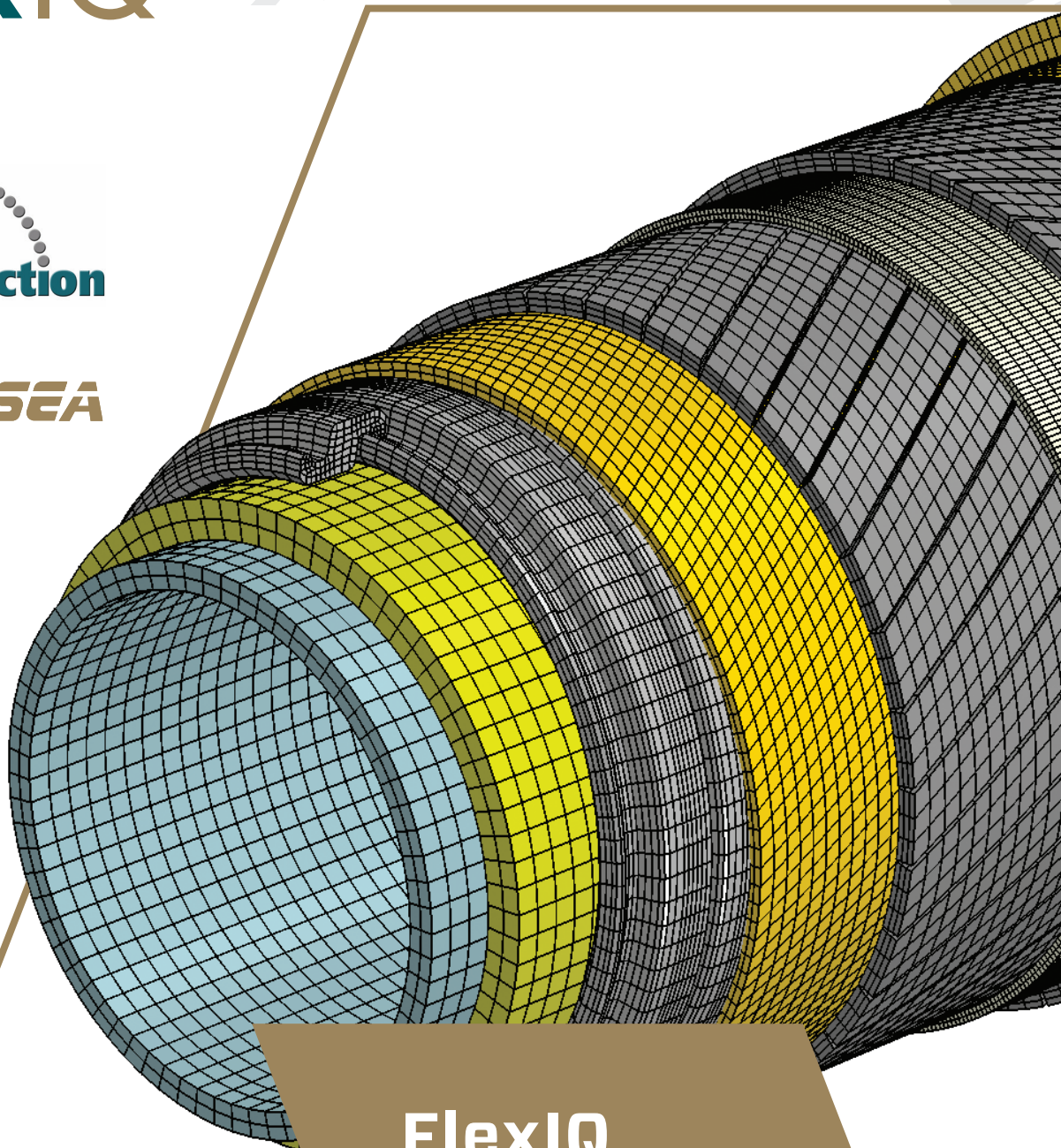




FlexIQ

Redefining Flexible Riser
Integrity Management

EXECUTIVE SUMMARY

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FlexIQ is a complete offering in the arena of flexible riser integrity management from the strategic alliance of INTECSEA and Innospection. This partnership looks to redefine the approach to flexible riser integrity management by offering clients best in class inspection and computational simulation techniques as part of an Integrity Management Framework. In turn, this leads to a significant improvement in understanding of operational risk and enables a fully integrated service for inspection, analysis and data management. The bottom line is we deliver insight, not just data.



The use of advanced technology is a key driver in solving some of the challenges we face in the oil and gas industry. The alliance between INTECSEA

and Innospection enables two unique and highly advanced technologies to be embedded within an integrity management framework which we call FlexIQ. The primary aim of FlexIQ is to reduce uncertainty, increase understanding and reduce costs in the arena of flexible pipe integrity.

Andrew Low
Global Technology Director
INTECSEA



In decades of industry experience, with the majority in offshore asset inspection and integrity assessment, I have found the complexity of flexible risers to be

unique. Reliable integrity assessment and remaining life evaluations of flexibles require focused and advanced technology and innovation, combined with expertise. At both Innospection and INTECSEA, these attributes are present. The resulting combination of capabilities is FlexIQ, which provides operators of flexible risers the unique opportunity to work with a partner capable of providing the absolute best possible data and analysis.

