Sonardyne
SOUND IN DEPTH

Atteris

Managing Flowline Buckling and Walking with Real time Position Monitoring

Subsea Monitoring, Analysis and Reporting Technology

SUT
Society for Underwater Technology

Stephen Fasham
Global Business Manager – Sonardyne International

Subsea Controls Down Under 2016
Enhancing Value Through Technology

What is Pipeline/Flowline Buckling?

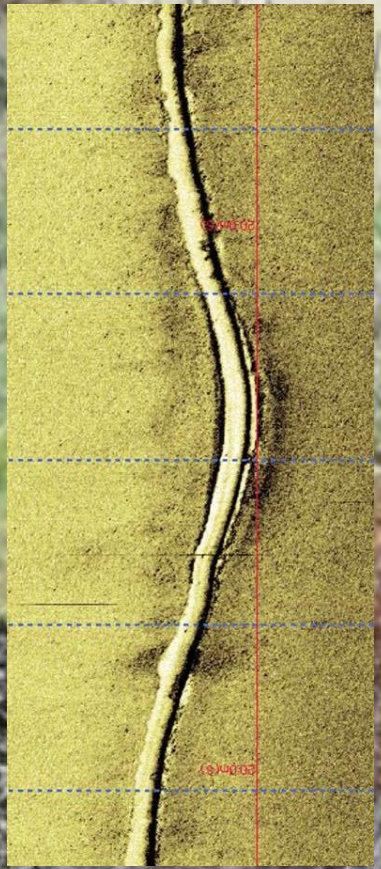
Why Should we Care About it?

What is Pipeline/Flowline Buckling?

Why Should we Care About it?

What is Pipeline/Flowline Buckling?

Why Should we Care About it?



What is Pipeline/Flowline Buckling?

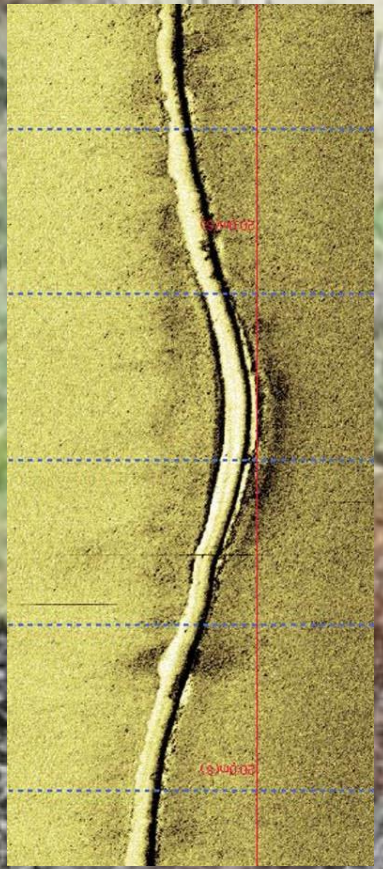
Why Should we Care About it?

Over the last 20 years temperature and pressure of pipeline product has increased dramatically

- Pressures > 15 MPa (HP)
- Temperatures > 120°C (HT)

