A REMOTE TECHNOLOGIES APPLICATION PROGRAM

AT NINE MILE POINT

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ABSTRACT

Traditionally, the use of robotics and remote technologies within the nuclear industry has been limited to hot cell facilities for fuel processing and highly radioactive sample handling. However, now faced with increasing pressures to reduce occupational radiation exposures as low as reasonable achievable (ALARA), the nuclear utility industry is looking beyond the traditional exposure reduction methods and is slowly and carefully entering into robotic automation. The purpose of this presentation is to describe the efforts, achievements, and experiences of the personnel at the Niagara Mohawk Power Corporation (NMPC) Nine Mile Point Nuclear Stations to become involved in this emerging technology.

INTRODUCTION

Through the creative imaginations of gifted writers and film directors the word "robot" has taken on a variety of definitions and misconceptions. The Robot Institute of America definition states in part, "a reprogrammable, multifunction manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks." The only problem with this definition is that few, if any, such system exists today for applications of interest to the nuclear utility. The proper term used to describe the machines discussed in this paper is "teleoperated mobile manipulator" since they are remotely controlled by a human operator. This terminology is cumbersome, therefore, the word "robot" will be used in this presentation.

In September 1984, the multi-departmental Nine Mile Point site ALARA Committee recognized robots and remote technologies as a viable means of reducing personnel radiation exposures and thus warranted further investigation. The ALARA organization contacted the NMPC R&D Department to discuss funding and engineering assistance for developing a program to introduce robotics to Nine Mile Point Unit 1 (NMP1). The proposed project fit the R&D criteria of having a high potential benefit and probability of success, but with more risk than justifiable for Corporate capital expenditure. Therefore, it was decided that the site ALARA Coordinator and the R&D representative would jointly provide overall program leadership and for each particular project a site "sponsor" would serve as project coordinator. KLM Technologies, Inc. served as the R&D representative for the program.

The managers of the major Corporate and site departments were polled to determine their departments interest and the degree of effort they were able to contribute to the robotics program. As a result, a Robotics/Remote Technologies Task Force was organized to plan the direction of the program. The task force consisted of the supervisor/engineering representatives from maintenance, radwaste operations, inservice inspection, nuclear engineering, health physics, ALARA and R&D.

Program Objectives

The initial meeting (in early 1985) of the Robotics/Remote Technology Task Force was to formulate the program's near term objectives. As task force knowledge increased, program objectives for 1985, 1986 and 1987 were established. The goal of the objectives was to gradually increase NMPC's involvement in robotics. The following objectives were established:

1985 Objectives

1. Conduct a detailed literature/vendor search of the available technology and organize the materials into a retrievable format. This first objective was the educating step since many of the task force members were only familiar with the well publicized EPRI and TMI robots.

2. Develop a robotics application plan for the decontamination, demolition, and refurbishment of a radwaste building elevation in conjunction with a major radwaste retrofit project. The purpose of this task was for radwaste, ALARA, and engineering personnel to examine the tasks involved with the retrofit project and determine what tasks, if any, could benefit from the currently available robotic technology.

3. Develop an inservice inspection application plan for a mobile robotics system that would have a high potential for reducing inspector radiation exposures. The purpose of this objective was to write a specifica-

tion such that the current technology would to be improved to meet the inservice inspection criteria.

4. Participate in a robotics application program. The purpose of this objective was to introduce NMPC to robotics.

1986 Objectives

5. Conduct a controlled demonstration program of the Automation Technology Corporation (ATC) Surveyor vehicle. As a result of objectives 2 and 3, the ATC Surveyor vehicle was selected for the radwaste retrofit project and the inservice inspection task. This vehicle is to be made available to as many NMPC personnel as possible for introduction testing and evaluation purposes.

6. Identify other potential applications of the ATC Surveyor vehicle and upgrade hardware and payloads, if necessary. The purpose of this objective is to challenge current manufacturers to develop task specific hardware.

