

Increase safety

Robotic inspection inside
confined spaces

Case studies



Summary

Driven by all major oil and gas companies, the FAST RVI was introduced by Waygate Technologies Robotics in 2016. With a simple idea, a highly maneuverable robot carries an advanced inspection camera, it went for its first inspections. The target was always very clear: avoid human entry in confined spaces and deliver a high quality internal inspection. This paper summarizes use cases provided by real customers on real inspections. A special Thanks to Chevron, Statoil, Gassco and Shell for the trust when opening doors to their facilities and to Service Providers like Tecson Inspection, IKM and IRISNDT for willingness to innovate processes and providing valuable feedback.

Use cases

- 75 m (246ft) high reactor in a US refinery with robot deployment from side entryway
- API 510 compliant inspection of a horizontal pressure vessel
- Visual Inspection of a flare knockout drum on an offshore platform in the North Sea
- Inspection of double-walled vessel at a Chlorine Factory



Introduction

Asset owners

Major oil and gas and chemical companies, such as BASF, BP, Chevron, DOW, Gassco, Statoil or Shell have announced strategic targets for the next years to reduce or completely avoid humans entering into confined spaces. DOW Chemical for example revealed their strategy of "no human entry in confined space by 2025". Chevron drives a program called "no human entry in confined spaces for inspection by 2020". The reasons to avoid confined space entry are very obvious, cost and time savings during turnarounds, increasing productivity and keeping their staff safe.

Insurance companies

Safety is also the major driver for insurance companies and their rates. Every employee on an industrial site is insured; high risk activities have high insurance fees. Confined spaces are a major source of injuries and fatalities. Typically, insurance rates are based on statistics and associated risks. A death for example can result in several million USD payout from the insurer. If an asset owner/operator can prove that confined space tasks are performed by a robot, insurance rates can be lowered by up to 50%.

Inspection service providers

The vast majority of inspection and maintenance service on the above mentioned sites are performed by external 3rd party service providers. These are subject matter experts, trained and certified in the field of Inspection and Non Destructive Testing (NDT).

Training is mandatory

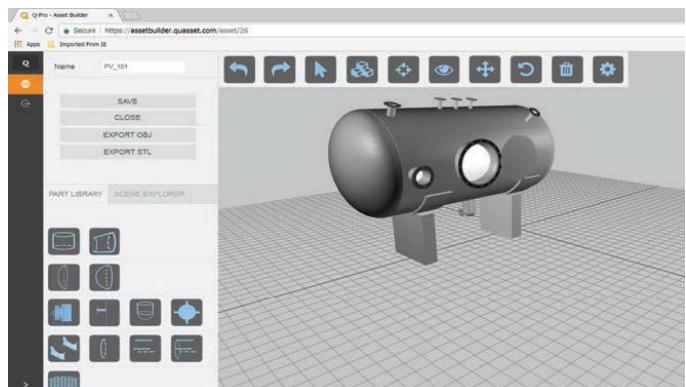
Performing an inspection or maintenance task in confined spaces using a robot is very different from entering by human. A robot simply doesn't have the human intuition, it cannot judge danger or make decisions based on experience. At least not in the first place.

A robotic inspection needs trained operators to find the individual features inside the asset. Waygate Technologies Robotics highly recommends operator training prior to any robotic deployment. Training consists of remote navigation and path finding, deployment and retrieval of the robotic platform and detailed inspection planning.

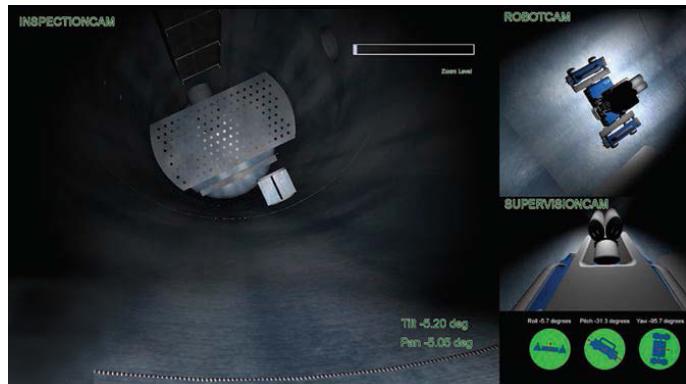
Inspection planning

Unlike the human inspector, a robotic inspection tool needs commands for every single action. Commands can come from human operators manually controlling the robot or from a predefined automated program. Regardless of the operation mode the travel, the inspection path needs to be planned upfront. This path is very detailed, every inch of driving, every rotation of the robot and camera system is known and entered into the program. This procedure not only ensures a flawless inspection but also increases quality and repeatability of the operation.