Pipelines also insulated to mitigate wax and hydrate formation

HTHP causes expansion which, if restrained, induces compressive axial forces

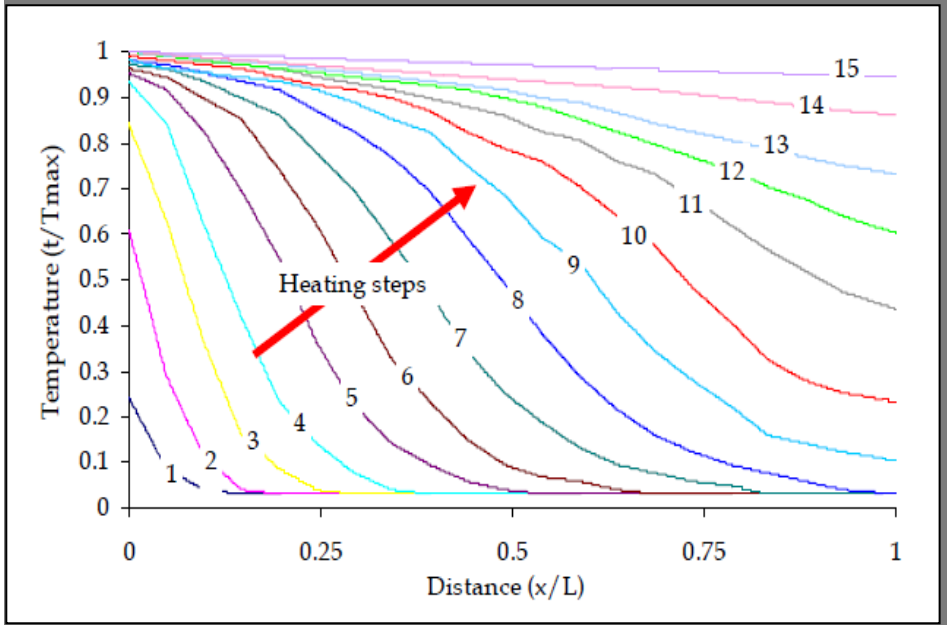


How is it Different to Buckling

- For shorter pipeline we may not reach fully restrained condition due to friction
  - Unlikely to buckle so everyone happy and no problems…

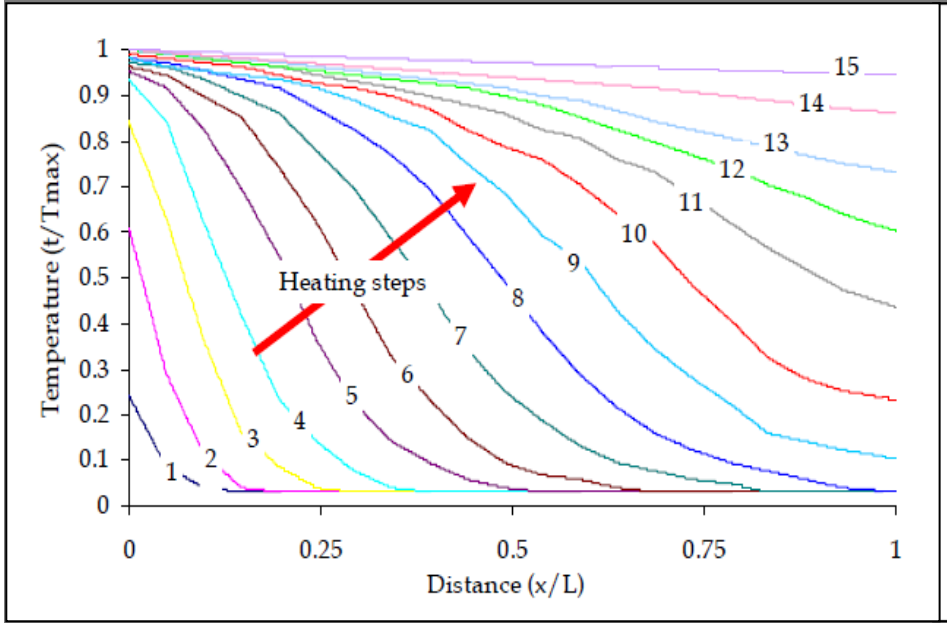
How is it Different to Buckling

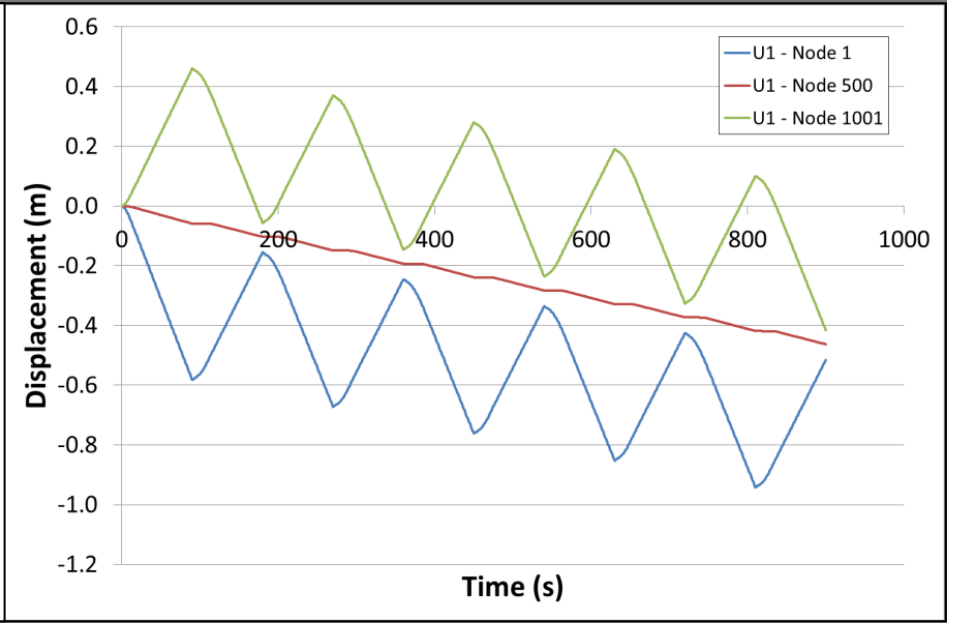
- For shorter pipeline we may not reach fully restrained condition due to friction
  - Unlikely to buckle so everyone happy and no problems…
  - But still have expansion – calculate expansion, put in loop and no problems…



