1. Exploitation of individual results

Bytest – Transducer design

Bytest intend to use the transducer design to build a GUW tool for internal inspection of oil-field tubulars. The concept is shown in Figure 11.

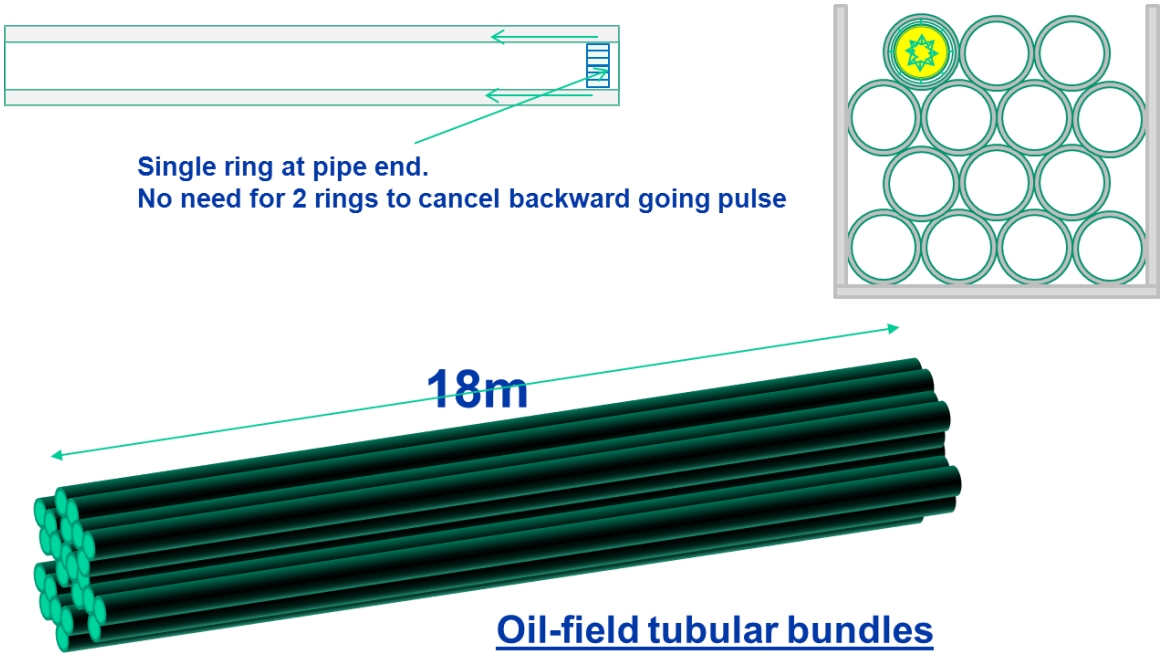


Figure 1 Concept of internal pipe inspection tool

Oil field tubulars are stacked in bundles for storage. They cannot be inspected until removed and placed into an automated ultrasonic test rig, which scans the length of the tube with an array of ultrasound transducers. Bytest manufacture these test rigs.
The GUW transducers will be cross-polarised for coupling to the concave surface of the tube internal diameter and incorporate hydraulic cylinders in each housing to extend transducers to fit a range of pipe wall-thicknesses (Figure 2).