Andreas Boenisch
Managing Director
Innospection

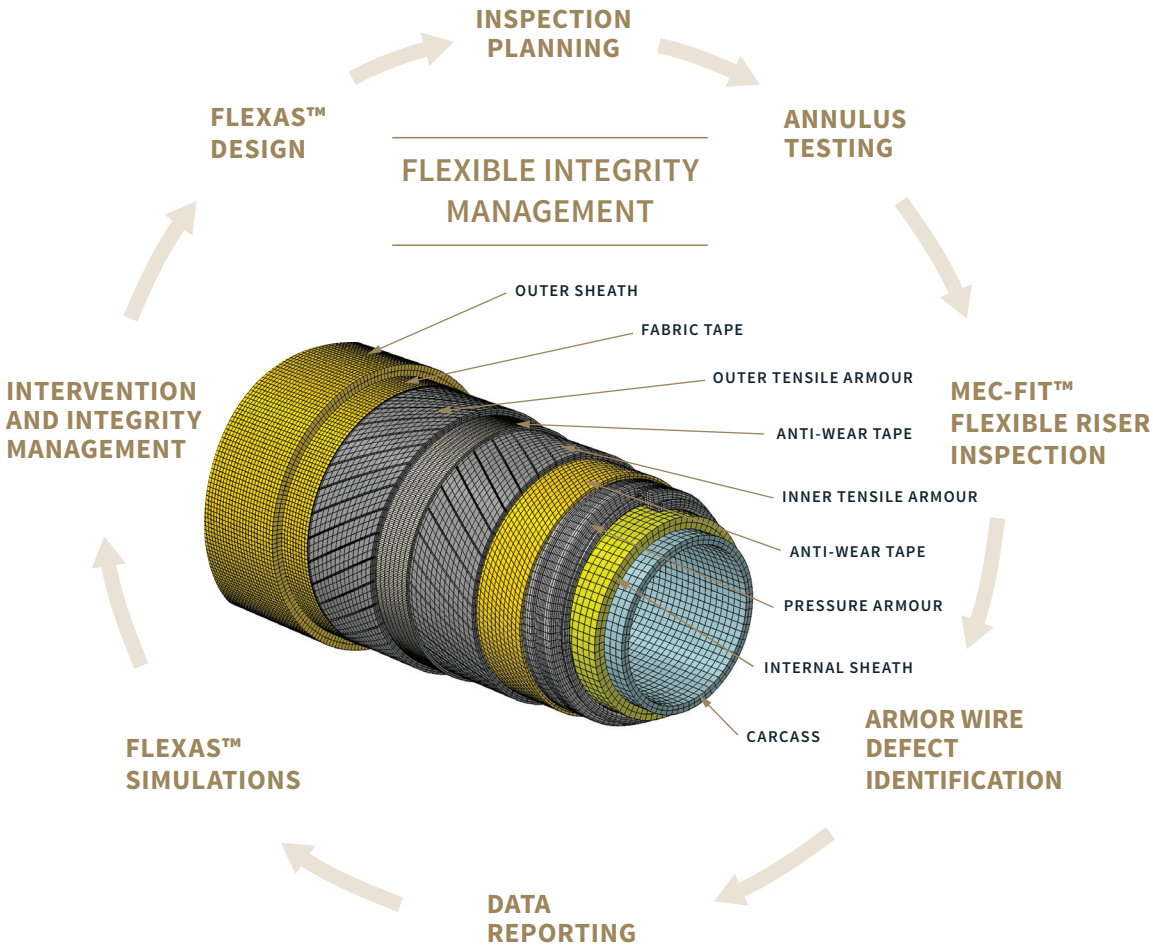
OUR SERVICE OFFERING



FlexIQ offers clients a complete flexible riser integrity management program. FlexIQ is available as discrete packages or as a full service offering, dependent on clients' needs. Central to the value and distinctiveness of FlexIQ are the state-of-the-art and proprietary inspection and numerical simulation capabilities of MEC-FIT™ and FLEXAS™. Combining these

capabilities with industry-leading annulus testing and a formal risk-based approach to flexible riser risk assessment and life extension completes FlexIQ, delivering all aspects of flexible integrity management through a single provider.

- Risk-based integrity management and inspection planning
- State-of-the-art annulus testing
- Visual and MEC-FIT™ (Magnetic Eddy Current) inspection
- Dynamic riser simulation using detailed, multi-layered finite element models with FLEXAS™
- Intervention planning and construction management
- Life of field riser analysis and model updates



ALLIANCE PARTNERS

A strategic alliance of **industry leading capabilities.**

INTECSEA

WorleyParsons Group

INTECSEA offers independent insight, engineering and project management

to deliver full lifecycle asset management, in any offshore environment from concept to decommissioning.

Backed by extensive technical expertise, INTECSEA people work with clients to turn complex challenges into practical results. Bringing real insight to support critical business decision making, their imagination

can reveal unseen options. And they can help you choose solutions from all appropriate sources.

With the full capability of Advisian and the wider WorleyParsons Group readily available, INTECSEA is the obvious choice. A leader, not a follower, committed to delivering value by collaborating with clients as well as competitors, INTECSEA's independence of thought and action is clearly the informed choice for offshore infrastructure projects now and in the future.



