

INTECSEA

WorleyParsons Group

THIS ISSUE
President's Letter 02
Lateral Buckling 04
Subsea Technology 06

LIUHUA 4-1 PROJECT

by Jim Chase, Project Manager

INTECSEA Kuala Lumpur has been awarded with the Liuhua 4-1 Oil Field Development Front End Engineering Design (FEED) by China Offshore Oil Corporation (CNOOC). The project team is based in Kuala Lumpur with the INTECSEA Houston office providing engineering support such as the umbilical and power cable riser analysis, subsea electrical power supply systems engineering and materials engineering.

The Liuhua 4-1 field is located in the South China Sea approximately 215km from Hong Kong. It will be 100% owned and operated by CNOOC with the first oil from the field planned for 2012.

The development is comprised of eight wells clustered around a central manifold with a pipe-in-pipe flowline tying back to the existing Liuhua 11-1 field, approximately 11km away.

The existing Liuhua 11-1 field was developed with two separate floating facilities; i.e. the FPS (Floating Production System), a Sedco 700 semisubmersible and a ship shaped FPSO (Floating Production Storage Offloading facility). The two vessels are moored approximately 2.8 km from each other.

Both the existing Liuhua 11-1 development and the new Liuhua 4-1 development have very low reservoir pressure and require down-hole electric submersible pumps (ESPs) to produce from the reservoir.

Control and power generation for the subsea wells are provided by the FPS which is moored directly over the twenty five existing LH11-1 wells. Legacy INTEC Engineering designed this critical subsea electrical power cable system as well as the flowline from the

manifold to the FPSO for the original development. The FPS also has a drilling rig which can be used to service the existing wells.

Each existing well is supplied with electrical power by a cable suspended from the FPS. CNOOC will modify the FPS with additional power generation facilities and variable speed drives to supply electrical power to the new development at Liuhua 4-1.

The Liuhua 4-1 development is located approximately 10km from the FPS and will not have a permanently moored drilling rig available to service the wells. To improve production availability, each Liuhua 4-1 well will have dual ESPs, with one pump operating and another pump in standby mode. Switch over to the standby pump will be achieved by a subsea switch mounted on the subsea tree. The switch will be remotely operated via the Liuhua 4-1 subsea control system.

No choke valves are required on the Liuhua 4-1 subsea trees as control of the production rates will be achieved by changing the electrical supply frequency to vary the speed of the down-hole pumps. However, dual high voltage electrical penetrations through the subsea tree may require qualification of new designs for at least one subsea tree vendor.

A new electro-hydraulic control system will be used for the Liuhua 4-1 field. The existing direct hydraulic control system used for Liuhua 11-1 would not provide an adequate response time because of the distance to the Liuhua 4-1 field. Control, monitoring and chemical injection for the Liuhua 4-1 field will be provided via a new main umbilical approximately 14km in length.



I was reflecting the other day on April 1 of 2008. I was on my first trip to The Netherlands to announce to the staff in the then INTEC Engineering Delft office that WorleyParsons had purchased the company from Heerema. Following the announcement, I had the opportunity to speak with some of the staff members in the office whom I found were extremely proud and passionate about the company and their work. Fast forward 2 years and I have now visited most of our offices as a part of my gaining a better understanding of the business that is now my privilege to lead. INTEC is now INTECSEA, having merged with WorleyParsons SEA allowing us to offer complete subsea and floating systems solutions to our clients. Not only have I found pride and passion across all of the INTECSEA operations, but I have also been impressed by the technical expertise in the business and the truly qualified and intelligent people that we have working for us.

I have also seen firsthand the synergies and opportunities being realized that I discussed with the staff during meetings in Delft back in 2008. We have projects in all of our main operating centers which we are executing with WorleyParsons. These are all major projects where the combination of INTECSEA and WorleyParsons skills, use of the same execution processes and our technical abilities allow us to offer a more complete, "single" entity solution for our customers. On the flip side, INTECSEA is recognized as one of the global leaders in our particular field and we continue to win major work in our own right. I think this is a great situation for us to be in as it enables us

to offer our people a broader range of projects to work on while ensuring that we maintain our focus on our core business. We have some great opportunities ahead of us as we further expand our capabilities in deep water developments, subsea processing and Arctic developments.

