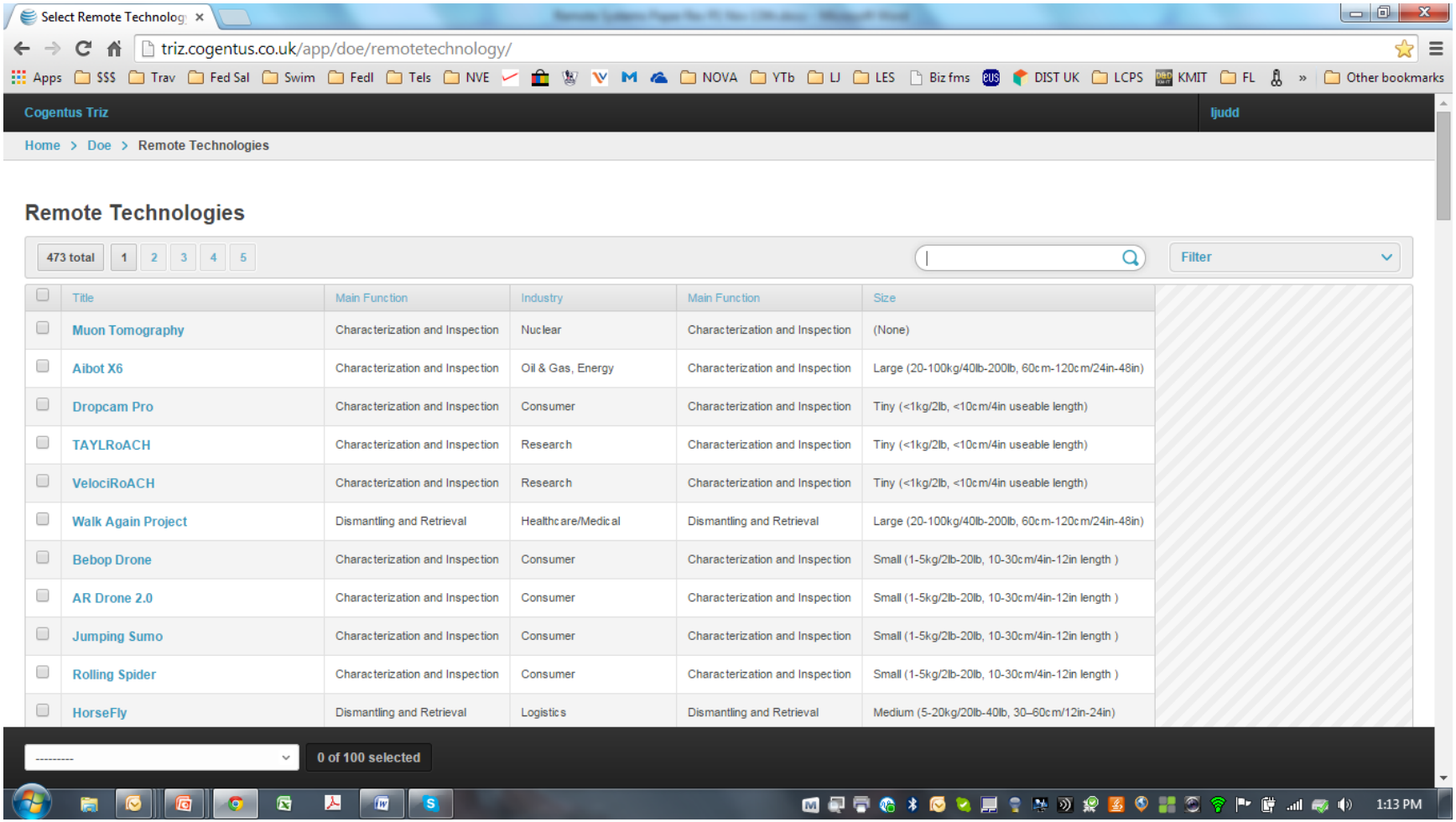

Figure 1: Following database access, technologies and their main attributes are listed in terms of their name, main function, primary industry, and approximate size. Note also the ‘Search’ function which can be used as a shortcut.