To be as close as possible to reality, Waygate Technologies Robotics recommends to use "RoboSim", a 3D Simulation software that is based on real Physics. An asset can be created within minutes using predefined modules. Then the 3D model of the robot is loaded and positioned in the asset to start the "virtual inspection". This is also recommended for inspection planning and training of the operators.



Picture: Vessel Builder (screenshot)



Picture: FAST RVI in RoboSim simulation (screenshot)

Remote Visual Inspection of Flare Knock Out Drum on an Offshore Platform

Flare knock out drums, also called relief drums or flare/vent scrubbers, are the last assets in the production chain on an oil rig. The knock out drum removes any liquid droplets that carry over with the gas relief sent to the flare. Most knock out drums are horizontal with a length-to-diameter ratio between 2 and 4. A horizontal knock out drum must have a diameter large enough to keep the vapor velocity low enough to allow entrained liquids to settle or drop out. Inspection intervals of these knock out drums in offshore operations are typically 5 years. Inspection consists of Visual Testing (VT), assessing all internal components and installations like heating lines, nozzles, welds, separators. In case of findings during a Visual Inspection, other Non-Destructive-Testing (NDT) methods may be applied. The vast majority (>80%) of the inspections do not require any further testing other than the VT.

This use case is about a knock out drum on an oil platform in the North Sea. The platform is operated by Statoil and was due for a turnaround in 2016. For the first time Statoil

requested to perform a non-intrusive inspection of the flare knock out drum using the FAST RVI platform. Statoil had reliable data from the previous inspection in 2011, so a real comparison between a remote robotic inspection and a human entering the drum could be made. Statoil selected IKM as their inspection service provider to perform the inspection. IKM assigned two inspectors to get trained and rented the FAST RVI platform for this job. The inspection path training and a virtual inspection in the RoboSim software was used to train the operators and to ensure a smooth execution offshore.

The deployment of the FAST RVI and the inspection was a great success for all parties. The total saving compared to the inspection 5 years back was more than 100,000 USD. Statoil has changed their standard inspection procedure based on these results and will do all future inspections of this asset using a remote operated robot.

[Here is the story published by Statoil:](#)

Article published by Statoil:

Knock Out Drum on Statfjord C Platform Inspected by a Robot

Using a robot for the visual inspection of a knock out drum at Statfjord C in spring this year (2016) helped to save one million NOK and to improve HSE. It was the first time that a so-called crawler, a small robot on wheels equipped with a camera, was used on the Norwegian shelf to inspect a knock out drum instead of sending personnel into the knock out drum. By avoiding blinding, cleaning and scaffolding inside the knock out drum, we saved about 1,500 hours. Additionally HSE was improved by not exposing personnel when entering into the knock out drum, said turnaround manager Paul Chr. Warloe in OTE Operational Projects.

After testing the robot at the supplier Waygate Technologies Robotics it was decided that this robot can do the job. Total scope of work planned for the overall turnaround was around 48,000 hours. To limit the duration and cost the traditional approach has been challenged. The Knock out drum was identified as a candidate for the deployment a robotic crawler for visual inspection. The task was to check inside the knock out drum whether the inlet arrangement was intact, that there were no loose bolts or plates and that the coating on the bottom side was in place. An NII analysis (Non Intrusive Inspection) was conducted and the results showed that the flare knock out drum was suitable for inspection without entering.



Magnetic crawler

Warloe contacted the research center at Sandsli and IKM Testing to get suggestions for solutions. Various technologies came up, including the use of an inspection arm and a magnetic crawler. The inspection arm could not be used as manhole on flare knock out drum was too small. The choice was therefore to proceed with the crawler to verify that this can work.

The inlet arrangement, the heat coils and the knock out drum shell was inspected using crawler. The coating, the bottom zone and welds were also scanned and inspected. Building integrity, material and inspection and operation group, decided in closed interaction using the robotic visual inspection results that the tank did not have to be opened for entering during the turnaround this year.