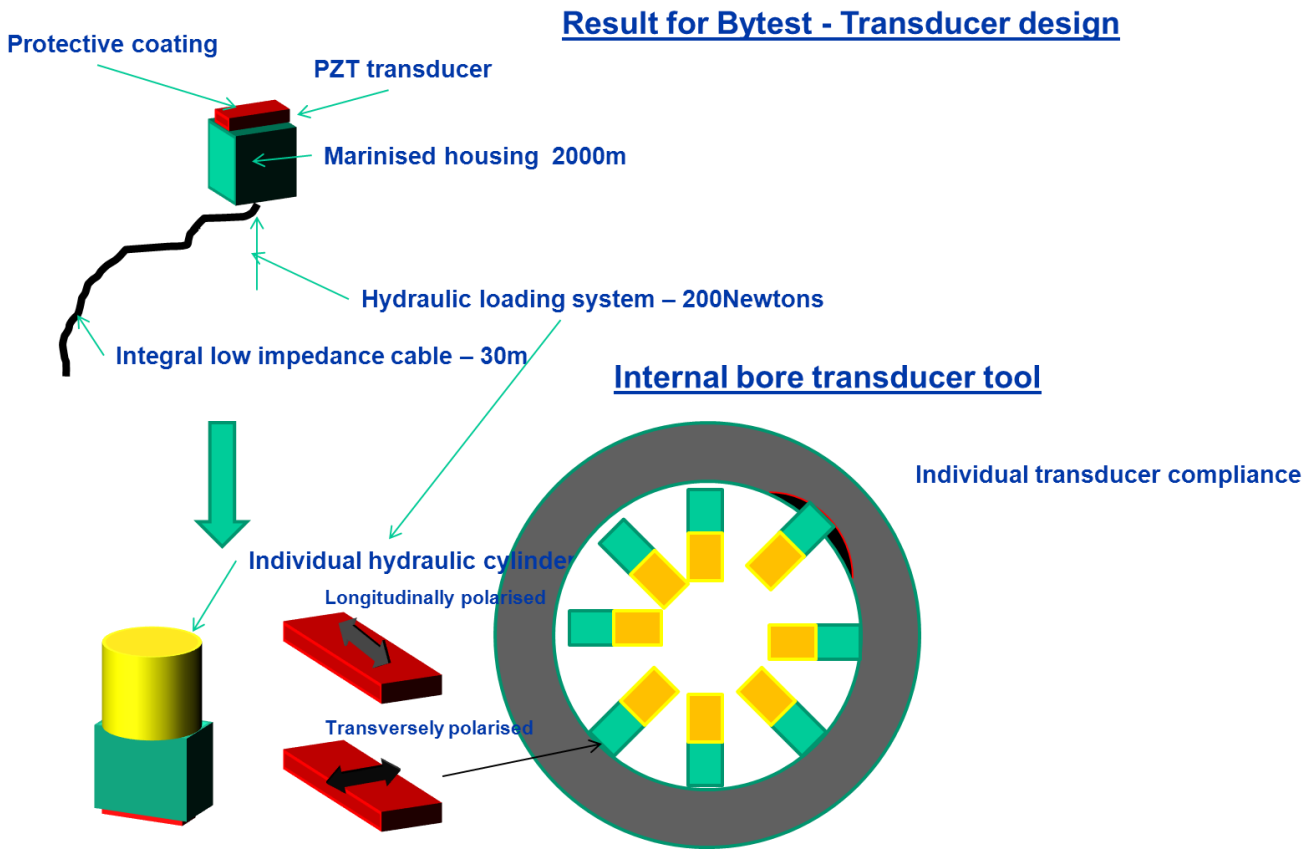


Figure 2 Internal bore transducer design

Table 1 Bytest's plan

Exploitable result	Transducer design
Description (functionality, purpose, innovation etc):	
Hydraulically operated marinised PZT transducer housing with integral cable for use in water/oil extreme environments for incorporation into GUW collars for internal-bore inspections . (see concept diagram)	
Methods of exploitation (direct or indirect):	
Build for use with Teletest© GUW system. Direst sales to TubeTest (Bytest customer) or Teletest© operators, licence to PI or service provision.Su	
Technical considerations: (technology push)	
Transducer housing with individual hydraulic cylinder in place of pneumatic bladder to cope with range of pipe-wall thicknesses. Single ring operation from tube end – no need to remove backward going GUW pulse.Cross-polarised transducers for contact with concave surface. Integral cable for robustness. Built into ID collar.	
Market considerations: (market pull)	
Oil field tubular inspections in-situ without having to remove from stacks. Possible down-bore usage.	
Current TRL 6	
Development Plan to take it to next TRL (from prototype to operational equipment, possible collaborations)	
Collaborate with PI and Tubetest to develop tool. Discuss application with Italian companies with interest in oilfield tubular integrity (eg ENI). Define specification. Build internal transducers and internal bore tool.	
Technical Barriers Development Plan	
None	
Commercial Barriers to Development Plan (funding, existing technology, potential non-technical obstacles):	
Cost of prototype for internal bore inspection – €100K	
Other potential impacts from exploitation (e.g. socio-economic):	
Better quality control of oilfield tubulars. Fewer failures with possible environmental and human loss.	