Innospection was established in 1998 as a specialist in electromagnetic inspection

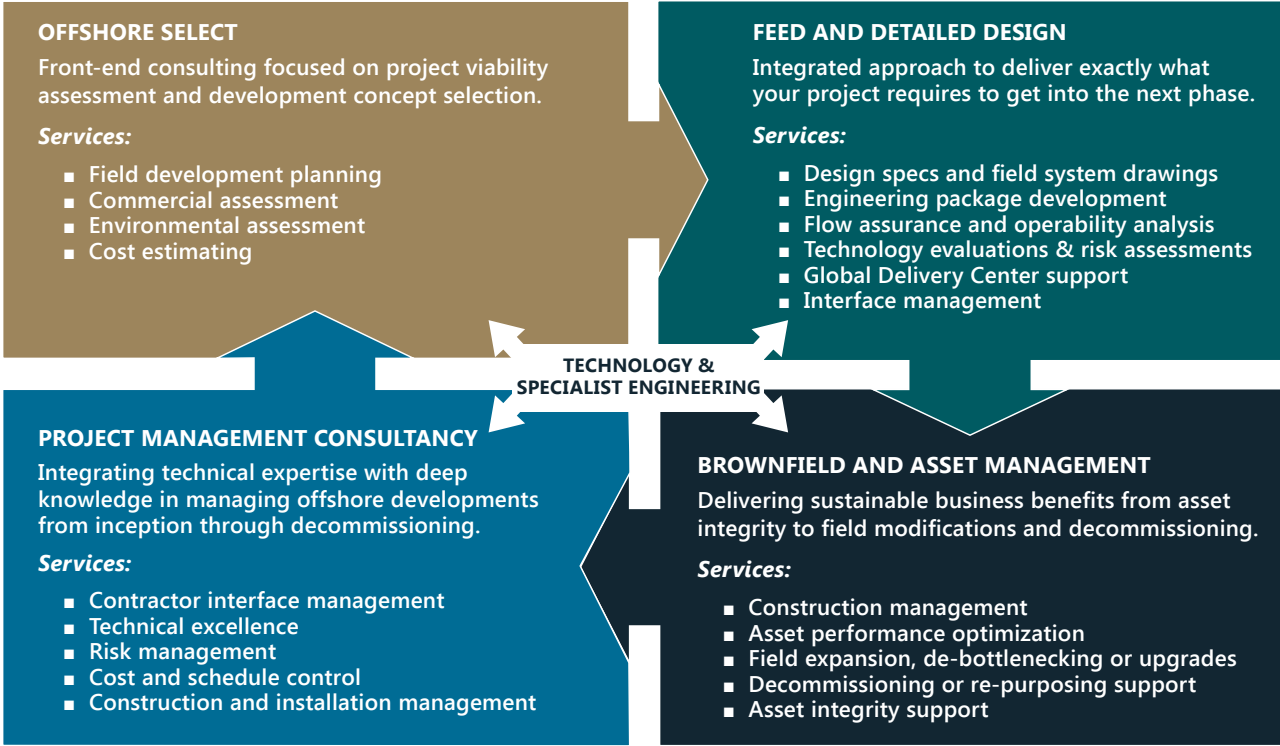
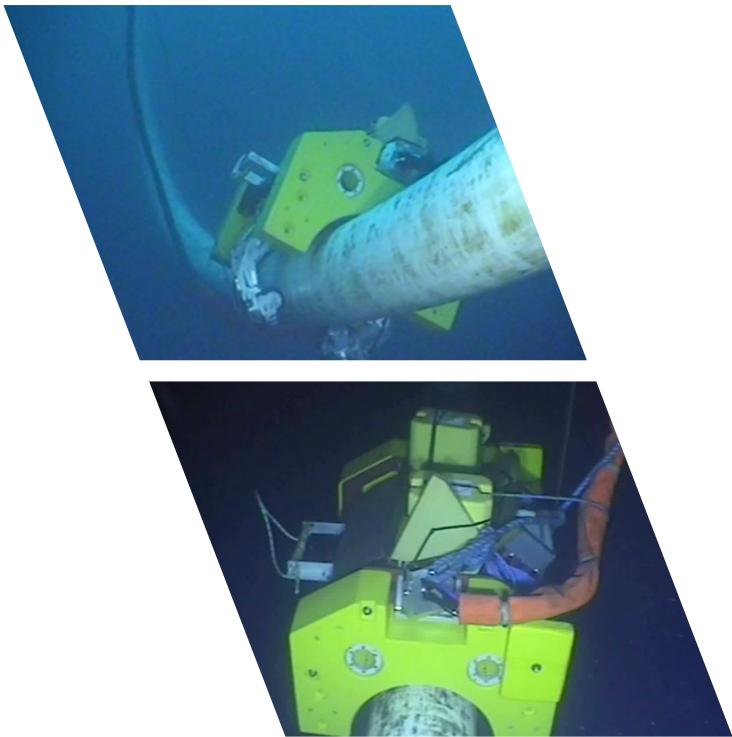
technologies such as Eddy Current and Saturation Low Frequency Eddy Current (SLOFEC™). Innospection has successfully delivered advanced non-destructive testing solutions to the worldwide process industries including the offshore oil and gas industry for over 10 years. As well as delivering standard pipeline inspection technology, the research and development department uses in-house expertise in electromagnetic non-destructive testing technologies and applications to develop bespoke inspection solutions and adapt to specific client requirements.