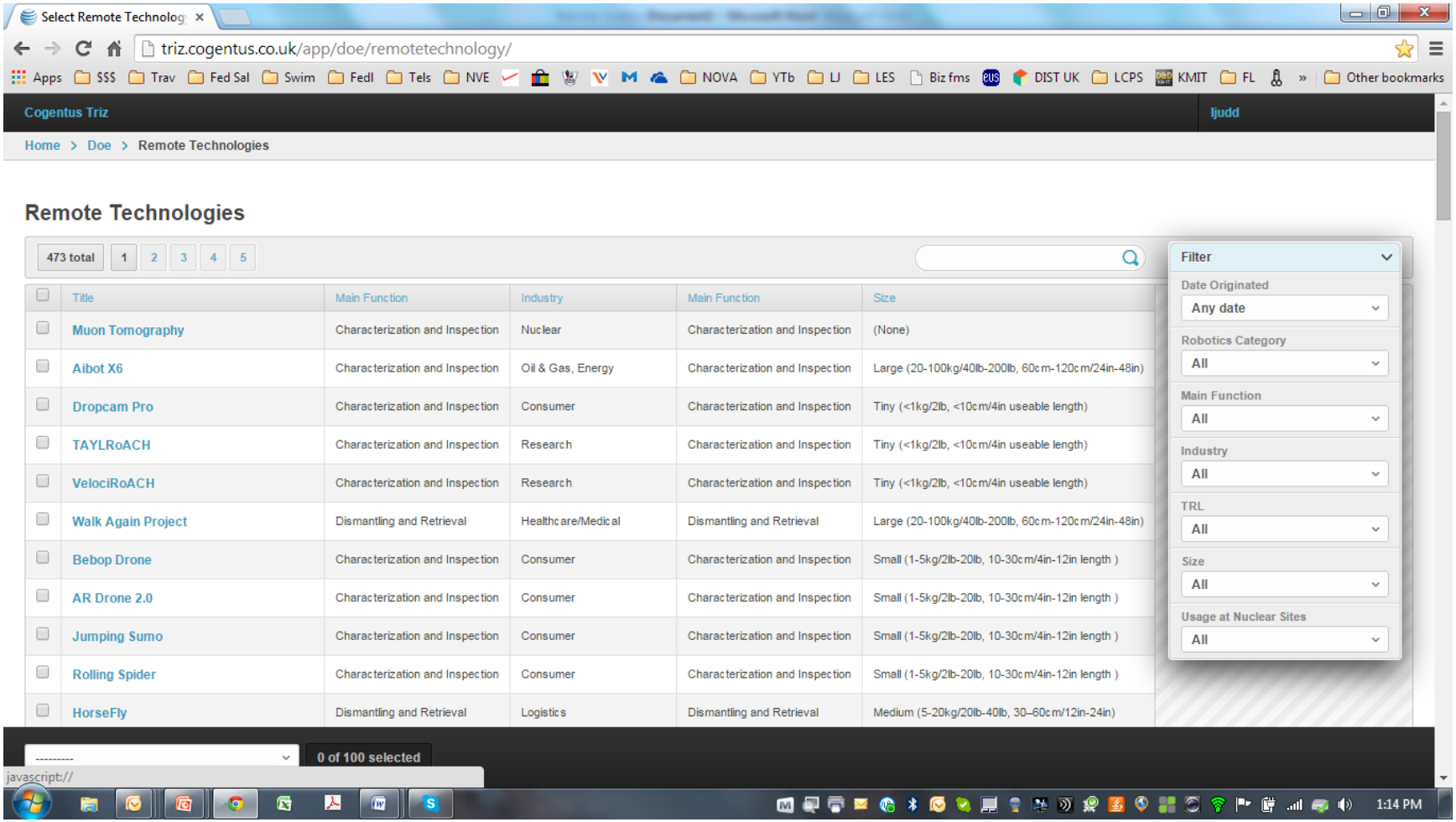

Figure 2: The “Filter” dropdown provides a list of critical search terms – date of entry, type of remote system (e.g. manipulator, snake robot, land based platform, underwater platform etc), primary function (e.g. characterization, size reduction, pick and place etc), primary industry, TRL level, Size and nuclear sites where it has been used