Our business has emerged from the global financial crisis in a strong position. We have a good spread of projects across all of our offices which is allowing us to strengthen and build our capabilities and teams. We have a clear strategy that defines where we need to develop new expertise to allow us to better serve the needs of our clients.

The business is continuing to expand and we have recently opened offices in Jakarta, Indonesia and St. John's, Newfoundland, to allow us to better service the Indonesian and Canadian markets. Both offices are able to draw on the resources and skills within our global organization as we build local capability in each of these operations.

I have met with a number of our clients and appreciate the positive feedback and encouragement of our efforts to support their project needs. Working as a global business, I am sure that we will be able to meet their expectations and continue to provide creative solutions in technically challenging environments.

Power for the Liuhua 4-1 ESPs will be provided by three new 5kV power cables that will follow the umbilical route from the FPS to the Liuhua 4-1 field. Each of these power cables will contain three triads (9 cores) to supply 3-phase electrical power to the ESPs. A subsea electrical power distribution system will distribute power from the three cables to the eight wells, with one 3-phase triad to each well plus one spare.

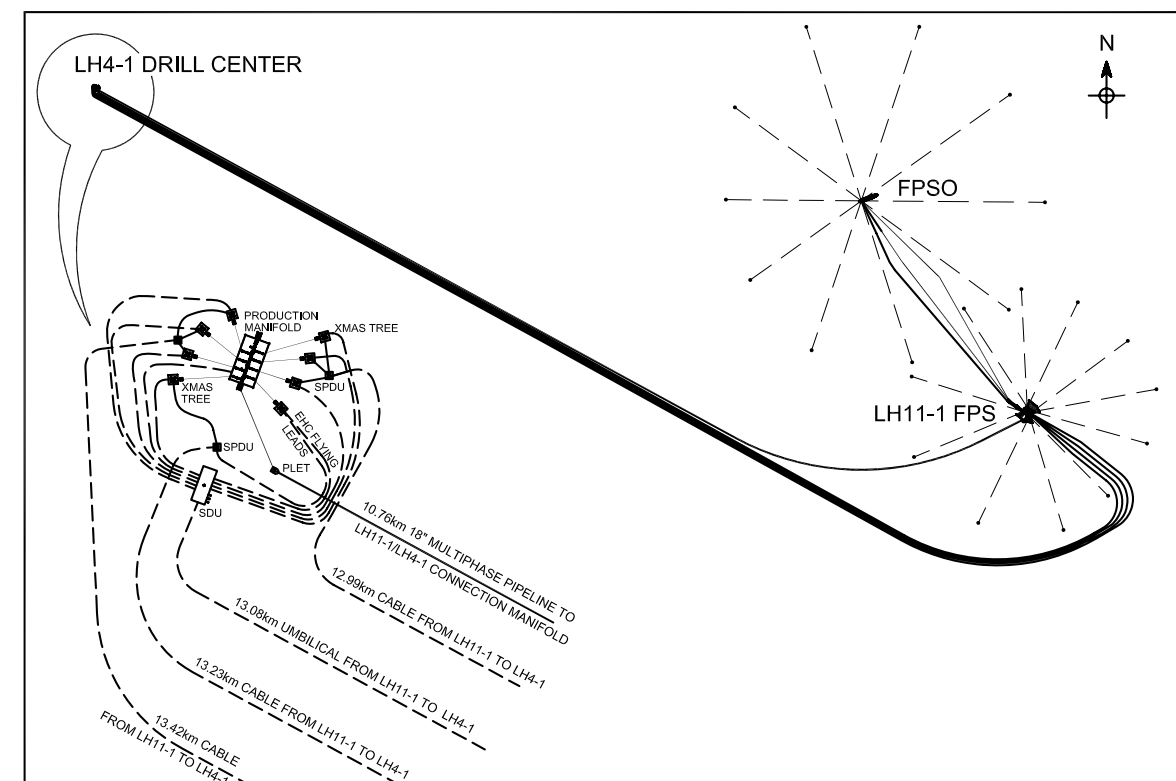
The tie-in to the existing subsea facilities requires a bridging manifold located close to the existing Liuhua 11-1 manifold. The plan is to remove the existing jumpers connecting the LH11-1 manifold to the flexible risers and place the bridging manifold in a location where it can be connected with new jumpers to the existing LH11-1 manifold, the end of the LH4-1 pipeline (PLET) and the existing flexible riser bases. The bridging manifold will allow well fluids from the new Liuhua 4-1 field and the existing Liuhua 11-1 field to be mixed before flowing through the existing flexible risers to the FPSO for processing and offloading to a shuttle tanker.