7. Identify and investigate a specific maintenance task that would benefit from automation. This task would include a feasibility study, benefit/cost analysis, and design specification.

8. Conduct a feasibility, benefit/cost and design specification study of a site specific decontamination device. This particular task will concentrate on an underwater applications for tanks, sumps, pools, etc.

9. Continue to participate in EPRI and other robotic development programs. The purpose of this objective is to continue the education process and to maintain the R&D programs broad perspective of available technology.

1987 Objectives

10. Develop and implement the hardware determined in Objectives 7 and 8.

Program Objectives Activities

During 1985, the task force successfully completed each objective. The first objective of conducting a literature/vendor search was conducted by KLM Technologies, Inc. Since this objective is a dynamic task which must continue, the most valuable accomplishment was the development of a vendor/NMPC rapport that keeps NMPC informed of technology advances.

NMPC's first robotic endeavor was the test of the ATC Dolphin-Nuclear robot. Dolphin-Nuclear is a modified version of an underwater, tethered device designed to scrub and vacuum swimming pools. The device was tested in a Nine Mile Point radwaste tank in April 1985.

ATC proposed to conduct the activities for this evaluation project under the sponsorship of two nuclear utilities. Niagara Mohawk Power Corporation (NMPC) and Pennsylvania Power and Light Company (PP&L) funded and actively participated in this program. NMPC Research and Development offered the use of the Nine Mile Point Unit I Nuclear Station. PP&L Nuclear Support provided technical support and test personnel during the testing and report phases.

The project was based upon the current off-the-shelf model of Dolphin which was designed to function cost-effectively in a commercial swimming pool environment. The participants recognized the limitations of Dolphin-Nuclear, but they believed this device could serve as "proof-of-concept" for a remote underwater cleaning device. The goals of this project were to identify the decontamination applications, perform a field test, and, if successful, identify the necessary modifications for next-generation devices. These specific goals were to be attained by completing the following tasks:

1) Select a test/evaluation facility with project participants.
2) Identify applications for evaluation programs, to include use of video/charged coupled device (CCD) and radiation monitoring surveillance devices.
3) Conduct an evaluation program using an unmodified unit, including examination of operation, maintenance and decontamination procedures.
4) Identify and define system design requirements.
5) Prepare and issue final report.

Dolphin-Nuclear is an underwater device designed to scrub and vacuum the horizontal and verticle surfaces of pools, tanks, cavities and sumps. The equipment has autonomous operation with the power supplied via a tether. Dolphin-Nuclear was lowered into the NMP-1 Waste Surge Tank as a "test of concept" that a modified design of the Dolphin swimming pool cleaner could be adapted to nuclear applications. Dolphin-Nuclear was easily lowered through the man-way and submerged. When the power was turned on, Dolphin-Nuclear could be seen swimming toward the side of the tank, climb the wall, descend the wall and then become lost in a pile of sludge. Dolphin-Nuclear had successfully demonstrated "proof-of-concept." During the June-July 1985 period, Dolphin-Nuclear was tested for ease of decontamination. Several decontamination methods including manual scrubbing, ultrasonics, and freon were evaluated. The results of the tests provided the data necessary for an improved design. The data gathered through observations, photographs, and video is being used to design a nuclear production grade Dolphin-Nuclear called Scavenger.

The radwaste retrofit project and the inservice inspection task were examined in detail and the performance requirements for a mobile robotic device were formulated.

1. A mobile autonomous robotic vehicle is required.
2. The vehicle must be capable of descending and ascending stairs at NMP1.
3. Remote control, video and sensor data transmissions on a non-interferring communication frequency is required.
4. The vehicle must be capable of climbing over obstacles including a 7 inch dam.
5. The vehicle must be capable of traveling through a 6 inch depth of water, and water and sludge mixtures.