Sonomatic – marinised transducer collar.

Sonomatic will include the transducer collar in there tools for subsea inspection, that can be either diver or ROV deployed (3). The collar will be used to inspect subsea pipelines and risers for corrosion, using the T-wave technique.

For diver deployment the collar will be attached with an umbilical to the surface, where the GUW instrumentation and hydraulics controller will be located. The collar will require buoyancy aids.

For ROV deployment, the collar wll be attached to the robot arm commonly used for ROV work. The GUW instrumentation and hydraulics controller will be incorporated in pods on the ROV.

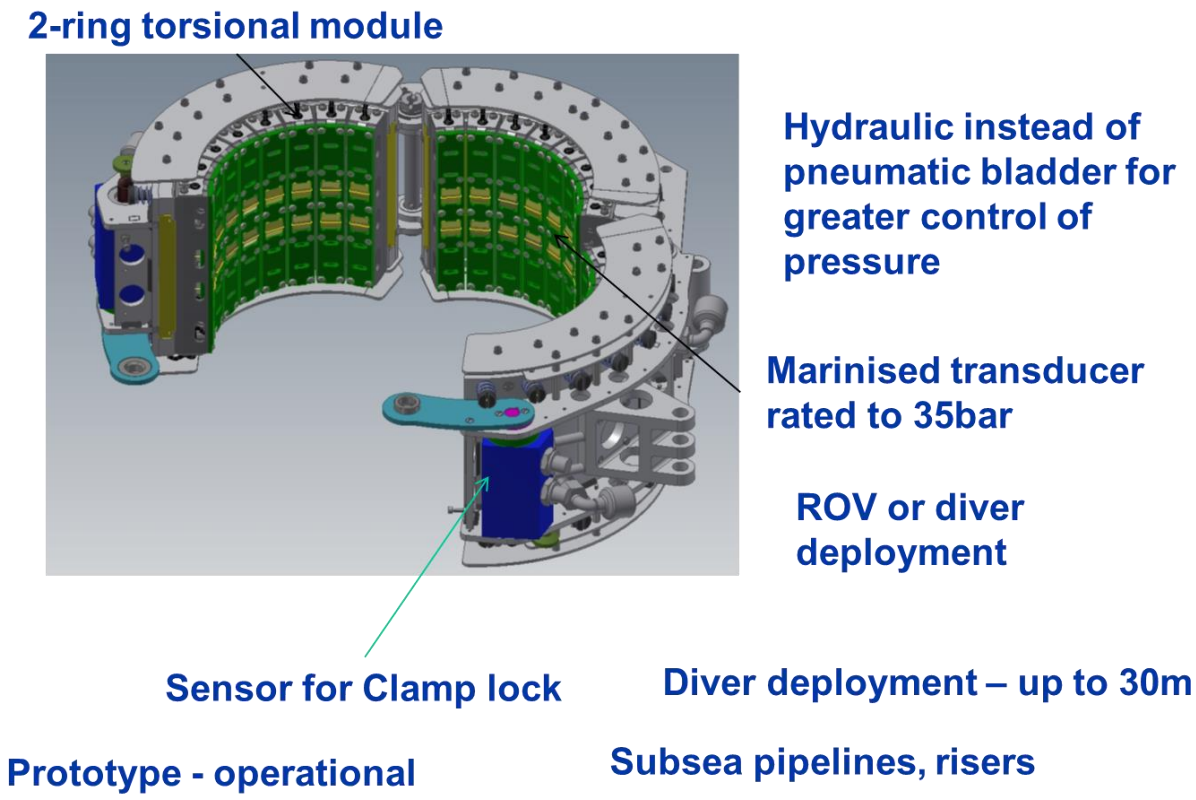


Figure 3 Marinised transducer collar design

Sonomatic's plans for taking the collar forward are shown in Table 22.