Reduced workload

By deploying the robotic crawler we have reduced the inspection scope and avoided sending people into the knock out drum. The inspection resolution provided by the inspection camera was so good that light surface corrosion was detected, which was verified and checked out with phased array from outside during the turnaround, says Andreas Eriksson in TI TCS MCS.

FAST RVI is a product developed by Waygate Technologies Robotics, based on results from the EU project Petrobot.



**Total saving of 1,500 hours
compared to inspection by
human entry**



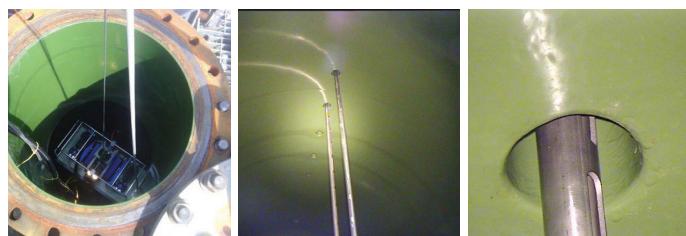
**No human entry into the
knock out drum**

API 510 Compliant Inspection of a Horizontal Pressure Vessel

IRISNDT performed a remote visual inspection, using the FAST RVI Robotic System, on a horizontal pressure vessel. The purpose of the inspection was to identify any problems in the welds, related with the service of the tank. The main advantage of using this state-of-the-art technology was that it eliminated the need for the inspector to enter the vessel, removing the traditional safety risks normally associated with working in confined spaces.

Setting up the FAST RVI was straightforward and time effective. The inspection was performed from the floor level below the entry point. Using an A-frame winch system, the operators carefully lowered the FAST RVI system from the top man-way, in a cage, to the bottom of the vessel.

Maneuvering the FAST RVI around the storage tank was straightforward with the aid of a floodlight to constantly illuminate the tank. The spotlight helped focus additional light on a specific area to further improve visibility for the Ca-Zoom camera. The strength of both lights were adjustable to the inspector's preference.



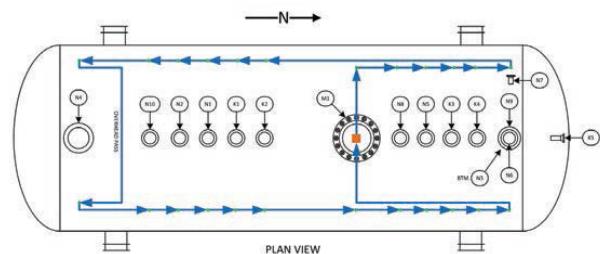
During the inspection, the Ca-Zoom camera captured and recorded clear, high resolution and high quality images. These images are stored and referenced and can offer a baseline representation of specific areas of the storage tank for future reference and comparison.

Having performed a visual inspection with the FAST RVI robotic system, IRISNDT found the following advantages over the traditional confined space entry method;

- Safety – eliminating the need for confined space entry, in turn, eliminates all associated risks, the need for a stand-by crew and, if applicable, the need for breathing apparatus.
- The duration of the inspection was relatively short once the FAST RVI robotic system was deployed.
- Time and cost of erecting scaffolding internally was eliminated as the FAST RVI could drive in all directions on all of the strakes inside of the vessel.

- The power of the Ca-Zoom camera gave it the ability to capture and record close-up, high quality and high resolution images from far away. This reduced the amount of driving required inside the tank, again saving time.

- Downtime of the tank was reduced, meaning it can be put back into service earlier.
- Capturing Images – recording high quality and high resolution images to a hard drive for reporting and future reference.



Remote Visual Inspection of a Spherical Gas Vessel

Accessing vessels in plants and factory sites is often both challenging and dangerous. So when Tescon Inspections needed to inspect a gas sphere, they needed a solution that was simple and safe—one that didn't require human entry. That's when they teamed up with Waygate Technologies, to use our Remote Visual Inspection (RVI) technology.

Tescon Inspections needed to inspect a spherical gas vessel. In situations like this, it is common to build scaffolding or use ropes to lower inspectors in. But these practices are not just expensive and time-consuming; they are also dangerous.

Tescon Inspections partnered with us to find a safe and efficient way to inspect this vessel.

With our FAST RVI platform, Tecson Inspections was able to easily deploy a robot into the gas sphere by lowering a tripod through its top manhole right to the bottom. We worked together to build a specialized tool to roll on and off the platform.

The camera's high-resolution images were displayed outside the sphere on big screens for the inspector, and stored according to industry standards for reference for future inspections.