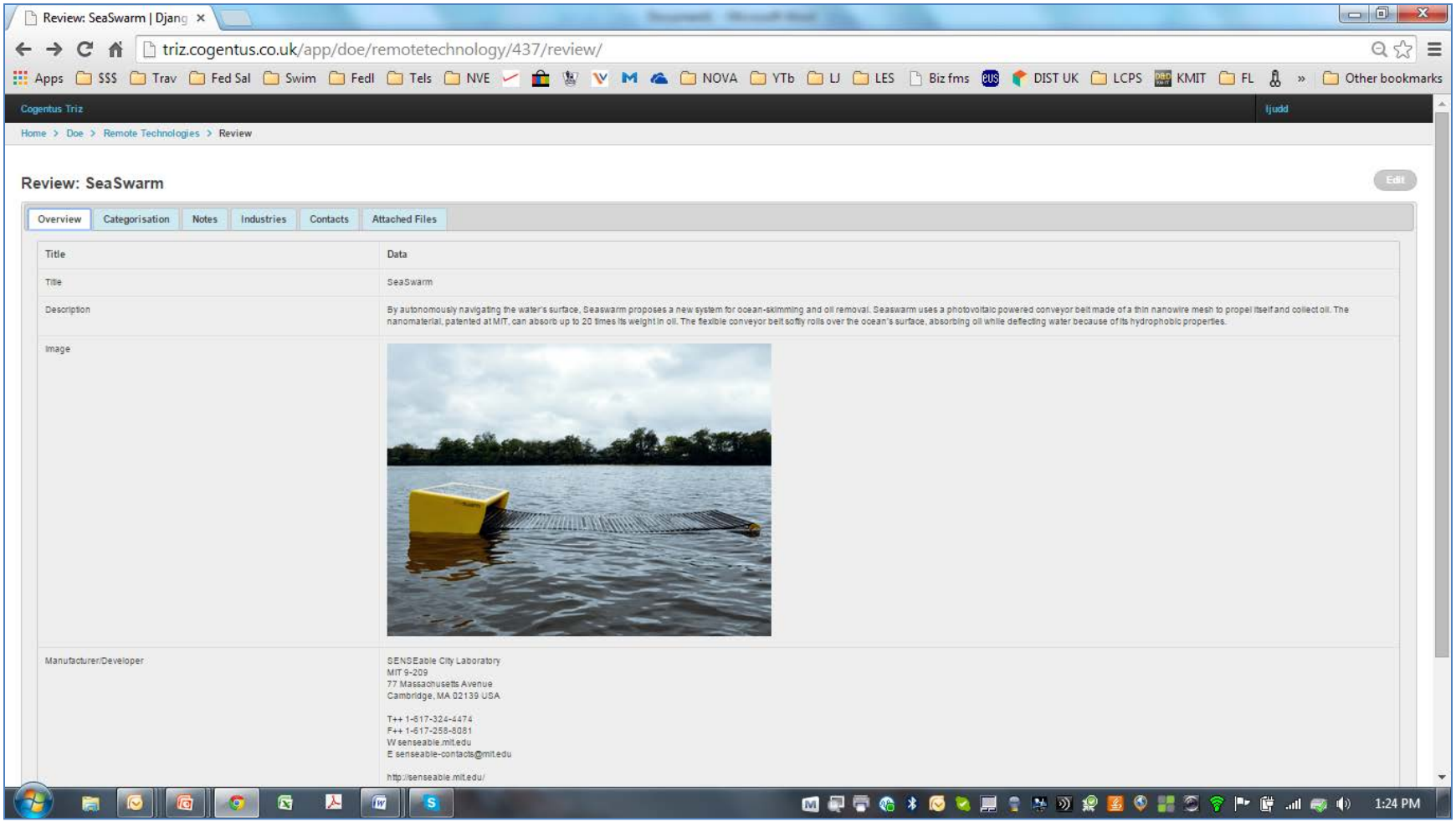

Figure 3: Clicking on a system name provides additional tabs for further information. The “Overall” tab provides the overall description of the system, its