In order to meet the continuing strong demand for energy, oil and gas firms have to explore ever-more difficult environments, with most of the world's easily-accessed oil and gas reserves now already tapped.

Fresh challenges continue to emerge as the industry progresses into deeper waters. These include how to design and safely operate the pipelines which carry hydrocarbons from wells to processing facilities. Pipelines can buckle due to compressive forces created by elevated operating pressure and temperature. Historically, the offshore industry trenched and buried pipelines to restrain them and prevent such problems. In deeper water however, trenching and...
The project is currently backed by the majors. These include BP, Chevron, ExxonMobil, Inpex, Petrobras, Shell, Statoil, Total and Woodside.

Other significant players in the subsea industry who are members of the project include ABS, BSEE, Bureau Veritas, DNV GL, Fugro, Subsea 7, Technip and Tenaris. Members have contributed £2 million in cash to date, plus an estimated £3 million in data. Atkins has also made a significant contribution in-kind by funding much of the internal research efforts.

The SAFEBUCK JIP has developed a design approach that deliberately encourages pipelines to buckle, but in a controlled and reliable way. By controlled initiation of lateral buckles at regular intervals, the loads are shared and reduced at each buckle site. A related issue addressed by the JIP is pipeline walking – gradual axial displacement of the whole pipeline with shutdown/restart cycles – which can ultimately lead to excessive displacements and failure of end connection systems.

**The research team**
As a result, research work has been completed around the world – in Aberdeen, and other parts of the UK, Europe, America and Australia. In addition to Atkins personnel, the research team includes a variety of leading companies and academic institutions, including Cathie Associates, Doosan Babcock, the Norwegian Geotechnical Institute, TWI and the Universities of Cambridge, Oxford and Western Australia.

The University of Western Australia is a key partner in the development of new methodologies for the assessment of critical pipe-soil interaction. Atkins' in-house geotechnical specialists are currently working closely with the University's Professor David White who has led this activity for most of the life of the project. Most recently, the University has developed a new framework to better understand the axial pipe-soil interaction which critically affects a pipeline's tendency to walk.

**Design approach**
Traditional pipe-soil interaction models give wide predictions of behaviour leading to uncertain and
potentially overly conservative design and costly mitigation. As the new framework is based upon a fundamental understanding of the complex geotechnical behaviour behind axial pipe-soil interaction and pipeline sliding, it allows better predictions of pipeline walking tendency and rate. For many projects, expensive mitigation measures such as seabed anchors with a capacity of several hundred tonnes could potentially be avoided. The new framework for this is calibrated against an extensive series of full-scale tests performed for the JIP by the Norwegian Geotechnical Institute and by other test data donated by the participants, including in-situ test data acquired by FUGRO SMARTPIPE® technology.

Figure 4. Full scale pipe-soil testing at NGI.

Figure 5. Small scale pipe soil testing in the centrifuge at UWA.

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The research findings and design guidelines have already been applied by SAFEBUCK members on a number of projects worldwide, with the JIP now in its third and final phase. All planned research work within Phase III has now been completed. The focus of the last 18 months has been to ensure that all design methodologies developed in the course of the JIP are truly robust – this effort has included a wide-reaching independent review.

Recommended practice
The final task of the JIP is now underway. It involves working with DNV GL, one of the top certification bodies in the world, to incorporate the SAFEBUCK design methodology into a major update of DNV GL’s recommended practice RP-F110 – Global Buckling of Submarine Pipelines. The first step is to develop a merged guideline encompassing the existing RP-F110 and the SAFEBUCK Guideline. This is expected to be completed in Q2 of 2014, after which the SAFEBUCK members will test out the guideline for 12 months. The finalised recommendations, incorporating feedback from the participants, will then be published in 2015 for use by the wider oil and gas industry.

To date, the existing SAFEBUCK guidelines have been used as an enabling tool on major deep water projects around the world. The guidelines have successfully gained momentum from early adoption off Western Australia on challenging major projects such as Pluto and Ichthys. There has also been an increasing use of the guidelines by additional operators in other deep water areas, including the Gulf of Mexico, West Africa and Brazil.

These guidelines effectively enable designers to concentrate solely on design rather than research, shortening the entire process. Previously, subsea project teams had to undertake research into pipeline buckling within their projects, with remaining technical uncertainties and risks, and also schedule delays. Ultimately, operators did not know if they were delivering designs that met industry target levels for probability of failure in operation. Now, SAFEBUCK provides a clear framework, giving confidence to project teams that they can deliver designs which meet industry safety and reliability targets.

The guidelines have been of great benefit for key projects over the last decade and will continue to gain momentum going forward. Many JIPs come and go with no lasting impact, but Atkins is focusing on securing SAFEBUCK as a viable industry guideline. It is not just about undertaking research, but instead developing new, yet robust, design methodologies for use internationally, and not just by participants of the project.

The ultimate goal is that SAFEBUCK will secure itself within a DNV GL recommended practice used worldwide for the next decade or more – a hugely rewarding opportunity for Atkins to be involved with a lasting legacy for the oil and gas industry. 😊