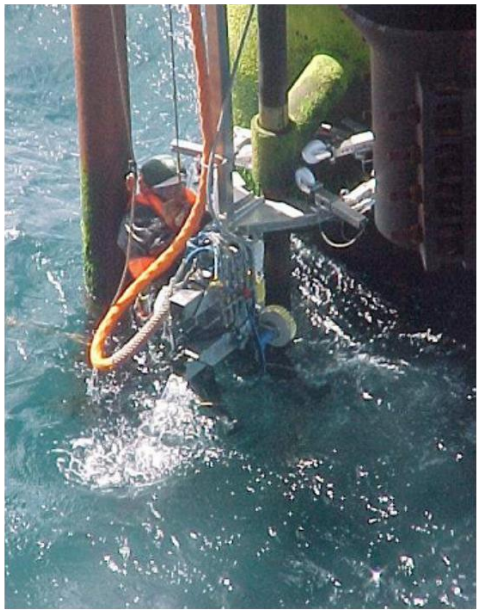
Table 2 Sonomatic's plan

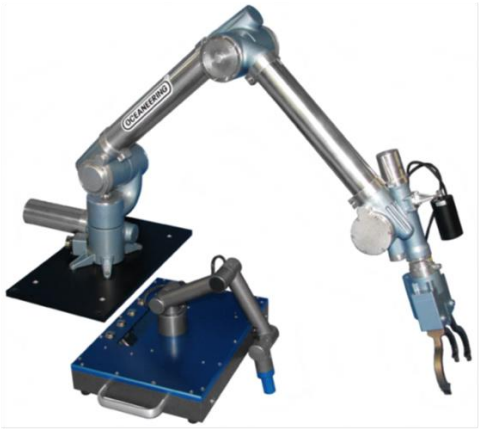
Exploitable result	Marinised collar
Description (functionality, purpose, innovation etc): Diver or ROV deployed hydraulically operated GUW collar for subsea inspection of chains and pipes and risers	
Methods of exploitation (direct or indirect): Direct offer of NDT services sub-sea.	
Technical considerations: (technology push) Modification of closing arms for use from ROV. Replacement with handles for manual use by diver. Umbilical subsea connectors. Marinisation to enable performance at greater depths (2km) Adaption for use on submarine pipelines and risers.	
Market considerations: (market pull) 'Major' oil companies having to base more of their operation off-shore to compete with 'National' oil companies.	
Current TRL 6	
Development Plan to take it to next TRL (from prototype to operational equipment, possible collaborations) Prove prototype collar can operate in operational conditions and make modifications if necessary. Build collars using common design for specific pipe diameters on job-by-job basis.	
Technical Barriers Development Plan None presently.	
Commercial Barriers to Development Plan (funding, existing technology, potential non-technical obstacles): None presently	
Other potential impacts from exploitation (e.g. socio-economic): Diver inspections eventually replaced by ROV ones – less dangerous and greater depth	

Robotnik – Inspection capsule

Robotnik will include the chain climbing robot in their range of robots. It will be used to deploy various payloads, including a cleaning system and a robotic arm (Figure 4).

Result – inspection capsule/chain climbing robot





Oceaneering robot arm

Other payloads

chain inspection through splash zone

Riser inspection through splash zone

Figure 5 Alternative payloads for chain climbing robot

Table 3 Robotnik's plan

Exploitable result	Inspection capsule
Description (functionality, purpose, innovation etc): Chain climbing robot that can climb through the splash zone	
Methods of exploitation (direct or indirect): Direct sales to chain inspection and cleaning companies	
Technical considerations: (technology push) Modification of platform to take alternative payloads to GUW collar. Adaption to climbing pipes (risers)	
Market considerations: (market pull) In the offshore O&G industry, increasing need for access to structure in the splash zone	
Current TRL 6	
Development Plan to take it to next TRL (from prototype to operational equipment, possible collaborations) Work with subsea engineering specialists (Tecnip) to produce operational equipment.	
Technical Barriers Development Plan	
Commercial Barriers to Development Plan (funding, existing technology, potential non-technical obstacles): Cost of ruggedisation - €100K	
Other potential impacts from exploitation (e.g. socio-economic): Improved safety of operations in the critical splash zone.	