main characteristics and the supplier information.

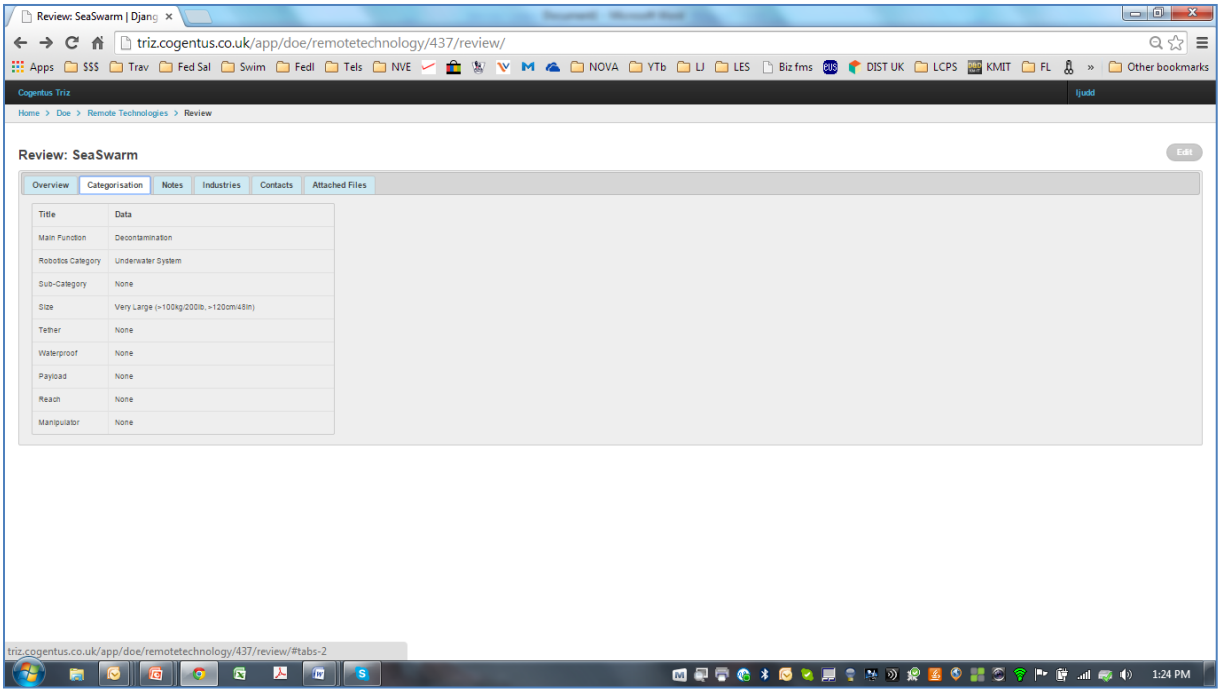

Figure 4: The “Categorization” tab provides functional, industry and categorization information.