6. The vehicle must be capable of traveling across concrete flooring, fiberglass and steel grating, wood, gravel, mud and sludge mixtures.
7. Obstacle avoidance either autonomously or via teleoperations is required.
8. The robotic vehicle must be capable of entering labyrinths as encountered at NMP1.
9. The robotic vehicle must be capable to enter and exit various cubicles at NMP1 including the ability to turn on its own axis.
10. The robotic system must be capable of remote video recording, including provision of necessary lighting.
11. The robotic vehicle must be capable of either tethered or untethered operations.
12. The vehicle must be capable of radiation mapping including 3-degrees of freedom.
13. Wide angle telephoto vision is required with video taping capability.
14. Inspection optics with 3-degrees of freedom is required.
15. Supplemental optics such as steriovision are desirable, including the capability to confirm equipment and component locations.
16. 360 degree video coverage in the horizontal plane is required; 270 degrees or greater video coverage in the verticle plan is desirable.
17. The robotic system must be capable of monitoring and surveillance of activities at all areas within NMP1.
18. It is highly desirable that the vehicle be capable of moving cylinderical non-stationary components such as overturned 300 lb. drums.
19. It is highly desirable that a liquid, solid and possibly gaseous sampling capability be provided.
20. It is desirable that the robotic vehicle be capable of taking a surface smear samples.
21. It is highly desirable that the robotic vehicle have a tool capability to bore, puncture and sample waste drums.
22. The robotic vehicle and any auxillary equipment must be capable of being decontaminated.
23. The robotic vehicle must be capable of being recovered in case of various single component failures.
24. It is desirable that the vehicle be capable of transporting a pumping/transfer station (vehicle) to various areas.
25. It is desirable that the robotic vehicle be capable of transporting and utilizing a hydrolaser to support facility decontamination.
26. It is desirable that the vehicle be multiple use in nature.
27. It is desirable that the device should require minimal modifications of NMP1 facilities.
28. The device should be capable of continuous performance when subjected to 130 F, 100% relative humidity and 100R/hr radiation environment.
29. The device should be capable of movement between plant areas without releasing contamination into pathways.
30. The device should be capable of reliability equivalent to industrial robot system with 300 hours between failure (MTBF).

A matrix of the performance requirements versus the currently available mobile robots was constructed. Nine robotic devices were considered to varying degrees. It should be noted, however, that other devices were reviewed but either were not available for loan, lease procurement or were totally inappropriate for consideration at NMP1. Based upon the evaluation, the Automated Technology Corporation SURVEYOR system was recommended for use at NMP1.

Experiences - Lessons Learned

During the development of the NMP Remote Technologies Application Program many key lessons were learned that would help other utilities developing an equivalent program.

1. Research the end user needs. Before starting any robotic application program solicit the end users need. The NMPC Remote Technologies Application Program was designed with the end user as program directors. The end user is an active participant and only projects desired by the end user are pursued.

2. Plant advocates are needed. In order to support any robotics project, one must have the complete support of the particular work group for which the robot is intended to assist. Without this support, the project may be burdened with a negative attitude, and the credibility of other projects will be damaged.

3. Project planning is critical. In order to maintain a positive attitude among the project supporters, the robot application test must be carefully planned. Do not let the expectations exceed the robot's capabilities. Simply, plan the work and work the plan.

4. Small successes are important. People who are generally skeptical of an emerging technology will keep a success/failure score card. Do not overlook even the smallest objective and its successful achievement.

5. Maintain the positive attitude. Maintaining a positive attitude among advocates is extremely important, and the attitude to keep is that the technology is new, it has great potential for improving station operation, and there is a lot yet to be learned.

6. Maintain the momentum. Maintaining the program's momentum keeps those involved interested and thinking of other applications. During the inactive periods between hardware orders and delivery, keep people informed of technology advances with vendor fliers and published materials. Meetings with vendor material are useful.

7. Project scheduling. Since the end user is the center of the program, schedule projects according to the station planned activities. Plan feasibility studies during outage years and hardware applications during non-outage years.

8. Dedicated project engineer. A dedicated project engineer is critical to the success of a robotic application. Plan the robotic test projects so that the individual is dedicated to completing the task. Delays create confusion, loss of objectivity, and poor data acquisition.