TO BOLDLY GO

Thirteen years after it spewed deadly radioactive waste on millions of unsuspecting people, the ruins of the Chernobyl nuclear reactor threaten to cave in and cause another catastrophe...

Pioneering work is being done at what remains of the Chernobyl reactor in Ukraine, where disaster struck without warning in April 1986. The American high-tech robot Pioneer will venture where no man can dare—into the deadly ruins of Chernobyl—and provide scientists and engineers with pictures and test samples from the site. The concrete sarcophagus that was hastily built around the reactor plant after the catastrophe has been exposed to extreme radiation and is showing signs of crumbling. Rainwater seeping into the cracks will encourage contaminated particles to escape and endanger the groundwater. Besides, the ruins threaten to collapse as they are standing on marshy land that is prone to frequent earthquakes. The once-prestigious reactor is in bad shape... just how bad, nobody knows.

One thing is sure, though. According to the latest tests, the deadly radioactivity at the core of the reactor is 35 Gray per hour (Gray is the International unit for measuring absorbed doses of radiation). According to American and Ukrainian

WHERE NO MAN CAN

safety specifications, workers in Chernobyl can be mustbe exposed to not more than 0.5 Gray per year. The present exposure is 100 times what is normally received in the form of radiation from X-ray machines and the sun over an entire year.

Mission impossible?

The situation is so tricky that only Pioneer—which is insensitive to high radiation—can withstand it. According to the US Department of Energy (DOE), the robot can tolerate 10,000 Gray—this makes it so powerful against radiation that it can crawl around in Chernobyl for several days without needing regular showers with non-contaminated water.

"The high gamma radiation is the greatest problem," explains Maynard Holliday, Head of the Pioneer Project at DOE. "It damages glass, even elastomere, rubber or waste material. Naturally, it also damages the electronics." That is why a casing made of wolfram protects Pioneer's sensors, processors and other electronic components. Unlike the conventional lead casing, wolfram is lighter and much more tolerant to radiation. Besides, the light reaches the sensitive rays in the camera lens indirectly through a mirror whose lead coating blocks the damaging radiation.

Scientists at Westinghouse Laboratories, Pittsburg tested to what extent Pioneer is actually radiation-tolerant. The robot was pushed into a 'hot cell' and bombarded with gamma rays. Pioneer easily survived the bombardment without its camera lenses becoming tinted or the electronics and metal hinges getting damaged.

Project Cleanup

Immediately after the disaster, the Russian Government had requested the Robot Institute at Carnegie Mellon University for help.

On receiving the order, the Head of the Robot Institute, William L Whittaker, along with Jim Osborn, founded RedZone Company and started manufacturing the products. But American authorities prohibited any technical exports to the former USSR and blocked the sale of the machines. This hurdle was removed later.

The $2.7 million Pioneer project is managed by the Lawrence Livermore Laboratory, a DOE establishment in California. Other participants include engineers from the NASA Space Community that is co-financing the project, and scientists from American universities and private companies—around 50 experts in all.

Modular design makes it possible for Pioneer to undertake any kind of work

The project came into being only two years ago. Pioneer had three predecessors that proved themselves in clearing-up operations including the US reactor Three Mile Island in Pennsylvania in 1979.

Despite Pioneer's background and its technical capabilities, Ukrainians are sceptical. "It is not the first time that western robots are being used in Chernobyl," says Maynard Holliday. The Ukrainians have had bad experiences, as German and Japanese robots that were sent into the reactor immediately after the disaster failed miserably. "One cannot blame the Ukrainians if they are a little reserved about our robot," admits Holliday. He is sure Pioneer will soon dispel Ukrainian doubts and prove itself.

The not-so-lean mean machine

The 450-kg Pioneer functions as a combination of bulldozer, tank and television tower. It is approximately one metre long, equally wide and 1.2 metres high. Thanks to its large bulldozer shovel, Pioneer can plough its way through the rubbish that litters the reactor. The stripped-down robot will be taken into the reactor and assembled there. This will take place on a kind of staging area—at a place where the radioactivity is not so high and engineers dressed in special outfits would be able to piece Pioneer together. Pioneer will then be sent to the most dangerous zones in the reactor directly from the staging area.