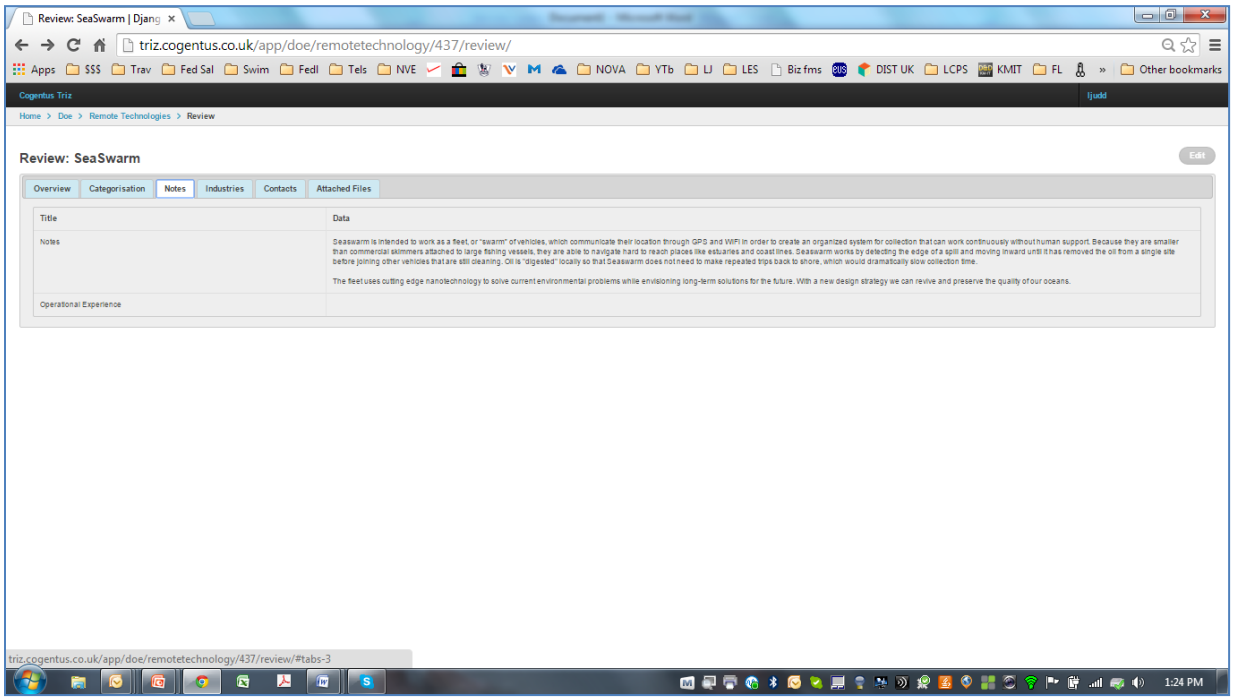

Figure 5: The “Notes” tab collects other pertinent data about the system and links to more detailed articles and information.

