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# ROBOTICS IN THE NUCLEAR INDUSTRY
# - AEA TECHNOLOGY'S PART IN THE TELEMAN PROGRAMME -

Dr Ed Abel CEng, FIEE

## SUMMARY

The development of advanced robotics in the nuclear industry has been accelerated by the CEC's TELEMAN Programme. TELEMAN is a five year cost-shared research programme directed towards remote handling in hazardous and disordered nuclear environments. AEA Technology's own telerobotics development includes products such as stereoscopic TV and nuclear engineered robots. The TELEMAN Programme objectives are described and AEA Technology's contributions to this significant new Programme are summarized.

## THE TELEMAN PROGRAMME

The TELEMAN Programme was authorized by Council Decision in July 1989. Funding has been set at 19 million ECU over a period of five years to support a cost-shared research programme covering remote handling in hazardous and disordered nuclear environments[1].

The Programme is split into two phases. The first phase consists of a co-ordinated set of sixteen multi-partner, multi-national projects which integrate new technological development into building blocks. These building blocks will be brought together in the second stage of the Programme, where the construction of research machines will demonstrate significant advances in teleoperated machines, manipulators and vehicles.

The TELEMAN Programme will benefit from non-nuclear research in CEC programmes such as BRITE and ESPRIT, as well as from the nuclear Fusion and Decomissioning programmes. Many of the organizations in the sixteen phase one projects have direct experience in these other programmes. A TELEMAN Users Group advises the TELEMAN Programme of the applicability of the projects, and has influenced the definition of the types of research machines that will be the subjects of phase two.

The CEC budget for phase one is just over 9 Million ECU, and for phase two it is about 7 Million ECU. With cost-sharing, the Programme total effective value is expected to be equivalent to about 35 Million ECU. In phase one, the sixteen projects have a combined 130 man-years of effort and the Table shows the spread of the technical areas addressed.

The CEC have stressed the importance of inter-project co-ordination, and encourage joint access to results between the projects. In particular, one project concerned with the environmental and radiation tolerance, and systems reliability aspects of telemanipulated devices runs for four years. It will act as a common database and information dissemination agency for the other projects and phase two research machines.

The majority of phase one projects run for about two years or less; a few have durations of up to three years. The second call for proposals covering research machines and product evaluation is expected in 1992. The research machines will focus on

Dr Abel is with AEA Technology at Harwell Laboratory, Oxon

- improved light mobile machines that can be used to collect information, relay signals, or provide auxiliary views or grasps.

- more robust mobile machines for maintenance repair, post accident intervention or decommissioning, and includes manipulators attached to gantries and teleoperated cranes.

- improved long reach devices that can work through restricted access across containment boundaries.

Product evaluation will include end-user evaluation of TELEMAN teleoperators, monitoring trends in teleoperator development, and evaluation the performance of tools.

## AEA TECHNOLOGY AND REMOTE HANDLING

AEA Technology is Europe's largest organization involved in nuclear development work and operates in six major nuclear sites in the UK. Remote handling R&D is carried out at the Harwell Laboratory, and for the last seven years the emphasis has been placed on developing advanced viewing and telerobotic products that can be easily applied to a wide range of nuclear industry facilities. Robot applications have been successful in AEA sites at Winfrith [Radwaste Treatment] and Windscale, [reactor decommissioning] and now following successful trials, work at Harwell has begun on a glovebox decommissioning project using NEATER, the nuclear engineered advanced telerobot. NEATER is a re-engineered PUMA 762 CR robot, tolerant to extremes of radiation, developed with Stäubli Unimation [2]. New telerobotic control and force-reflecting input devices have been produced [3].

In parallel with telerobotic hardware, a vigorous viewing program has produced a range of stereoscopic television systems, TV$^3$, which are also available in radiation tolerant formats.[4] TV$^3$ systems show immediate benefits for users of remote equipment such as manipulators or vehicles, and are easy to use and give none of the operational problems such as eye strain or headaches associated with many of the alternative systems that are commercially available. Stereoscopic images can be recorded on standard videotape for training or plant walk-through[5].

## AEA TECHNOLOGY AND TELEMAN

AEA Technology at Harwell is involved with seven of the sixteen phase one projects, as co-ordinator, partner and sub-contractor. The main contribution is as a member of the CIRCUIT group [Components for Intelligent Robot and Crane and Control, Usability and Intelligent Teleoperation] where ten organizations from four countries carry out four of the TELEMAN phase one projects. The rôle of AEA Technology in the seven projects is as follows

TM 1 ARTIST [Advanced Radiation Tolerant Information and Sensor System for Teleoperation]
Co-ordinator: IPB Pietzsch

ARTIST integrates several different sensor systems into a high precision pan and tilt platform that will be tested on a KHG remotely operated vehicle at the Emergency Brigade's facilities.

AEA will produce a rapid prototype stereoscopic radiation tolerant camera with zoom lenses and minimal cabling that can be interfaced to an advanced workstation.