Water depth varies between approximately 260m to over 300m. All subsea installation and hook up will be accomplished without diver assistance using remotely operated tools and ROVs.

INTECSEA is responsible for the design and specification of the subsea facilities at each end of the pipeline as well as the high voltage subsea power cables and umbilical that follow the pipeline for most of its route.

INTECSEA's scope includes field architecture, specification of subsea equipment and subsea control systems, subsea electrical power cables and power distribution system, design of subsea structures including two manifolds, pipeline end terminations and design, and analysis of new umbilical and power cable risers at the existing LH11-1 facility.

The most challenging aspect to the project has been the design of the new subsea facilities located in the existing Liuhua 11-1 field. The bridging manifold, new power cables and umbilicals have to be installed in an area congested with existing subsea equipment and suspended cables. In particular, the new cable and umbilical risers have to be designed so they will not clash with existing cables and structures, even when the FPS and the cables are moving due to the waves and currents experienced during tropical cyclones.



In October 2008, a design for lateral buckling control was presented to the Engineering Department of Petrobras, in Rio de Janeiro, Brazil. It established a mitigation strategy for the two identical 12-inch rigid flowlines from Platforms P-56 to P-38 to be installed in Marlim Sul field, Campos Basin, offshore Brazil (Figure 1). The flowlines are thermally insulated with 70mm of polypropylene and will be operated in HPHT conditions, i.e. design temperature of 90°C and design pressure of 352bar.

The flowlines will lay on the seabed crossing ten existing pipelines along the routes. The project was developed by an integrated team combining the INTECSEA Rio de Janeiro and UK offices and followed the specifications defined by Petrobras, which are mostly based on the results from the SAFEBUG JIP.

One of the challenges was to carry out a fast track design during the FEED in about 40 working days in order to obtain a preliminary mitigation strategy able to ensure the pipeline integrity under lateral buckling behavior. We also needed to provide information for the ongoing bid process and recommendations for the detail design. The mitigation strategy for lateral buckling control was established by introducing buckle initiation along the pipeline using distributed buoyancy, in order to avoid an excessive mechanical strain at the crown of the buckles.

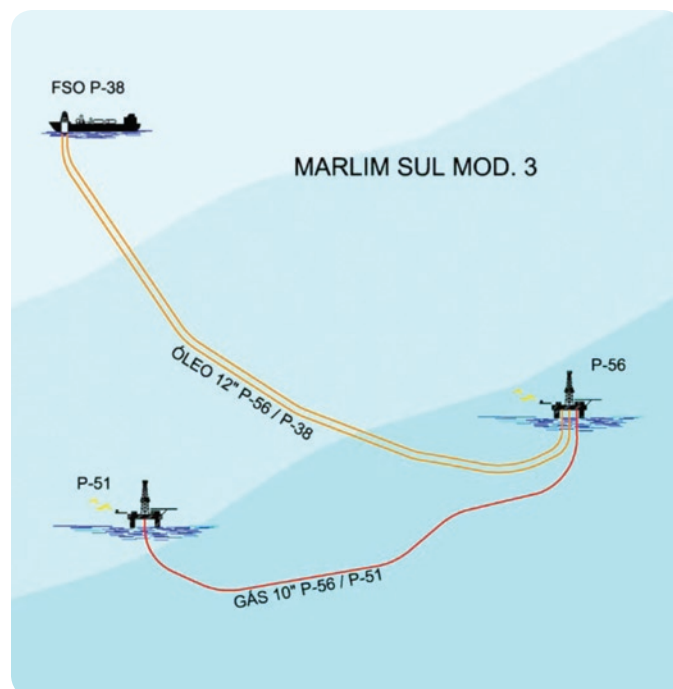


Figure 1: Pipelines Schematic View

The analysis addressed the following design issues:

- Pipe-soil interaction assessment following recommendations published in Bruton et al. (2006)
- Limit state criteria application in order to determine the allowable compressive mechanical strain
- Pipeline buckling susceptibility
- Maximum allowable Virtual Anchoring Spacing (VAS) length identification using 2D ABAQUS FE model
- Initiated buckle locations selection within the following criteria:
 - VAS length to stay below the tolerable VAS;
 - Accidental rogue buckle formation would not cause excessive axial compression strain; and
 - Effective axial force along the route after buckling to stay below the critical buckling force to avoid uncontrolled buckles.
- Fatigue damage checking due to stress variation from partial and full shutdown operational cycles
- Susceptibility analysis for pipeline walking was primary performed, employing the analytical method purpose based on Carr et al. (2003)