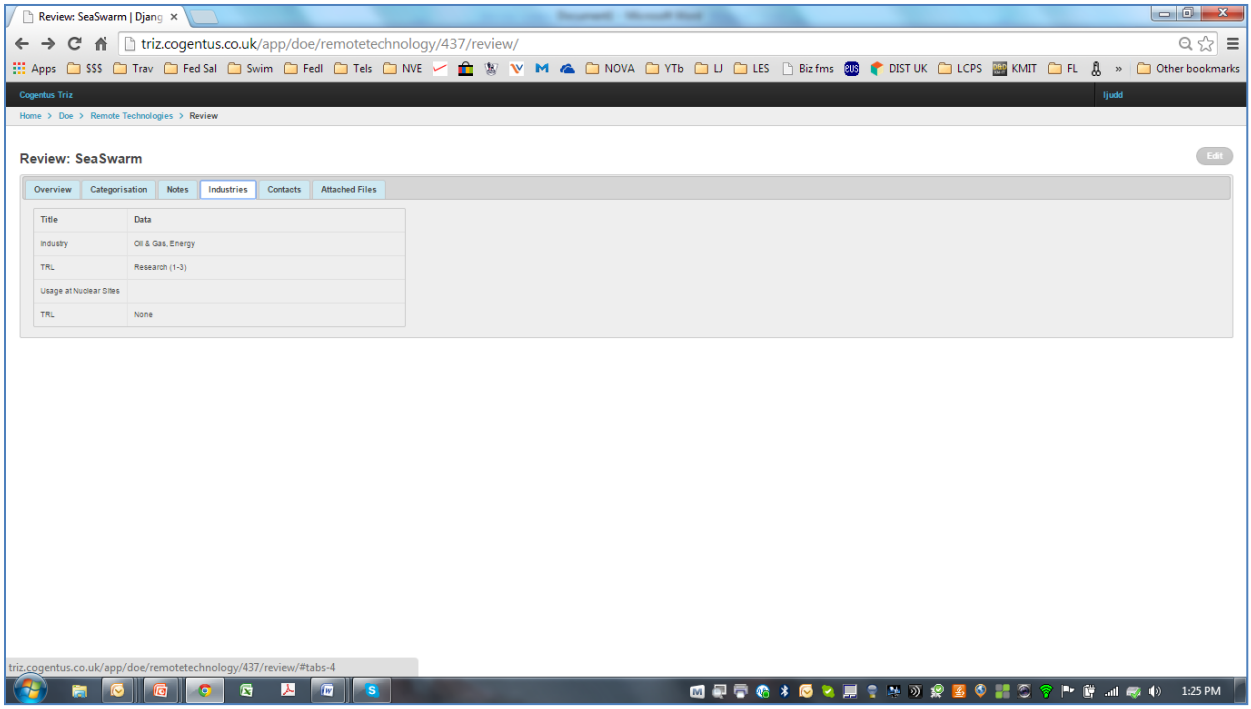

Figure 6: The “Industries” tab provides more information on where the system has been used or is aimed at and its TRL level.