In the offshore and subsea area, Innospection offers innovative technologies and sophisticated equipment to solve niche inspection challenges for flexible and rigid risers, caissons, subsea structures and pipelines, non-piggable pipelines, ship hulls, conductor pipes, and mooring lines, as well as complex areas like subsea welds and manifolds.

Branded under the name MEC (Magnetic Eddy Current), the range of sophisticated MEC subsea inspection tools are designed and built to provide comprehensive splash zone and subsea inspection data within a

single deployment by remotely operated vehicles (ROVs), divers or rope access personnel.

Based on the next generation fast corrosion mapping MEC technique, which is a further development of the industry proven SLOFEC™ technique, other supporting inspection techniques such as high resolution ultrasonic mapping, Pulsed Eddy Current (PEC), laser triangulation, camera systems, etc. can be easily incorporated into the versatile MEC subsea inspection tools to provide a total and customized inspection solution.





KEY

- Innospection Office
- INTECSEA Office

**Global
Expertise**
Local Delivery

**DECADES OF INNOVATION
and groundbreaking achievements**

KEY PLAYERS AND EXPERIENCE

Turning complex challenges into **practical results.**

Dr Arya Majed
Mechanical Engineer



Dr Arya Majed is a mechanical engineer with strong expertise and differentiated skill sets in nonlinear dynamic simulations of a wide array of complex structural/mechanical systems. He is the developer of FLEXAS™ nonlinear solver designed for high speed computation of highly nonlinear dynamic systems not possible by commercial finite element solvers. He has applied FLEXAS™ to flexible risers, umbilicals, hoses, connectors, and dropped object simulations. Arya is currently Technical Advisor at INTECSEA and has acted as an advanced simulations consultant to 30+ companies in the offshore, aerospace, defense, and power generation industries.

Chris Spraggon
Mechanical Engineer



Chris Spraggon is a Chartered Mechanical Engineer with APM Level D qualifications and 15 years of mechanical and project engineering experience. The last 11 years have been spent specifically in the engineering and management of offshore work packages with flexible pipes and associated ancillary components to major clients in the UK Continental Shelf, Middle East, and West Australia. Chris is well versed in all aspects of design, manufacture, quality, installation, and integrity of flexible pipelines to API and ISO standards, including significant exposure to failure analysis and pipeline integrity and ongoing development of flexible pipeline integrity data and inspection capability.

Jeroen Timmermans
Project Manager



Jeroen Timmermans has more than 20 years of experience in the offshore industry. He has worked for a major oil company as project engineer and project manager for several field developments and pipeline projects in the Norwegian North Sea. His strengths include a significant technical background, a thorough understanding of the subsea and pipelines industry, specialist knowledge of flexible pipe and subsea pigging systems, experience in asset integrity management, and the interpersonal / communication skills required to lead multi-disciplined teams.

Jim Hunter
Project Engineer



Jim Hunter has over 15 years' experience. The majority of his experience is related to flexible pipelines, including design, engineering, manufacture, inspection, testing and installation. Jim has invaluable offshore experience, acting as technical representative during the installation of flexible pipelines in the North Sea, Middle East, South East Asia, and Africa. He has also performed and project managed riser integrity testing/inspection campaigns, using both annulus testing and scanning techniques.

Dr Kirsten Oliver
Asset Integrity Consultant



Dr Kirsten Oliver is an Asset Integrity Consultant with a range of technical and management experience related to the Upstream oil and gas, power and utility sectors. Kirsten's areas of expertise include onshore, offshore pipeline integrity, internal corrosion degradation, oilfield corrosion and chemical management, technical due diligence, pipeline integrity assessment, and wellhead to export inspection and integrity. She has chaired a number of risk-based workshops, and implemented integrity management programs for clients in the UK, North Africa, and Middle East.

Sebastian Hartmann
Business Development Manager



Sebastian Hartmann is a trained Mechanical Engineer with more than 20 years experience in the pipeline industry. His main expertise is with the development, adaptation, deployment and operation of highly automated inspection solutions for both applications, internal and external. Through his position as a Business Development Manager with Innospection he has worked on a number of complex topsides and subsea inspection projects to ensure flexible pipe and riser integrity.

Nathan Cooke
Senior Engineer



Nathan Cooke has five years of cumulative experience in the oil and gas industry, ranging from component-level design and product development to integrity management. Through his current pursuit of a master's degree in mechanical engineering, he has established a strong technical background in finite element modelling using state of the art software packages. His research and recent industry experience have enabled him to specialize in local and global flexible pipe analysis.

Luca Chinello
Senior/Lead Engineer



Luca Chinello has 12 years of experience in numerical analysis, namely Finite Element Analysis (FEA) and Computational Fluid Dynamics (CFD). He has worked on a number of offshore and onshore oil and gas projects as senior/lead engineer and study manager. His expertise includes FEA and CFD of offshore pipelines, rigid/flexible risers, subsea/offshore/floating structures, centrifugal pumps, and electric submersible motors.