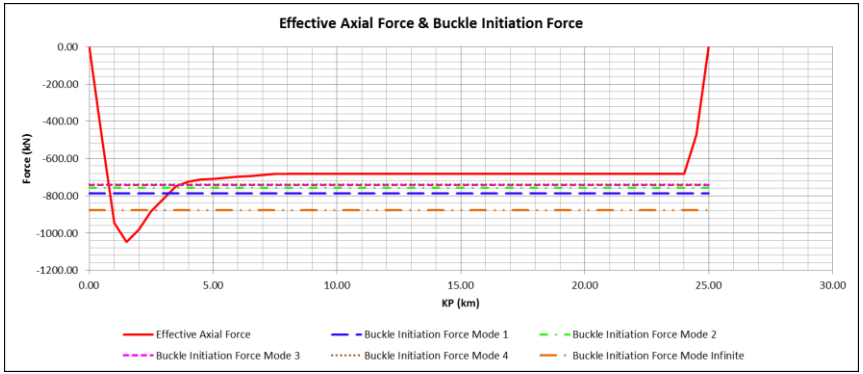
How is it Different to Buckling

- For shorter pipeline we may not reach fully restrained condition due to friction
  - Unlikely to buckle so everyone happy and no problems…
  - But still have expansion – calculate expansion, put in loop and no problems…
- True for symmetrical conditions but – the real world is rarely ideal





Analytical and FEA Modelling



Analytical Methods

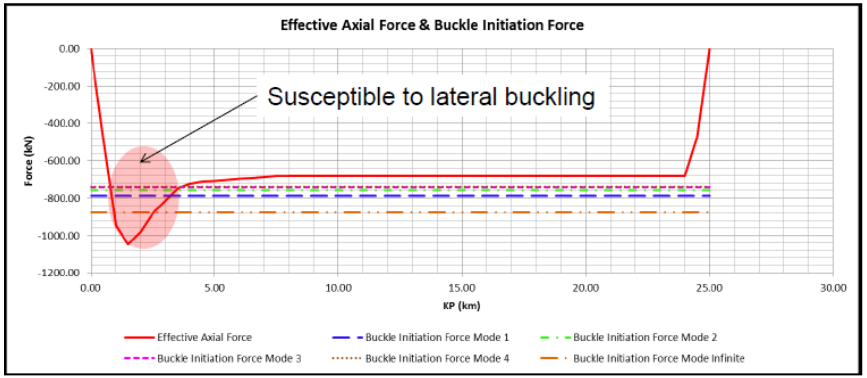
Initial assessment involves Hobb's analytical solution

Atteris has developed tools to carry out analysis and the expertise to interpret them.

Determines propensity of pipeline to lateral buckling

If not susceptible then only axial walking assessment required

Analytical and FEA Modelling



Analytical Methods

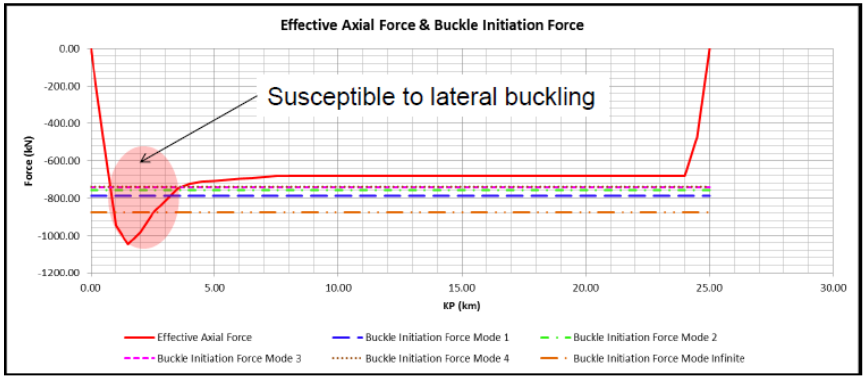
Initial assessment involves Hobb's analytical solution

Atteris has developed tools to carry out analysis and the expertise to interpret them.