The selected mitigation strategy for lateral buckling control is shown in Figure 2. Three buckle initiation points were selected to ensure the lateral buckles are initiated in a controlled manner. By introducing the three initiated buckles, four short pipelines were created and the susceptibility for pipeline walking behavior was identified. Therefore, further FEA for pipeline walking is required during the detailed design, in order to assess the effects of more complex pipe-soil response, non-linear transient profiles and lateral buckling.

The applied philosophy succeeded in providing a quick response for lateral buckling mitigation strategy during the FEED phase. This quick response was possible because of INTECSEA's experience accumulated over the years in FEED and detailed design of thermo-mechanical analysis all over the world and the close communication and clear design specification defined with the client. The work was published in the Rio Pipeline Conference IBP1062-09 by P.F. Solano, who was responsible to establish the design specification.

The same basic design philosophy was also applied recently for the oil export from P-55 to PRA-1 Platforms, but using 2D ANSYS FE model. The design was comprised of a steel insulated 12-inch pipeline, 41km long under HPHT, with the operating temperature reaching 90°C.



Figure 2: Effective Axial Force Profile (Base Case) and Locations of the Structures and Crossings

References

BRUTON, D., CARR, M., CRAWFORD, M., POIATE, E., The Safe Design of Hot On-Bottom Pipelines with Lateral Buckling using the Design Guideline Developed by the SAFEBUG Joint Industry Project, DOT 2005.

BRUTON, D., WHITE, D., CARR, M., CHEUK, J., BRUTON, D., WHITE, D., CARR, M., CHEUK, J., Pipe-Soil Interaction Behavior During Lateral Buckling, Including Large-Amplitude Cyclic Displacement Tests by the SAFEBUG JIP, OTC 2006-17944, May, OTC 2006.

CARR M., BRUTON, D., Pipeline Walking – Understanding the Field Layout Challenges, and Analytical Solutions Developed for the SAFEBUG JIP, OTC2006-17945, May, OTC 2006.

SOLANO, R. F., MENDONÇA, S., FRANCO, L., WALKER, Walker., EL-GEHALY, S., A Fast-Track Preliminary Thermo-Mechanical Design Of Oil Export Pipelines From P-56 Platform, Rio Pipeline Conference, IBP1062_09, September, 2009.

AOG EXHIBITION AND CONFERENCE, MARCH 2010, PERTH WESTERN AUSTRALIA by Tilak Dulam

The Australasian Oil and Gas (AOG) Exhibition and Conference held at Perth Convention Exhibition Centre, Perth, Australia during 24 - 26 March 2010 was yet another success story. The expo brought together the industry's leading companies and leaders with more than 9,000 visitors, which was a 35% increase in attendance from the previous year. More than 500 exhibitors showcased their latest products and services to local, interstate and international visitors.

The Subsea Australasia Conference was held in conjunction with Australia's largest oil and gas exhibition. Hundreds of

Oil and Gas professionals attended the Subsea Conference, with 35 keynote speakers presenting on various commercial and business topics impacting the subsea market. The conference focused on many of the new technical issues and challenges that face the subsea industry today. The emphasis was on exploring new opportunities, overview of Australasian subsea projects, technical challenges, systems engineering, long distance tiebacks, geophysics and geohazards associated with oil and gas exploration, production and transportation within the subsea industry.



Subsea Active Production Technology

by Dr. K. Janardhanan and Ron Bass

Subsea Active Production Technology is a key enabler to meet future challenges for offshore field developments such as:

- Deepwater developments, possibly far from existing infrastructure
- Smaller discoveries, that may require single line tie-back for economic viability
- Complex fluids that are difficult to transport
- Utilization of existing facilities
- Arctic/Sub-Arctic/ice covered environments

Key subsea processing technologies include: subsea separation, subsea pumping, subsea compression.

Ancillary technologies include subsea sea water injection, solids management, subsea power distribution, Direct Electric Heating (DEH) and associated controls systems. Deployment of subsea processing technology and equipment requires an integrated systems approach, including matching operator needs with (appropriate) industry equipment capability.