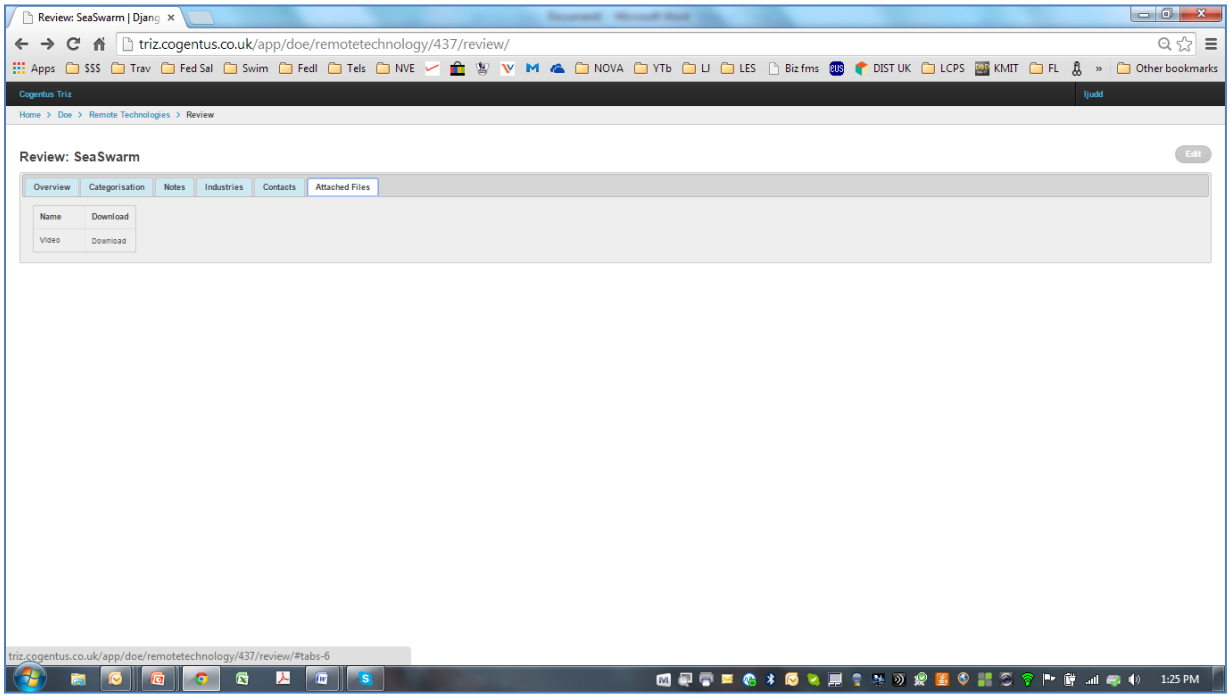

Figure 7: The “Additional Files” tab provides links to videos on the system.

TECHNOLOGY APPLICATION WORKSHOPS

Having developed the catalog and database of available remote technologies, it was agreed to pilot workshops at DOE sites to discuss a small number of pressing needs in detail and then try to identify technology solutions from the database.

A two-day workshop was arranged with CWI and DOE Idaho on August 18th and 19th 2014. In preparation for the workshop, a number of discussions were arranged to outline the purpose and format of the workshop and to ensure that sufficient preparation had been completed to maximize the benefit of the two days. The workshop used the process illustrated in Figure 8 to drive the participants to drill down to the core of defining the problem in a very specific and detailed manner and then working in a methodical and structured manner to identify and downselect possible solutions.

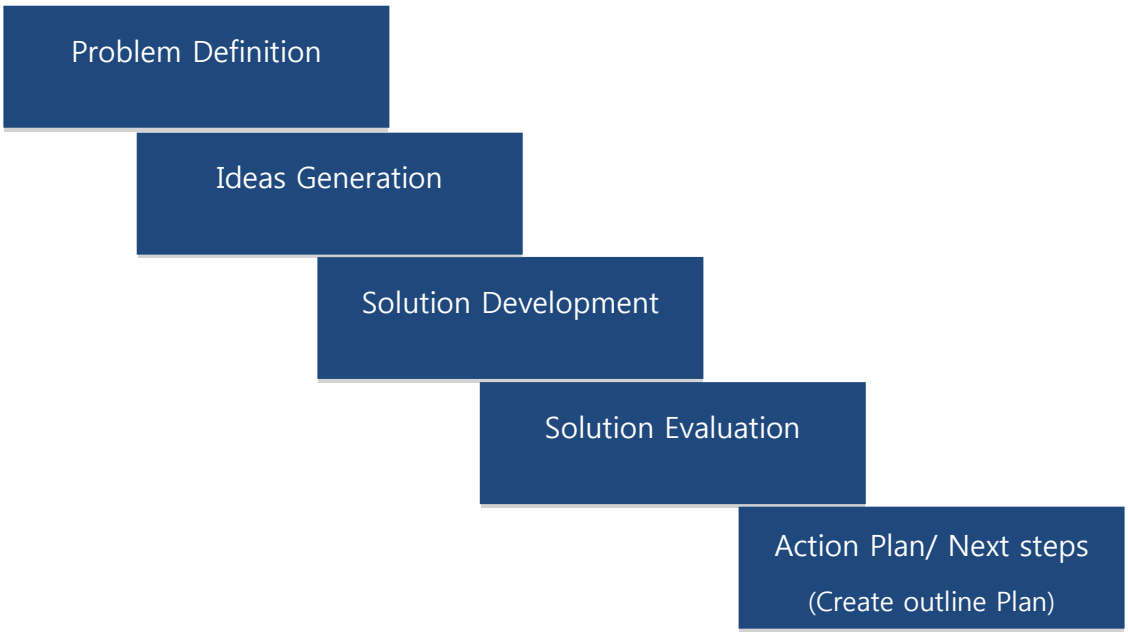

Figure 8: A Structured Process is used to Identify Challenges and Potential Solutions

By using this approach, the team was able to focus on identifying potential remote-system solutions to six critical current and future D&D needs as follows;