MEC-FIT™ INSPECTION

The MEC-FIT™ (Magnetic Eddy Current Flexible Riser Inspection Tool) inspection technique was developed in response to market demand for general riser and flexible riser inspections operated from offshore installations. At the same time, Innospection has also gathered experience in applying this technology to subsea inspection of mooring lines and umbilicals.

MEC-FIT™ offers rapid external scanning with the ability to penetrate into multiple armour layers. It features a patented inspection technique which combines the direct magnetic field lines with eddy current field lines, allowing for deeper penetration into the ferritic steel material.

The key capability of the electromagnetic MEC-FIT™ technique is the detection of localized material defects such as wire cracks, wire ruptures and corrosion / wall loss beneath the coating.

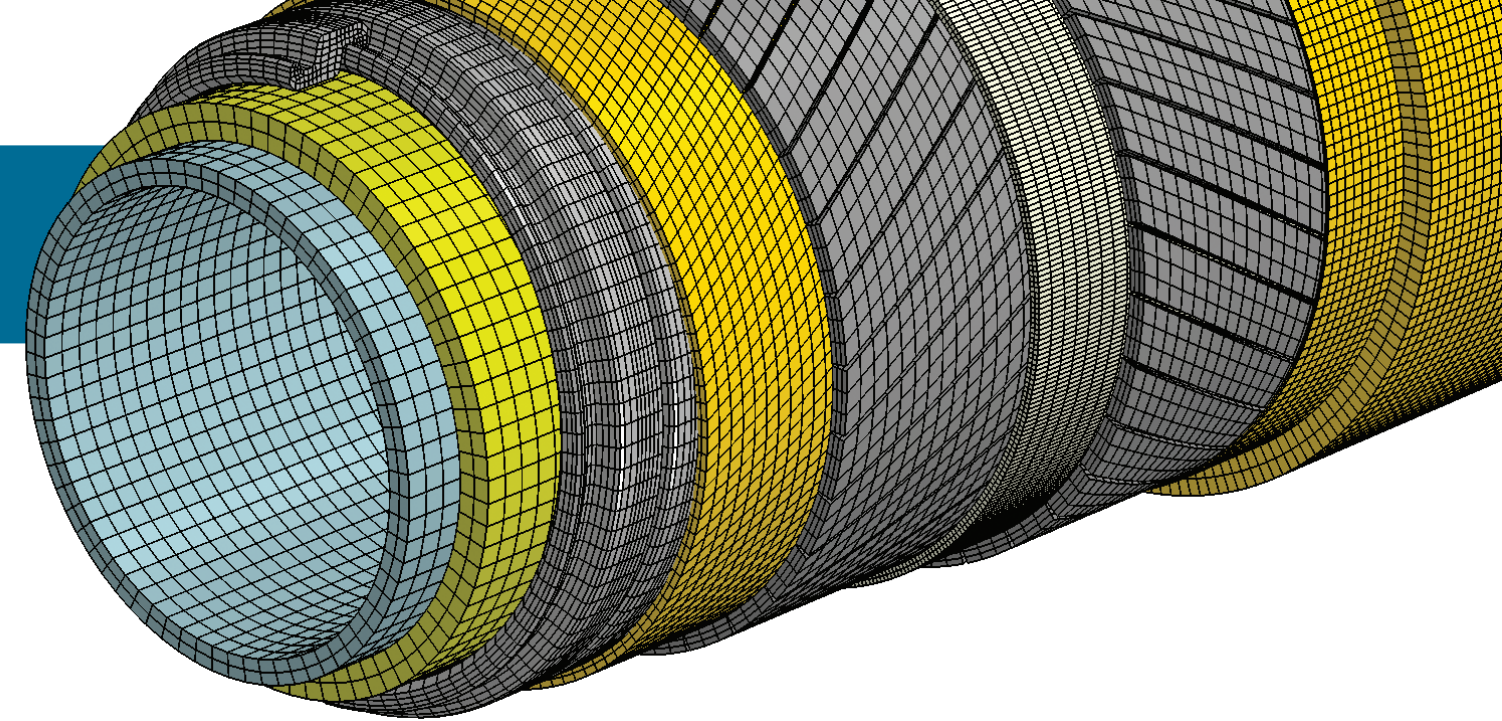
This technology has been proven in different verification trials with a number of major operators, and has been used successfully on flexible riser as well as horizontal pipe sections.

Various tool types based on the MEC-FIT™ technique are available to allow deployment directly from the installation platform or floating structure, via ROV or diver support.

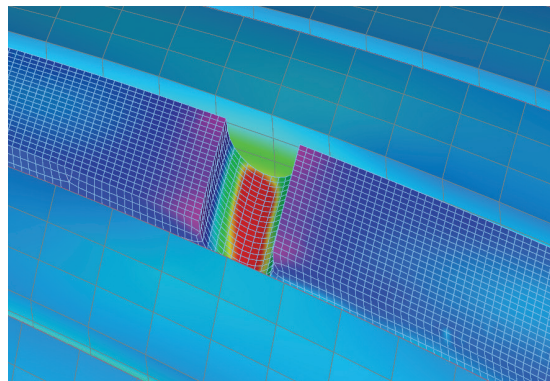
- Combined DC magnetic and eddy current fields to detect single or multiple wire damage in up to 3 metallic layers.
- Detects cracking, pitting, general corrosion, and wire misalignment and gaps.
- Mapping of wire layers and identifying details of individual findings.
- No requirement for annulus to be flooded.
- Deployment from topside or ROV.