Determines propensity of pipeline to lateral buckling

If not susceptible then only axial walking assessment required

Analytical and FEA Modelling



Analytical Methods

Initial assessment involves Hobb's analytical solution

Atteris has developed tools to carry out analysis and the expertise to interpret them.

Determines propensity of pipeline to lateral buckling

If not susceptible then only axial walking assessment required

FEA Modelling

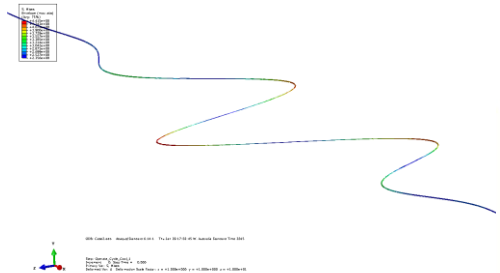
Determine if uncontrolled buckle acceptable

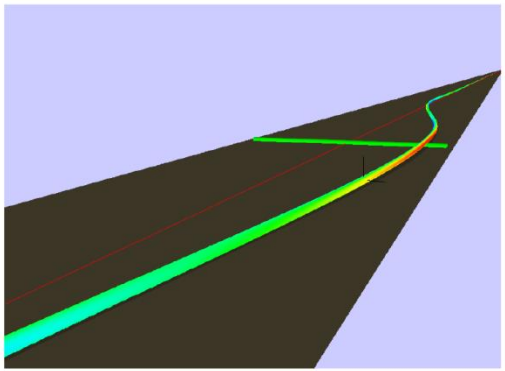
If not determine spacing so rogue buckles are acceptable / planned buckles reliable

Determine mitigation measures and initiation forces

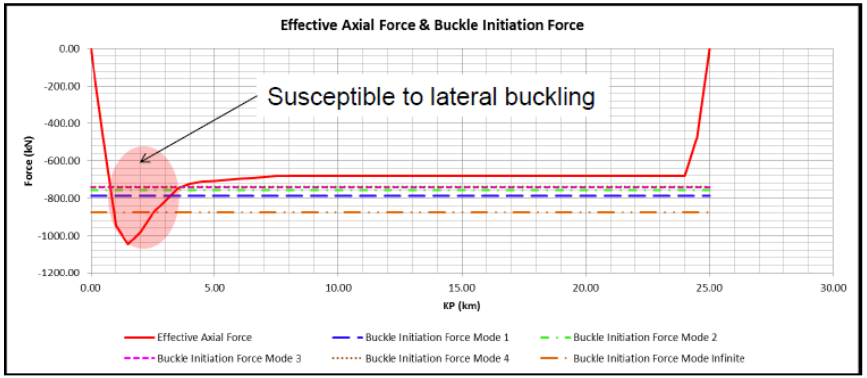
Ensure global acceptability

Confirm walking compliance





Analytical and FEA Modelling



Analytical Methods

Initial assessment involves Hobb's analytical solution

Atteris has developed tools to carry out analysis and the expertise to interpret them.

Determines propensity of pipeline to lateral buckling

If not susceptible then only axial walking assessment required

FEA Modelling

Determine if uncontrolled buckle acceptable

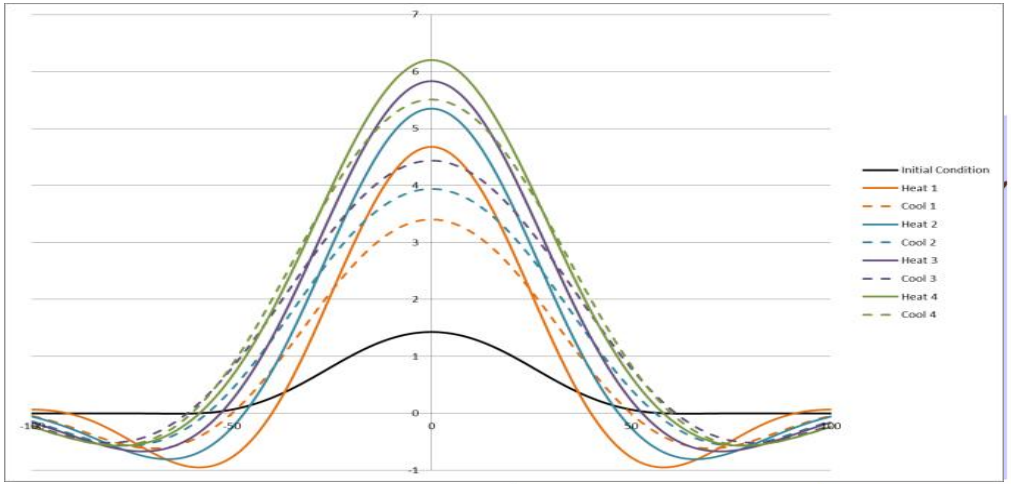
If not acceptable, planning measures are acceptable / planned buckles reliable