INTECSEA realized that while there are several ongoing RandD programs by vendors for developing different aspects of the Subsea Active Production Technology, there is a gap in information available for the operators to make an unbiased decision on appropriate technology and associated technical risks. To overcome this gap, INTECSEA embarked on a JIP in 2007 to assess the state-of-the-art for subsea processing. Since 2007, INTECSEA has been closely following the developments in subsea processing as an unbiased system designer and published summary of findings in open literature such as Offshore Engineer. The 2010 Worldwide Survey of Subsea Processing poster is third in a series of publications highlighting the state-of-the art.

Recent awards and start-ups indicate several new projects in the developmental stages plus new world records for installed systems. Subsea separation and boosting technology is now operational in 2,438m (7,999 ft) water depth in Shell's Perdido field. Starting production in 2010, Perdido has set the stage as the first commercial Paleogene production in the Gulf of Mexico. Extreme weather and a rugged seafloor were only half the battle.

Significant challenges were overcome in order to develop the field's ultra deep and remote oil reserves. Perdido's use of multiple subsea separation and boosting stations highlights one option for the future of offshore oil production.

INTECSEA provides overall subsea processing system design capabilities ranging from conceptual studies to detailed engineering, and so recognizes the steps needed to implement and achieve production subsea. Starting at the conceptual level, individual pump and system components are specified to meet the unique requirements of the development. Pumps are then sized to meet the desired production conditions over the entire life of the field. In addition to gas volume fraction and differential pressure, the selection of the pump type and configuration must consider single and multi-phase flow, viscosity, and reservoir drilling programs. Early involvement of INTECSEA in projects requiring Subsea Active Production technology has proven to shorten the delivery cycle by managing technical risks through a comprehensive Integrity and Risk Management program as well as new technology qualification.

INTECSEA has made advancements in the design and qualification of Direct Electric Heating (DEH) applications for mitigating flow assurance concerns such as hydrates and wax deposition, and will be a key enabling technology for single flowline tie-backs. DEH concepts are applicable to pipe-in-pipe as well as wet insulated reeled flowlines using INTECSEA's patented Hybrid DEH technology.



With Ron Bass joining INTECSEA from Shell we have added to our capabilities in Subsea Active Production Technology. Ron led the subsea processing RandD program within Shell which included initial development work on the caisson separator technology, with and without ESPs, up through ¼ scale model testing and conceptual design of control system. He also led development of all high boost and high viscosity pumps now coming available, including the Framo high boost multiphase pump, high boost hybrid Sulzer pump and Flowserve high boost twin screw. Ron also holds a patent for the Shell pipe-in-pipe pipeline heating system. Ron was also involved in project peer reviews within Shell, including technology selection, and helped in troubleshooting fault in Shell Perdido project.

INTECSEA is currently seeking participants for the next Joint Industry Project (JIP) to extend the previous work for the development of conceptual design, alternatives, safety and technology risks, high level cost, schedule, and application assessments of relevant technologies for a specific application, such as offshore Angola, on the Grand Banks, or Arctic applications. This system applications

study will enable operators to better understand available technologies and technology risks and assist in the decision support process for applying Active Subsea Production Technologies.

Technologies to be studied for their benefits include:

- Electric Flowline Heating (DEH)
- Downhole ESPs
- Sand handling
- Water treating for sea and/or subsurface disposal
- Water pumping for injection and/or disposal
- Manifolds/PLETs/PLEMs and other equipment connection point design
- Intervention/Control/Power Structures
- Equipment handling and installation subsystems

The 2007 subsea processing JIP was a successful collaboration of operators, equipment suppliers, installation contractors and consulting engineers.

We invite interested participants to contact us at ssp@intecsea.com to further describe the JIP deliverables.

FUTSAL

by Visanth Prabhakaran

On Saturday, February 20th, more than 400 people gathered at the Sports Planet Futsal Complex in Kuala Lumpur to witness 40 teams try to win the Malaysian Oil and Gas Engineering Consultants (MOGEC) Futsal Championship. This event was organized jointly by the MOGEC and Malaysian Oil and Gas Services Council (MOGSC) and brought teams from all over the Malaysian Oil and Gas community, including one promising rookie team from our INTECSEA KL office.