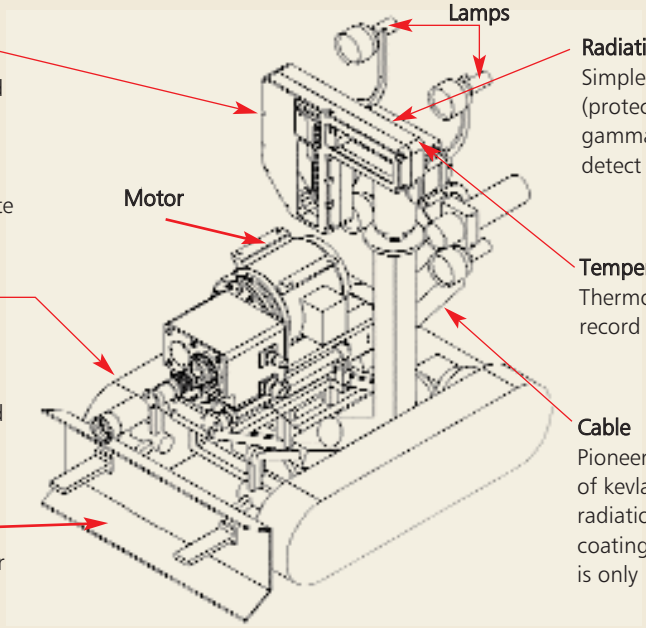
Robot on a leash

Pioneer will receive instructions for its tour around the reactor through a 100-metre long cable. This makes the robot quite flexible. For safety reasons, Pioneer will first be attached to a mobile control station, before being connected to the main control station—a lead-coated protective chamber inside the reactor—with another 300 metres of cable. Ukrainian engineers will manoeuvre Pioneer from there using a joystick. Each engineer will work for only about 90 minutes at a time—in spite of protective clothing, a long stint inside the reactor could prove fatal.

High-Octane support

Pioneer will collect pictures from inside the reactor using three video cameras that can be swivelled in any direction. It requires two cameras for the stereoscopic

ANATOMY OF THE ROBOT



Cameras and 3D mapper
Three rotatable video cameras take stereoscopic pictures. Mirrors coated with lead prevent the lenses from being irradiated and becoming 'blind'. 3D software enables one to process the measurements and create a picture

Drill
The drilling system is equipped with pressure sensors that will take cement samples from the reactor walls. The sensors measure force and torque while drilling

Shovel
Large bulldozer shovel is used to clear rubble from Pioneer's path

Radiation meter
Simple Geiger-Müller counter (protected by lead coating) measures gamma radiation. Two other devices detect neutrons

Temperature and humidity sensors
Thermometer and hygrometer record data

Cable
Pioneer is attached to a cable made of kevlar, which is protected against radiation with a steel reinforced rubber coating. The total diameter of the cable is only 1.5 cm

recordings, and the third camera will be used for taking more precise and detailed photographs. These pictures will be sent to a Silicon Graphics Octane Workstation located in the protective chamber. Pioneer will continuously measure the temperature, humidity and radioactivity on its way through the rubble. This data will also be stored in the Octane Workstation.

But this is not enough. The information collected by Pioneer reaches a second workstation that is linked with an Onyx2 supercomputer, a mainframe that specialises in data visualisation. Both the Octane and Onyx2 machines are located outside the reactor area, in the former administration building. Computer engineers there will create a 'Virtual Chernobyl' on their screens. The Onyx2 builds a three-dimensional drawing of the ailing reactor.

With this in hand, Pioneer's human colleagues are in a position to run through photographs of Chernobyl and evaluate the status of the reactor ruins, supported by 3D software developed by SGI and NASA.

"It is as if we are down there ourselves"

"This photo-realistic technique creates an impression as if we ourselves were moving around in the room and taking measurements," says Daryl Rasmussen, computer expert at NASA. "You can have the temperature or radiation for every space coordinate." Pioneer will profit from the experiences of NASA engineers who equipped Pathfinder, an artificial satellite that visited Mars, with a similar technology.

"The Octane workstation is the only commercially available system that can manage our work," believes Geb Thomas, Professor for Robot Technology at the University of Iowa. He programmed the 3D mapping software with his team. The software was already successfully tested with Pioneer's prototype, which had to crawl through a construction site at the University of Iowa.

"It is important that we depend on tried and trusted technology in this project," says Maynard Holliday. Even the sensors, the temperature, the humidity and radiation testing devices have been tested; they will be protected against radiation before being used with Pioneer.

The only system that is not yet available commercially and that could eventually be critical is the 'drill'. Maynard Holliday explains: "Special pressure sensors measure force and pressure moments during the drilling. In addition, the drill can change its speed to suit the respective terrain." So, the drill had to be developed by the NASA Jet Propulsion Laboratory in California for the small robot which has to virtually 'dig' into the reactor walls and floor and pull out cement samples. This will then be collected in a special container and examined later in a laboratory. From these samples, the scientists hope to arrive at conclusions about the stability and load-bearing capacity of the sarcophagus.

A small step for a robot...

Pioneer's entry into Chernobyl will definitely not be the only one of its kind. American authorities DOE and NASA want to use Pioneer-type robots for other dangerous operations, such as dismantling old nuclear plants in the US. Furthermore, Pioneer and its robot colleagues can be asked to track down and deactivate bombs or other similar weapons, to maintain subterranean tank systems or even to repair pipelines. Jim Osborn from RedZone sees a golden future ahead: "Robots like Pioneer will experience an enormous boom in the next few years."

Even NASA is keeping a keen watch on Pioneer's activities at Chernobyl. The robot is a hot candidate for setting up a base on the Moon or even building an international space station. There are places far more inhospitable than Planet Earth. Hence, Pioneer's small step could well be a giant leap for Robotkind.

P RAGHUNATH and DESIREE KARGE