1. Cutting an entry hole into the top of a bin in order to retrieve the calcine.
2. Bulk retrieval of the calcine
3. Removal of asbestos lagging from pipework
4. Inspection of pipework to identify ‘hold up’
5. Separation of sodium and cesium

6. Preparatory D&D work

Taking the first of these as an example of how the process and the database content added value to the CWI calcine disposition project engineering team, the issue at hand was how best to accurately and safely drill a hole in the top of a calcine bin from a distance of more than 20 feet (6 m) and in an area of high radioactivity. This is a challenging undertaking as:

- traditional drilling using liquid coolants or cutting fluids is not an option as the calcine material cannot be wetted
- the top of the bins are domed and so it is difficult to start the drill
- it is difficult to prevent and control drill 'wobble' given the distances involved and
- it is important to maintain contamination control during the process

The potential solutions identified included

(a) the use of a mobile platform with a manipulator arm capable of handling the drill bit and associated sensors
(b) the use of a static platform with a similar arm and sensors and
(c) the use of a device that can be lowered down onto the bin sets to perform the drilling operations.

For each case, a number of specific equipment and tooling options were identified (i.e. platforms and arms) from the database which offered a potential solution. More specifically;

- for (a), 3 platforms, 6 arms, 6 end effectors (cutting systems) and 2 sensors were identified
- for (b), 2 platforms, 6 arms, 6 end effectors and 2 sensors were identified
- for (c), no options were identified

The next step will entail CWI undertaking a review of each of the platforms, arms, end effectors and sensors in detail to better understand their capabilities and operating history such that an optimized system can be assembled.

A similar process was undertaken with challenges 2-6 above with similar outcome and follow on activities.

The primary objective of these workshops is to match available remote systems technologies with current and future technology challenges and that, in and of itself, is a major benefit in accelerating the introduction and implementation of remote technology into the DOE D&D program. In addition, introducing existing technologies is far more cost effective than developing new systems which again serve to reduce the cost and schedule of D&D.

In addition, the workshops help to get into the detail of the site technology needs. Through other work conducted by NuVision Engineering, technology needs statements have been collected and assembled to help support the development of a D&D Technology Development strategic plan. During this work, it became clear that the quality of information available at the sites is largely at the superficial level and that information in much greater detail is needed to really understand and qualify the need. Workshops of this type have demonstrated their value in getting to the real heart of the problems and, in the case of remote solutions, there is now the ability to highlight potential solutions to those problems.

SUMMARY AND CONCLUSIONS

The remote systems/robotics sector is one of the most exciting growth and innovation technology markets across the world at this time. The applications of the technology are developing with the increase in available systems but the nuclear market is not a target market for most, if not all, remote system developers since its systems tend to be custom, ‘one-offs’ and the lead time to market is so long. As a result, the nuclear market will need to rely upon adaptations of systems developed for other applications to meet its remote system needs.

In this project, more than 500 currently available remote systems have been identified and codified to provide a unique snapshot of the state-of-the art of remote systems worldwide. The database is a useful tool and has the potential to become an essential part of the D&D process – from planning support through to implementation of commercially available systems which are much more cost effective and timely than having to develop, demonstrate and prove new technologies and systems. However, without the required investment to maintain and expand the database, it will become dated very rapidly and lose its potential for change.

Through the facilitation of a focused, structured workshop at Idaho, it was demonstrated that pairing the knowledge of these systems with a detailed analysis of D&D challenges can generate ideas and options based on currently available systems which otherwise would not have been considered. Such an approach is a cost effective and technically proficient way to address D&D technical challenges in an optimum manner. Additional workshops should be considered and supported at other major facilities and D&D projects both within and outside of DOE.

In compiling the database of available technologies, an analysis has been undertaken to identify existing and developing systems in other Government technology development programs (e.g. the UK) and this has enabled a filtering of technology development needs to enable DOE to focus on a limited number of areas where it can make the biggest impact using its relatively scarce R&D funding.