Determine mitigation measures and initiation forces

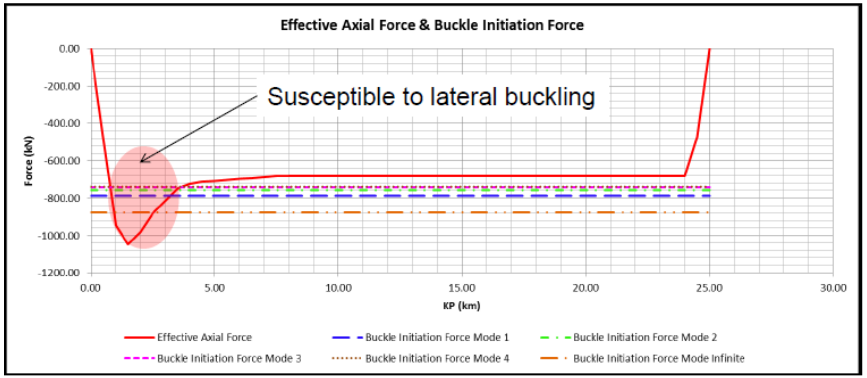
Ensure global acceptability

Confirm walking comliance

FEA toolset can also be used to examine fatigue and local buckling



Analytical and FEA Modelling



Analytical Methods

Initial assessment involves Hobb's analytical solution

Atteris has developed tools to carry out analysis and the expertise to interpret them.

Determines propensity of pipeline to lateral buckling

If not susceptible then only axial walking assessment required

FEA Modelling

Determine if uncontrolled buckle acceptable

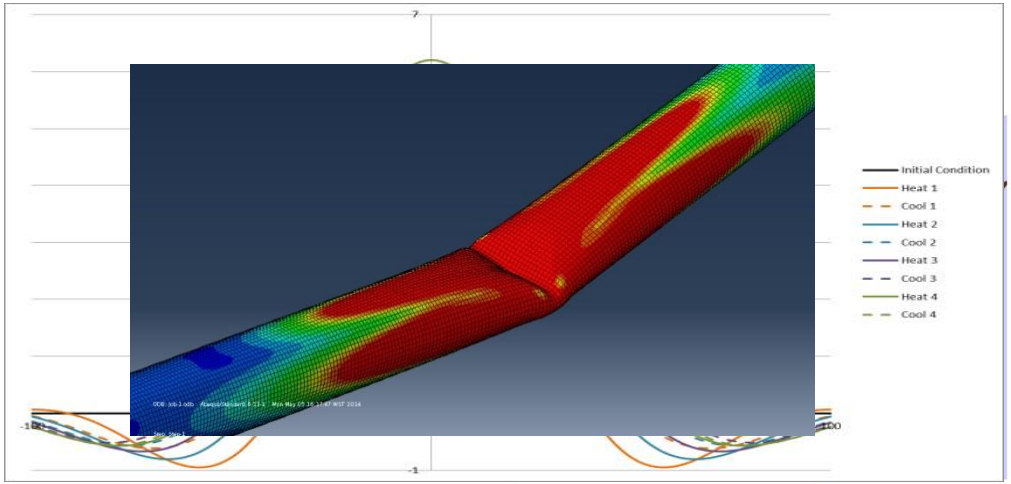
If not acceptable, planning measures are acceptable / planned buckles reliable