TM7 VISYS [Vision Systems and Sensors] Co-ordinator CEN/SCK, Mol
VISYS integrates sensing components developed in the project to produce a user friendly interface for teleoperated cranes and manipulators. AEA will produce a high dynamic range camera that can be applied to view poor contrast scenes experienced in low light conditions, and also conditions such as flame viewing for cutting and welding operations. VISYS is one of the CIRCUIT projects.

TM20 MAGIC [Manipulator and Gantry Intelligent Control]. Co-ordinator AEA Technology
MAGIC extends the current state of the art in on-line computer controlled cranes, gantries and large serving systems. Real-time force control strategies for manipulators and telerobotic control will be advanced. AEA will produce a robust telerobotic controller for force reflection, including a new input device, and devise hardware configurations for robot and gantry control systems to facilitate radiation tolerant design. MAGIC is one of the CIRCUIT projects.

TM22 [Development of an Intelligent Radiation Vision System]. Co-ordinator CIEMAT
TM22 will develop a small size system that can capture a radiation image of a source in a facility. The sensing system will be suitable for installation on a vehicle. AEA will be involved in the data interpretation of the sensing system, using new techniques.

TM26 SIMPLE [Simulation, Planning and Programming Environment] Co-ordinator KfK
SIMPLE is concerned with off-line techniques for robotic and gantry control. Many standardized interfaces will be used [from sources outside TELEMAN] to implement task planning, simulation, and tool deployment. An integrated software environment for off-line programming will result. AEA will look at developing off line programming using a synthetic task box modelled on GRASP and controlled, bilaterally, with the Cartesian Mini Master Arm [CARMA] developed in TM-20. At the end of the project CARMA and GRASP will be interfaced to the KfK software environment for off line programming. SIMPLE is one of the CIRCUIT projects.

TM34 RATOCA [Radiation Tolerant CCD Camera] Co-ordinator SOFRETEC
RATOCA will develop a CCD sensor that has improved radiation tolerance with a target dose rate of $10^3$ Gy/h. AEA will carry out radiation testing of the prototype.

TM41 ENTOREL [Environmental Tolerance, Reliability and Safety] Co-ordinator RisØ
ENTOREL will consolidate and expand existing knowledge of radiation and environmental tolerance of components and systems. It will act as a data gatherer and supplier for the other TELEMAN projects. Reliability analyses will be performed, if required, for the research machines, and a strategy for reliability assessments will be developed. AEA will contribute by carrying out specific radiation tests, supplying test data and advising on material/ component selections. ENTOREL is one of the CIRCUIT projects.

REFERENCES


[1] B Tolley and B Robertson "TELEMAN - A European Community R&D Programme on Robotics in the Nuclear Industry" Proc. 4th ANS Topical Meeting on Robotics and Remote Systems, Albuquerque, February 25-28 1991 pp 503-514.

[2] E Abel etal "NEATER - A Telerobot for the Nuclear Industry" ibid pp 611-620.

[3] K V Siva etal "The Development of a Bilateral Input Device for Use in Teleoperation", ibid pp 621-632.

[4] A A Dumbreck and C A Kittmer et al "3-D TV Systems for Remote Operations: Development and Applications", ibid pp 587-597.

[5] P M Scheiwiller et al "Videotape Recording of 3-D Television Pictures" ibid pp 599-609


# TABLE 1

| TECHNICAL AREAS | 16 CONTRACTS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 7 | 8 | 11 | 14 | 15 | 17 | 18 | 20 | 22 | 26 | 29 | 34 | 41 |
| 1 MANIPULATOR - HAND | | | | | | | | | | ● | ● | | | | | ● |
| 2 MANIPULATOR - ARM | | | ● | | | | | | | | ● | | | | | ● |
| 3 LOCOMOTION - GANTRY | | | | ● | | | | | | | ● | | ● | | | ● |
| 4 LOCOMOTION - VEHICLE | | | | | ● | | ● | ● | | | | | | | | ● |
| 5 LOCOMOTION - LEGGED | | | | | | ● | | | | | | | | | | ● |
| 6 OBSERVATION - IMAGES | ● | ● | ● | ● | | | | | ● | | | ● | ● | ● | ● | ● |
| 7 OBSERVATION - RANGE AND SHAPE | ● | ● | | ● | | | | ● | ● | | | | | ● | | ● |
| 8 MAN-MACHINE INTERFACE | ● | | ● | ● | | | | ● | ● | | ● | | ● | | | ● |
| 9 MAPPING - WORLD MODELLING | | | | ● | | | | ● | ● | | | | ● | ● | | ● |
| 10 MISSION PLANNING - CONTROL | | | | ● | ● | ● | | ● | ● | | | | ● | | | ● |
| 11 COMMUNICATIONS | ● | | | ● | ● | ● | | ● | | | ● | ● | ● | | | ● |
| 12 FAULT TOLERANCE NUCLEAR ENVIRONMENT | ● | | | ● | | ● | | ● | | ● | ● | ● | | | ● | ● |