FLEXAS™ SIMULATION



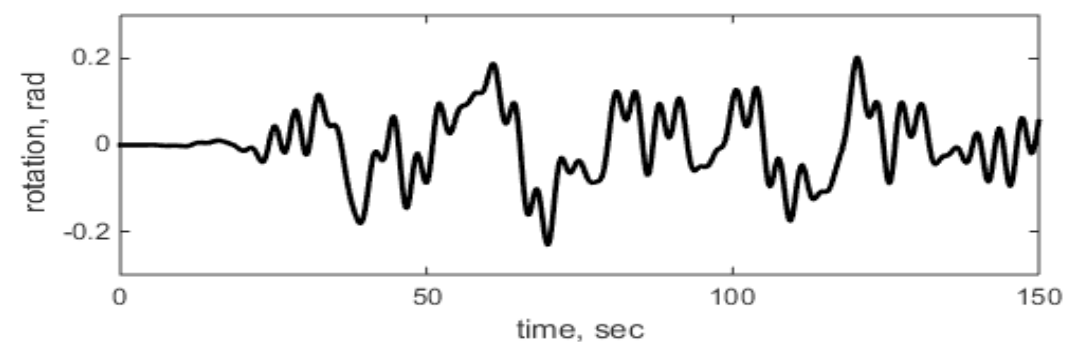
Flexible risers are complex multi-layered structures with contra-wound tensile armour wire layers. Accurate computation of wire stresses and fatigue life requires capturing the local layer nonlinear kinematics within the global dynamic simulation of the flexible riser. This necessitates inclusion of high fidelity 3D finite element models of the flexible in a



large scale nonlinear dynamic simulation with long duration irregular wave inputs. Current industry approaches lead to over-conservative and unreliable service-life predictions; and their inability to implement damage data in a meaningful way leads to reactive maintenance and high-cost untimely replacements.

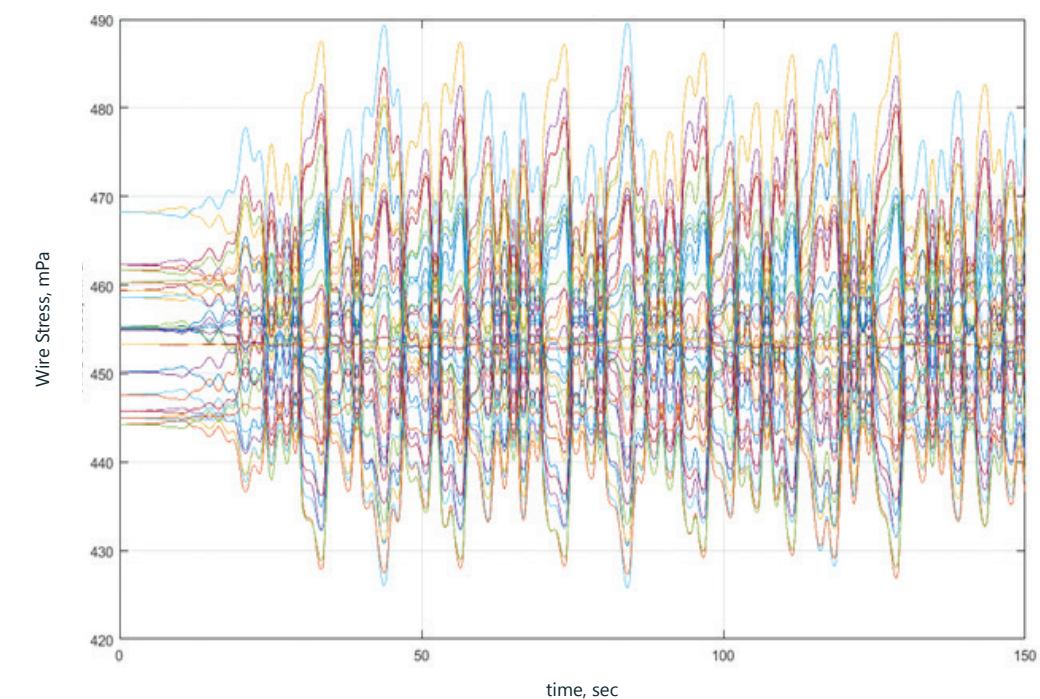
FLEXAS™ overcomes current computational constraints through advanced computational methodologies. The computational efficiencies provided by FLEXAS™ solver enable the direct inclusion of high fidelity 3D finite element models into the large scale, nonlinear dynamic simulations with long duration irregular wave inputs. This results in a high resolution fatigue spectra and accurate fatigue life predictions. Furthermore, this framework allows detailed inspection data (damage, flooding, and corrosion) to be captured in the 3D models and incorporated into the simulations, enabling a comprehensive risk-based strategy to be developed for integrity management.