Determine mitigation measures and initiation forces

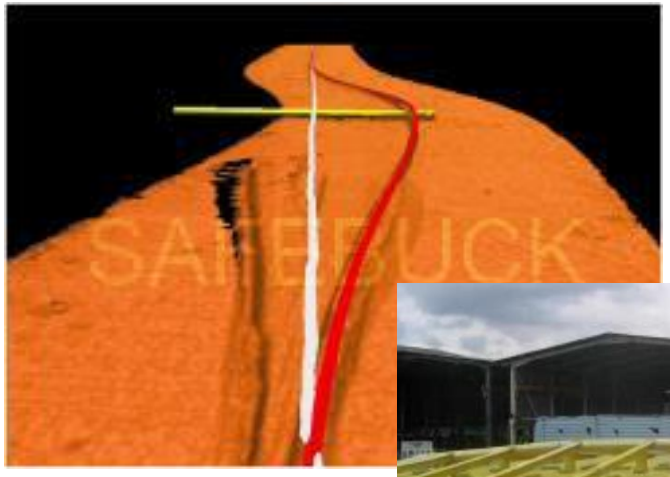
Ensure global acceptability

Confirm walking comliance

FEA toolset can also be used to examine fatigue and local buckling

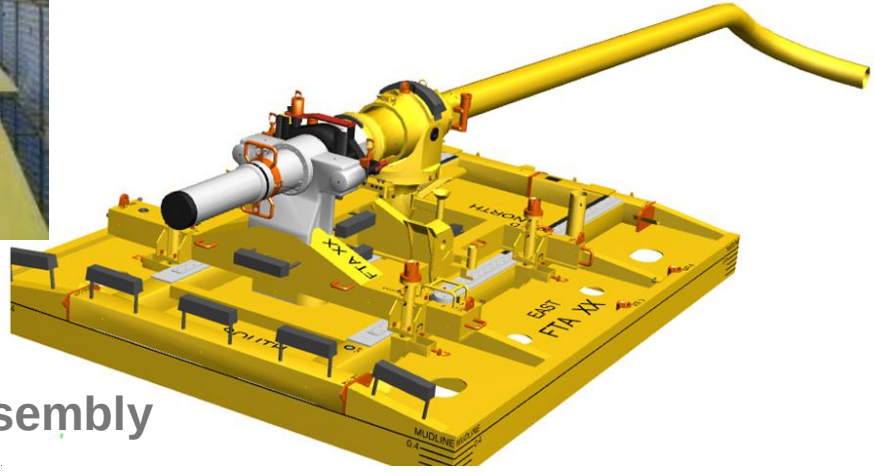


Mitigation Strategies



Buckle Initiator

Zero Degree Bend Radius



Sliding Flowline Termination Assembly

Why Should we use Near-Realtime Monitoring?

- There have still been pipeline failures despite knowledge of failure modes

Why Should we use Near-Realtime Monitoring?

- There have still been pipeline failures despite knowledge of failure modes

- Field data can improve modelling techniques

Why Should we use Near-Realtime Monitoring?

- There have still been pipeline failures despite knowledge of failure modes
- Field data can improve modelling techniques
- Designs showing no susceptibility for buckling at Start of Life (SOL) may be susceptible before EOL – particularly if life extension is considered

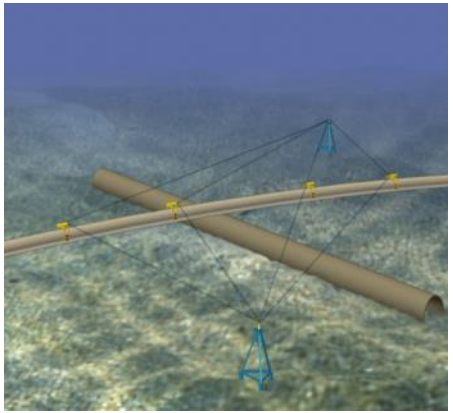
Why Should we use Near-Realtime Monitoring?

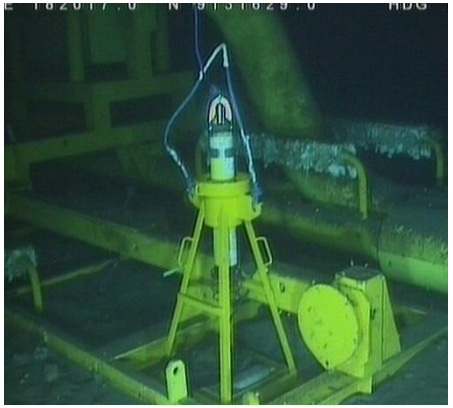
- There have still been pipeline failures despite knowledge of failure modes
- Field data can improve modelling techniques
- Designs showing no susceptibility for buckling at Start of Life (SOL) may be susceptible before EOL – particularly if life extension is considered
- Knowledge of actual behaviour allows operation optimisation - including possibility of reversing movement by changing operation parameters