As the day went on, competition became more intense beneath the sweltering heat as each team fought their way to the finals. INTECSEA managed to chalk up a win and two draws in the group stage, but were unable to make it to the knockout stage. Not too bad for rookies! Additionally, this event has encouraged INTECSEA's KL office to pursue more outdoor events in the future. Hopefully this annual futsal tournament will set a firm tradition and become a permanent feature in INTECSEA's social calendar! On behalf of the INTECSEA KL team, we'd like to thank the management for the sponsorship and encouraging support.



INTECSEA Announces Establishment of INTECSEA Canada in St. John's, Newfoundland

INTECSEA recently announced appointment of Dr. Mike Paulin as Operations Director Canada. Mike will lead the newly established INTECSEA office in St. John's, Newfoundland, and will have operating responsibility for INTECSEA's activity in Canada reporting to Uri Nootboom, COO of INTECSEA.

"I am pleased to be back with the INTECSEA family after a hiatus of seven years. When I left Houston in 2003 to return to Newfoundland, I had talked to some of my colleagues about doing something together again one day...and here we are! I had kept in touch with many of my INTEC friends and so, in many ways, it is like I had never left. The transition back has been that easy."

Mike brings 20+ years of experience in offshore pipeline/riser/facilities engineering including projects on the Canadian east coast, the Canadian Beaufort, the Canadian High Arctic, offshore Alaska, the Gulf of Mexico and Sakhalin Island. His experience includes innovative conceptual, preliminary and detailed structure and pipeline design for harsh environments.

"Arctic and cold regions engineering has been the focus of my career for the past 20 years. When I recently decided to rejoin the INTECSEA team, I was quite familiar with what heritage INTEC had done in terms of Arctic pipeline/subsea work over the past several years and that they had continued to be international leaders in this area. This was a major factor in my decision to rejoin – actually, it was a very easy decision! INTEC has carried out design of all of the offshore production pipelines in Alaska, engineering on Sakhalin 1 pipelines, work on pipelines in the Caspian, and numerous other studies. And the list continues to grow – what more could I ask for?"

"What I didn't know, but quickly found out, was how much more INTECSEA/WorleyParsons is doing in cold regions and the Arctic: there is significant onshore cold regions pipeline and facilities experience within WorleyParsons; INTECSEA has experience with the assessment and design of floating and fixed structures in ice environments; Westmar and INTECSEA offer Arctic transportation and ice expertise; and WorleyParsons is a global leader in cold regions topsides design. This company truly covers all aspects needed for the engineering, fabrication, and operation of exploration and production structures for ice covered waters."

"We are pleased to become part of the community in Newfoundland as we expand our operations into Canada, and I am looking forward to leading INTECSEA's Canadian Operation. We look forward to offering our specialty engineering and project management services to local and global clients through the St. John's office and in particular our expertise related to harsh environments, the Arctic and deepwater. Given our environment offshore Newfoundland and Labrador, our vast Canadian Arctic, and our proximity to Greenland, this is a logical place for INTECSEA to be."

In addition to growing the INTECSEA business in Canada, in particular in Newfoundland, Mike will also be a valuable



contributor in the provision of our Arctic specialty engineering services globally, which has been one of INTECSEA's core activities for more than 25 years. Mike's work has included:

- Arctic Offshore Technology Assessment of Exploration and Production Options for Cold Regions of the US Outer Continental Shelf (MMS)
- Arctic Developments for the US Beaufort and Chukchi Seas (Shell)
- Mobile Ice Resistant Drilling Rig for the Russian Arctic (Gazprom)
- Gas Development studies for the east coast of Canada
- FEED Project Manager, Offshore Pipelines, Sakhalin I Project (Exxon Neftegas)
- Offshore Superintendent for design, De-Kastri Export Terminal (Exxon Neftegas)
- Arctic Pipeline Studies for the Canadian and US Arctic
- Northstar and Liberty Pipeline Developments for BP Alaska

Mike has an undergraduate degree in Naval Architecture and a Ph.D. in Civil Engineering from Memorial University of Newfoundland. He is an Adjunct Professor at the Faculty of Engineering of Memorial University and is a registered professional engineer in the Province of Newfoundland and the State of Alaska.

Mike lives in Paradise with his wife Janet, who is also an engineer, and their two children, Eli and Penelope.

Mike can be reached at +1-709-749-3316 or mike.paulin@intecsea.com.