And within half a day, the entire inspection was finished.

With the FAST RVI, the inspection was much safer and more efficient. We reduced downtime by 35% and saved nearly \$20,000 by eliminating the need for scaffolding or human entry, helping Tescon Inspections please their customers and achieve their goals.

Advantages:

- Improved safety
- Ease of inspection
- High resolution images
- 35% reduced downtime



Complete Visual Inspection of Double-Walled Tank

Tecson Inspections uses industrial cameras to help companies in a variety of industries examine and inspect installations for safety, quality, and integrity. They work hard to provide the most customized, innovative, and decisive solutions for their customers. But when a customer asked them to inspect a double-walled, insulated chlorine tank without causing too much downtime or putting people at risk, they needed to find a safe and efficient solution. Waygate Technologies was brought in to help.

Tecson Inspections was asked to perform a visual inspection for a customer's chlorine tank. This double-walled tank stored chlorine at -35 degrees with insulation on the outside and a slight vacuum in the 500mm space between the two walls.

In previous inspections, an inspector entered the tank with rope access and a respiratory unit. But due to new safety regulations, human entry was no longer allowed. To be compliant, they would have had to unpack the outside for a wall thinness measurement—a process that would have been both time-consuming and costly.

They needed a safe and efficient way to conduct the manual inspection—one that didn't put any people at risk, or cause unnecessary downtime for their customer.

We recommended our FAST RVI platform. With FAST RVI, Tecson Inspections was able to deploy a robot from the outside manhole into the tank. Now, Tecson Inspections could inspect both the outside of the inner tank and the inside of the outer tank in a much shorter time—without requiring the removal of the outside insulation, or an inspector to enter the tank.

Our FAST RVI moves in any direction using magnetic wheels and takes sharp pictures with a high-resolution camera that can be displayed on large screens outside the tank, so zooming isn't necessary. All data is recorded according to industry standards and stored as a reference for future inspections, and this case was no exception.

With our FAST RVI solutions, Tecson Inspections was able to reduce downtime for their customer by 35%—saving them nearly \$30,000.

The robot was able to access the whole vessel easily, and was not limited by time like a human would have been. It didn't require confined space or professional treading permits, unpacking the insulation, cleaning between the walls, or renting breathing and safety units.

Using FAST RVI made this inspection safer, more convenient, and more efficient for Tecson Inspections. And because of that, they were better able to better achieve their goals.

Advantages:

- 35% reduced downtime
- Greater efficiency
- A safer way to inspect
- High resolution images
- Data to be used in the future



35% reduced downtime



A safer way to inspect

Customer statements

Chevron - USA

"It is of great importance to roll of the FAST RVI for the CHEVRON strategy regarding internal inspection of pressure vessels, tanks and other process equipment. It is our top priority to do internal visual inspections remotely, especially in confined spaces with the objective of reducing or avoiding inspectors entering these areas only for inspection purposes. We expect by the use of this advanced inspection system we will reduce the risk to the inspectors, reduce the time and costs associated to internal inspections, especially during maintenance shutdowns; and we also expect to increase the coverage and quality of the images and information collected, when compared to the traditional inspection process."

Tecson Inspections - service provider - The Netherlands

"The added value is that we can drive to the top of the vessel to inspect. As a result, no soil dirt gets caught and further cleaning is not necessary. Furthermore, the inspection quality is highly increased as the platform can drive close to the areas of interest. Since the roll-out of the platform we have already inspected several columns with a diameter of 3 meters and a height of 19 meters. Using this platform we saved days building scaffoldings and minimized the risk of dropping materials. Finally the downtime was significantly shorter."

"To promote our robotic inspection services, we now have a fully-equipped inspection van that also serves as a demonstration van. Inside the van we mounted a steel plate so we regularly can do on-site demonstrations with the platform, convincing the customer of the many benefits."

Shell - The Netherlands

"Many oil and gas operations involve process vessels and tanks. Maintaining these assets is a potentially dangerous and very expensive task. Shell is working on a project to develop inspection robots for operations in pressurized vessels and tanks. The Petrobot project is a joint-industry project facilitated by Shell with funding from the European Union (EU). The ultimate aim is to reduce human exposure to the risks of inspection in confined spaces. Preparing vessels for human entry is expensive and time consuming. Petrobot benefits include reduced costs and time for vessel inspection and reduced entry in confined space for inspection activities."