FLEXAS™ has been qualified by DeepStar and ExxonMobil in independent validations against numerical and experimental benchmarks and is considered the leading flexible riser simulation capability by Subject Matter Experts (SMEs) at multiple major operators.



Irregular wave input for real-world conditions

- Dynamic riser simulation using detailed, multi-layered finite element models with FLEXAS™
- More realistic simulations leading to increased accuracy for fatigue life predictions
- Incorporation of MEC-FIT™ detected damage into simulations
- Single integrated flexible riser global analysis with detailed multi-layer models and direct stress recoveries



Individual armor wire stress time-histories

INTEGRITY ASSESSMENT

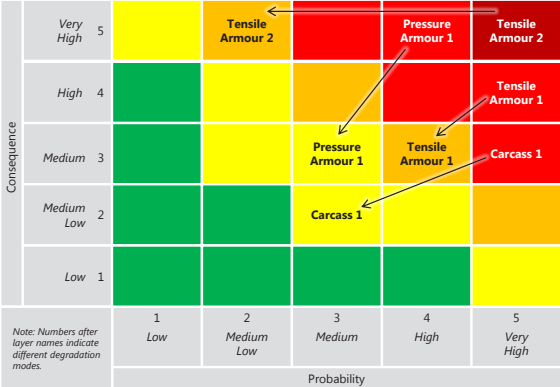
Improving risk assessment. **Increasing operational confidence.**

WORKSHOP INTEGRITY ASSESSMENT

Adopting a workshop driven, risk-based approach to integrity assessment of flexible risers enables risks to be quantified and mitigation measures to be justified using common terminology and industry standard approaches. This becomes particularly relevant when the inherent uncertainty in complex technology may lead to conservatism in design and therefore, a misrepresentation of perceived risk.

The primary objectives of the workshops include:

- Assess degradation layer by layer
- Understand risks for each layer



Risk reduction through execution of integrity management program

- Consider industry failure experiences
- Assess probability and consequence of failure

By defining the current risk profile for the riser, the effect of reducing uncertainty in key parameters for the critical degradation mechanisms can be evaluated.

INSPECTION PLANNING

A range of inspection techniques can be considered to ensure valuable data is collected that can feed back into the integrity assessment. Inspection activities include mobilisation and calibration of the MEC-FIT™ tool and annulus test kit, as appropriate, and identification of critical areas for inspection to ensure optimal use of offshore time. In addition, a site survey and Hazard Identification Risk Assessment (HIRA) shall be performed jointly between the FlexIQ team and the client prior to

mobilisation to ensure all simultaneous operations (SIMOPS) are planned accordingly and all risks are understood by all parties. The FlexIQ team can provide project management for the offshore work and coordinate any 3rd party vessel requirements.

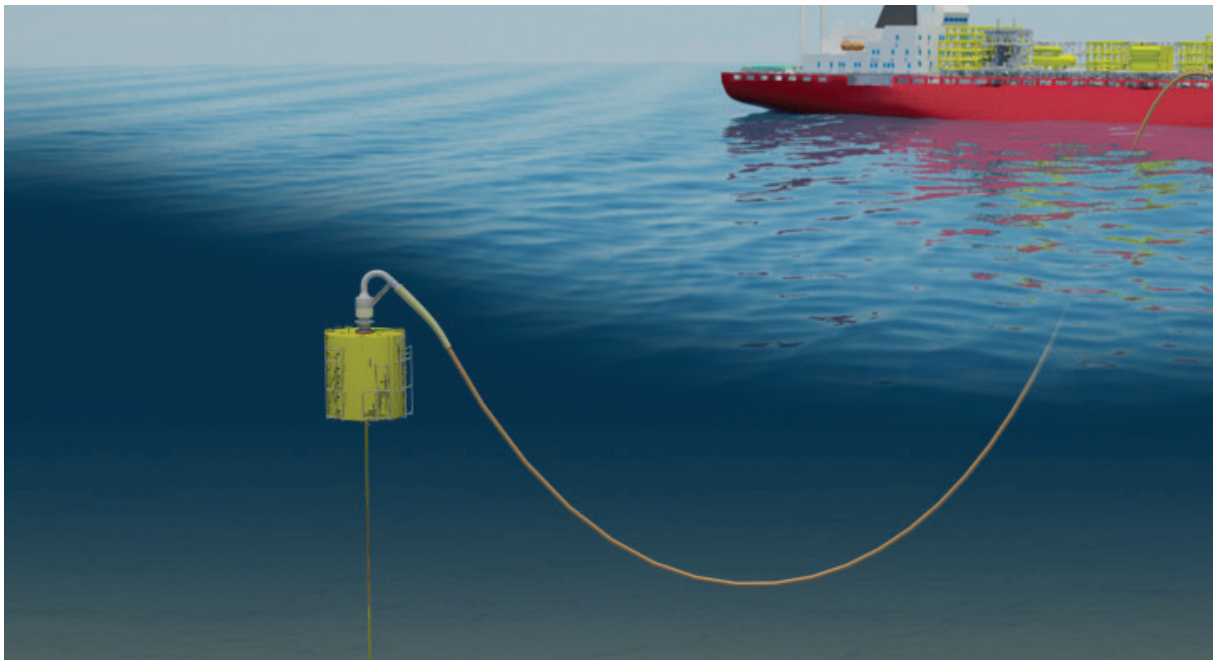


RISER LIFE EXTENSION

The industry has a number of recognized approaches for life extension of flexible risers. Each approach attempts to fully document and justify riser integrity for ongoing operation under projected operating conditions.