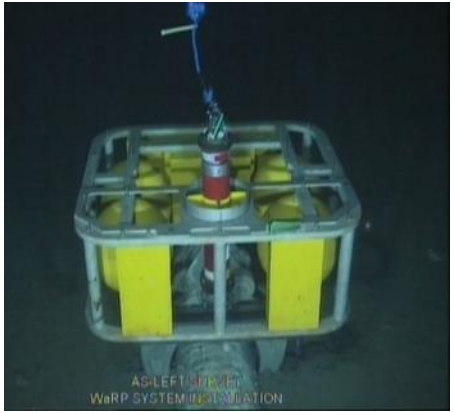
Robust Acoustic Monitoring System

High Accuracy Acoustic Ranging + Sensor Inputs

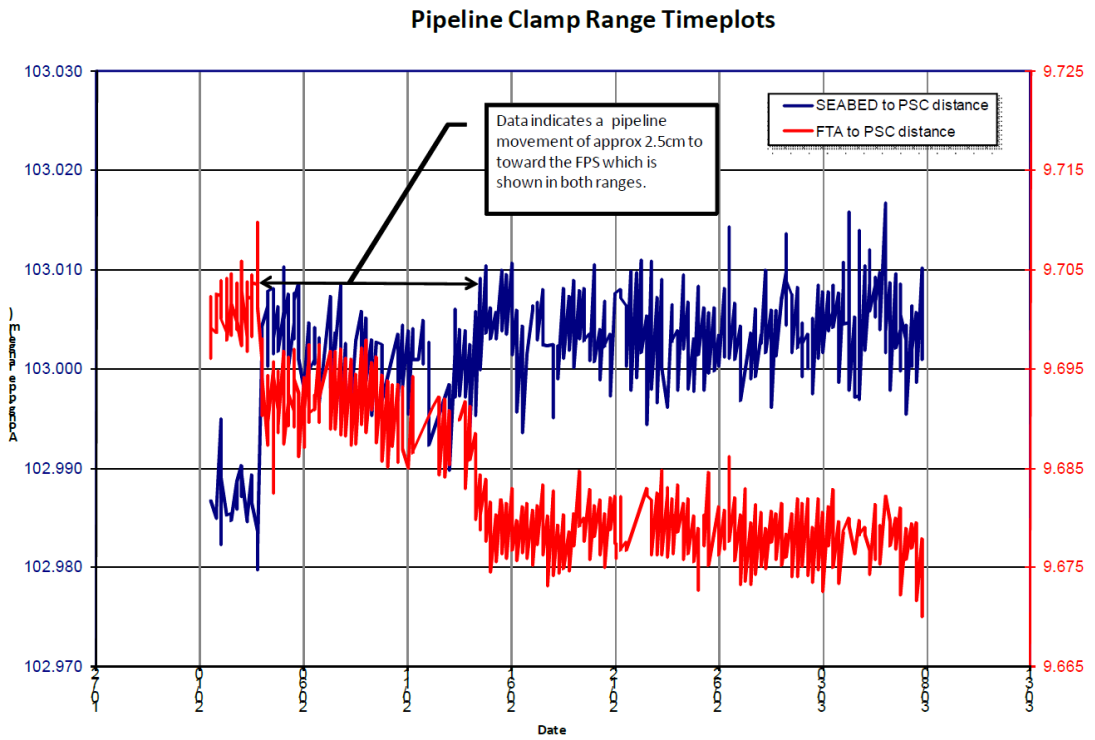
- Each unit an **Autonomous Monitoring Transponder (AMT)**
  - Two way ranging
  - High accuracy depth sensor
  - High accuracy inclination
  - Sound velocity sensor
- Create fixed reference array
- Units on suspect movement points (FTA, Flowline close to buckle initiator
- Pre-programmed data logging (autonomous)
- Each unit generates around 3 pages (1500 Bytes) of data/day for typical settings
- Typical 5 unit array (for FTA) generates 7500 Bytes/day
- Topside collection when vessel available