Orme – Automatic defect detection software

The software developed to analyse the GUW A-scan signals from mooring chains uses the pattern of repeat signals, caused as the GUW pulses circuit the chain each time through the transducer collar. Similar repeat patterns, though on a 1 mm scale rather than a 1 m scale are observed when using compressional ultrasonic waves to inspect spot welds (Figure 6). The neural network can be trained to identify changes in the A-scan pattern caused by a variety of defect conditions. Because of the high repetition rate for collecting test data from each spot weld, current manual techniques are slow and unreliable. The trained neural network will be improve efficiency and defect detection rates.

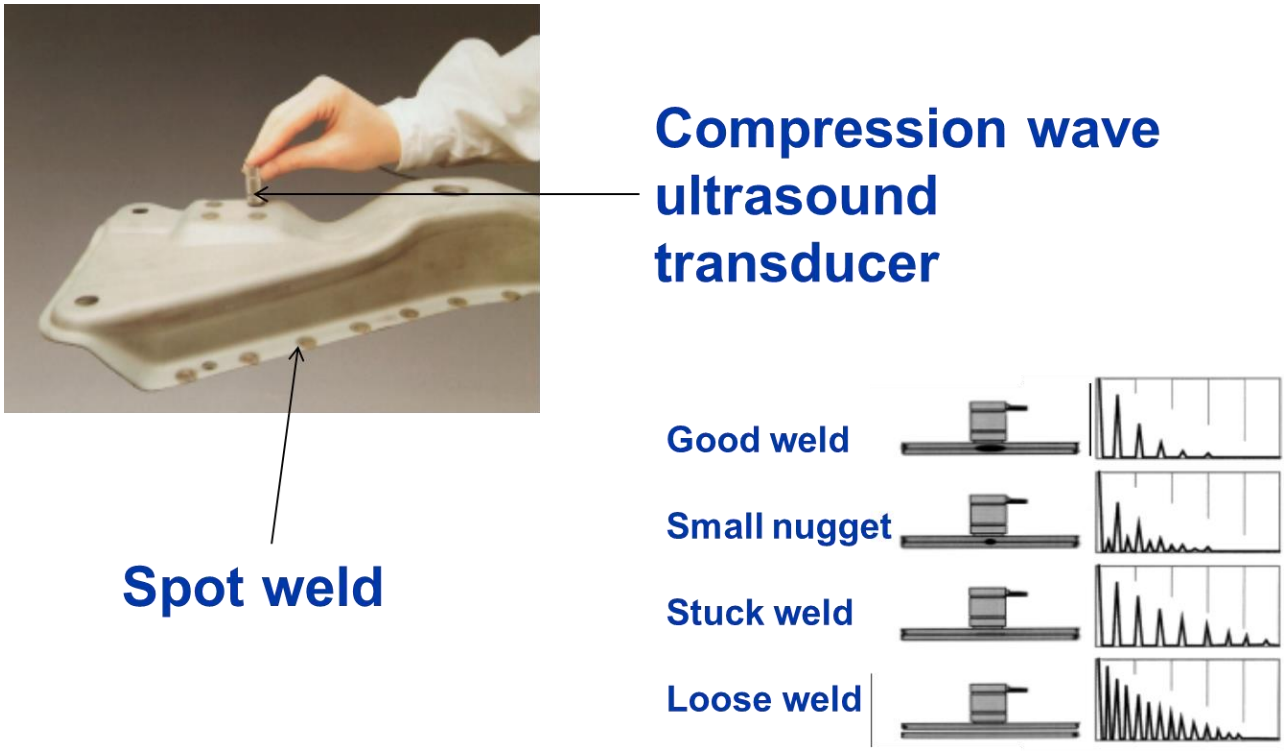


Figure 7 Ultrasonic testing of spot welds

Orme have a business in the automotive industry, using imaging processing to analyse crash impacts. Their plans for taking the technology forward are shown in Table 4.