In regulated environments, close communication with authorities is

essential to extending service life. The FlexIQ team provides support for this regulatory interface, as well as expertise in preparing formal documentation and performing regular inspection and monitoring required to demonstrate ongoing fitness for service.



ANNULUS TESTING

FLEXIBLE RISER EXPERTISE

Annulus testing is a critical benchmarking tool to understand the current performance of fundamental integrity-related components within the flexible pipe design. It is critical to know if there is a breach to the outer shield and ideally to know where that breach may be located. It is also important to determine if vent ports are open and venting annulus gases to the flare system and to identify the constituents of the flared gas. This allows the risk assessment to be carried out with real information and trending analysis which can lead to enhanced integrity understanding.

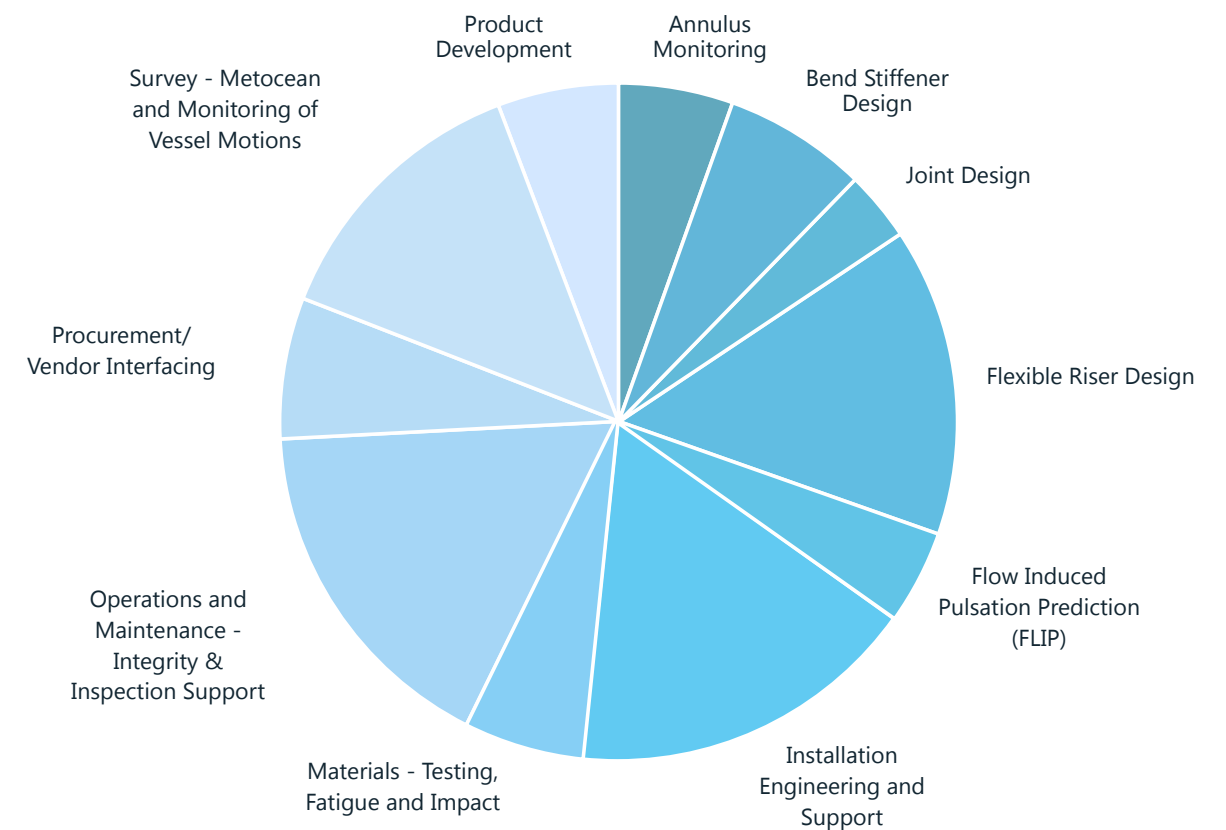


- Fast mobilization
- Only operated by trained, competent engineers
- Positive pressure annulus test and riser vent path assessment
- Temperature-calibrated for accuracy
- Gas sampling for corrosion assessments
- Secondary volumetric flow meter digital readout
- Improved quick connect kit to reduce pressure loss and eliminate leak paths

As part of FlexIQ, we provide a state-of-the-art annulus test kit developed in-house. Our test kit incorporates the latest components required to successfully implement an offshore annulus test, capturing information no other integrity company currently considers.

The FlexIQ team has experience across the full lifecycle of flexible pipelines and risers. Our wide array of project experience enables us to apply lessons

learned and the latest technology to assess the integrity of flexible pipelines and risers, and ultimately, help clients manage risk.



Our Flexible Riser Project Experience



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