Table 4 Orme's plan

Exploitable result	Automatic defect detection software
Description (functionality, purpose, innovation etc): A-scan signal processing algorithms to de-noise signal and neural network to detect defect signals in A-scans with a repetitive signal nature. Software adapted for use in ultrasonic testing of spot welds (see concept diagram)	
Methods of exploitation (direct or indirect): Sale of software to manufacturers of automated spot weld UT systems (Tecnitest)	
Technical considerations: (technology push) Improvement in A-scan de-noising from UT of spot welds. Training of neural network to recognise different defect conditiions in spot welds – stuck weld, small weld nugget, no weld.	
Market considerations: (market pull) Automotive industry need to improve efficiency of current spot weld testing and de-skill operation because of its repetitive nature.	
Current TRL 7	
Development Plan to take it to next TRL (from prototype to operational equipment, possible collaborations) Work with Tecnitest, who manufacture automated spot weld UT system, to modify software to meet requirements of spot welds and then validate with car manufacturer.	
Technical Barriers Development Plan Specification for modifying de-noising algorithms and neural network s.	
Commercial Barriers to Development Plan (funding, existing technology, potential non-technical obstacles): Finding collaboration for software development. Gaining acceptance of automotive industry	
Other potential impacts from exploitation (e.g. socio-economic): Greater use of Aluminium in car bodies, because it is more difficult to weld.	

2. Exploitation of knowledge

As well as the practical results of the project, there will be new areas of knowledge and expertise available to the SMEs as a consequence of the work carried out. The exploitable knowledge at the end of the project is given in Table

Table 5 Exploitable knowledge from MoorInspect project

Exploitable knowledge	Exploitable product	Exploitable service	Route to exploitation	Exploiter
Hydraulically operated GUW transducer collar	GUW collar for use by divers and ROVs	Subsea inspections of pipelines and risers	Incorporation into existing product lines	Sonomatic
Hydraulically operated, environmentally robust transducers	Internal GUW collar for use on oilfield tubulars	Inspection at manufacture and during service	Development of internal collar with PI	Bytest
Arm-climbing mechanisms for structures	Climbing robots	Manufacture only	Range of climbing robots with Innotech	Robotnik
Design of neural networks to aid interpretation of A-scans	Software for incorporation in ultrasonic test (UT) systems	Manufacture only	Refinement of software with IKH, and work with UT system manufacturers	Orme

3. Dissemination activities

These are listed in Table 6

Table 6 Dissemination activities

Type	Title	Venue	Date	Audience	Countries addressed	Size of audience	Partner involved
Website	Moorinspect.eu		Since beginning of project	Worlwide			PI
Paper	Development of an advanced medium range ultrasonic technique for mooring chains	British Institute of NDT, Daventry	11-13th September 2012	NDT practitioners and researchers	UK and worldwide	500	All RTDs
Paper	Lessons learned in developing MoorInspect system	British Institute of NDT Telford	10-12th September 2013	NDT practitioners and researchers	UK and worldwide	500	PI & Sonomatic
Video & talk	MoorInspect demonstration in-air	FPSO Forum, Houston	16th October 2013	Operators of FPSOs	USA and worldwide	100	TWI
Paper	Lessons learned in developing MoorInspect system	Italian Institute of NDT Trieste	23-24th October 2013	NDT practitioners and researchers	Italy and worldwide	250	Pi & Bytest
GSP project launch	An Effective Methodology for Implementing Structural Health Monitoring and In-Service Inspection of Mooring Chains	TWI Cambridge	20th November 2013	TWI Industrial members O,G&P	Worldwide	20	TWI
Demonstration	Underwater demonstration	TWI North	16th December 2013	Project partners & interested partise	Worldwide	20	All

In addition, there is a website at moorinspect.eu