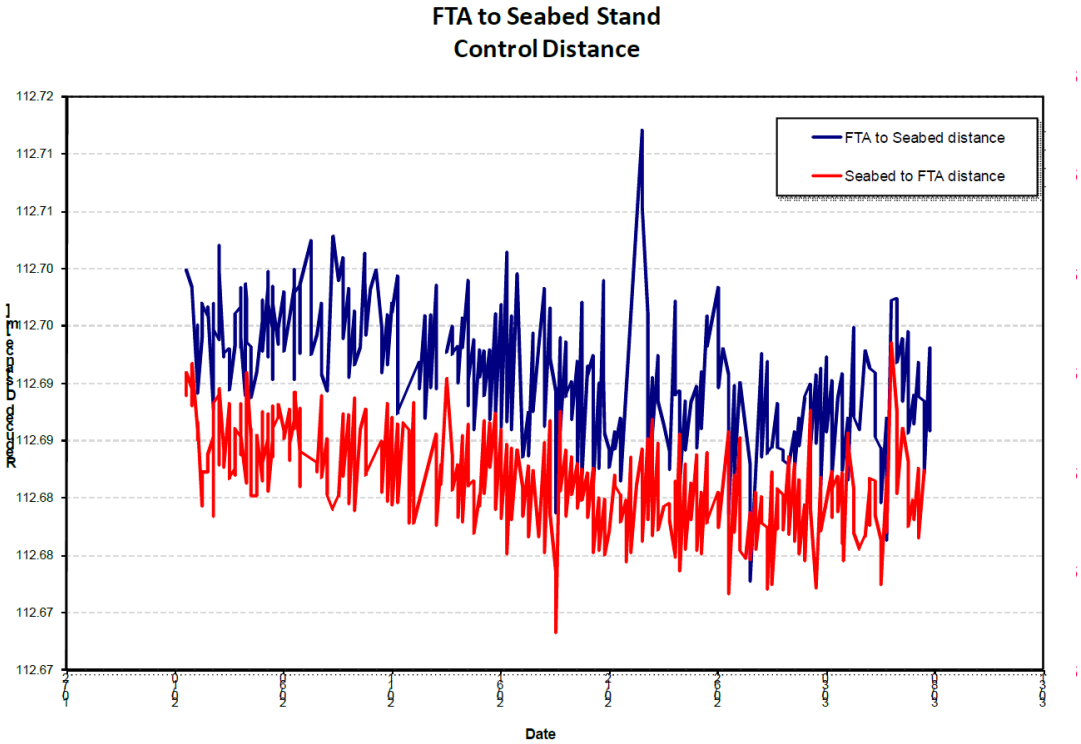


Field Data Results



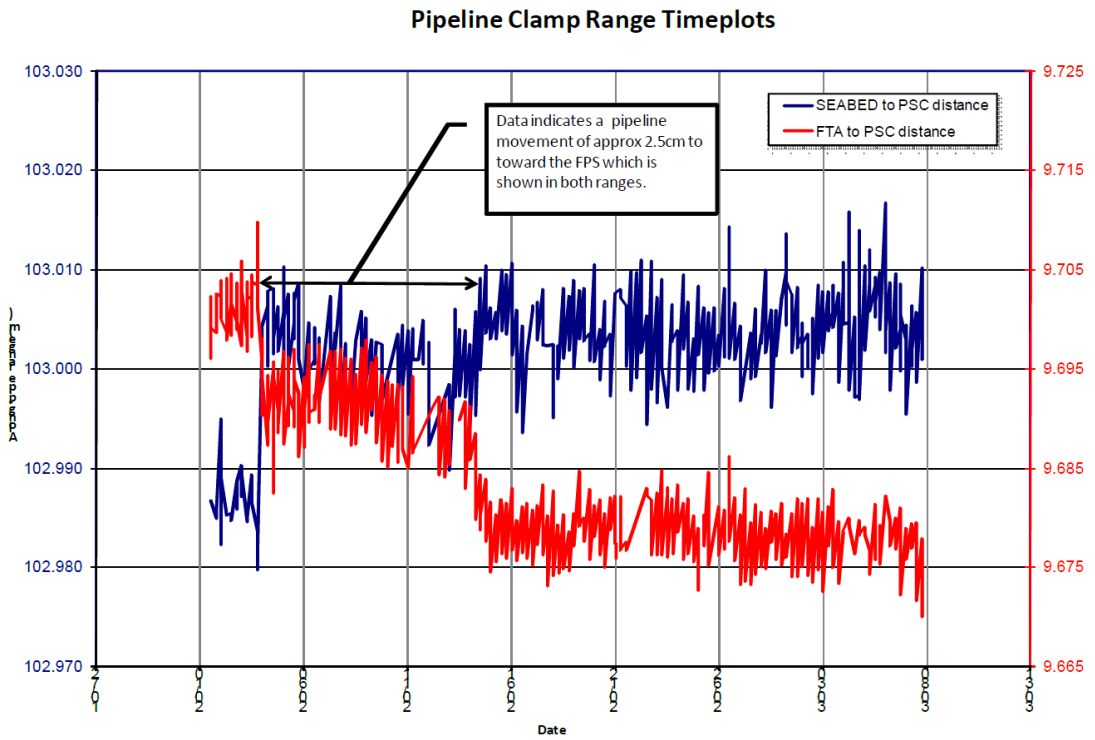
- Range and sensor data processed topside to produce movement information
- Plot shows a 25mm movement over 3 days – validated as change seen to two fixed transponders

Field Data Results



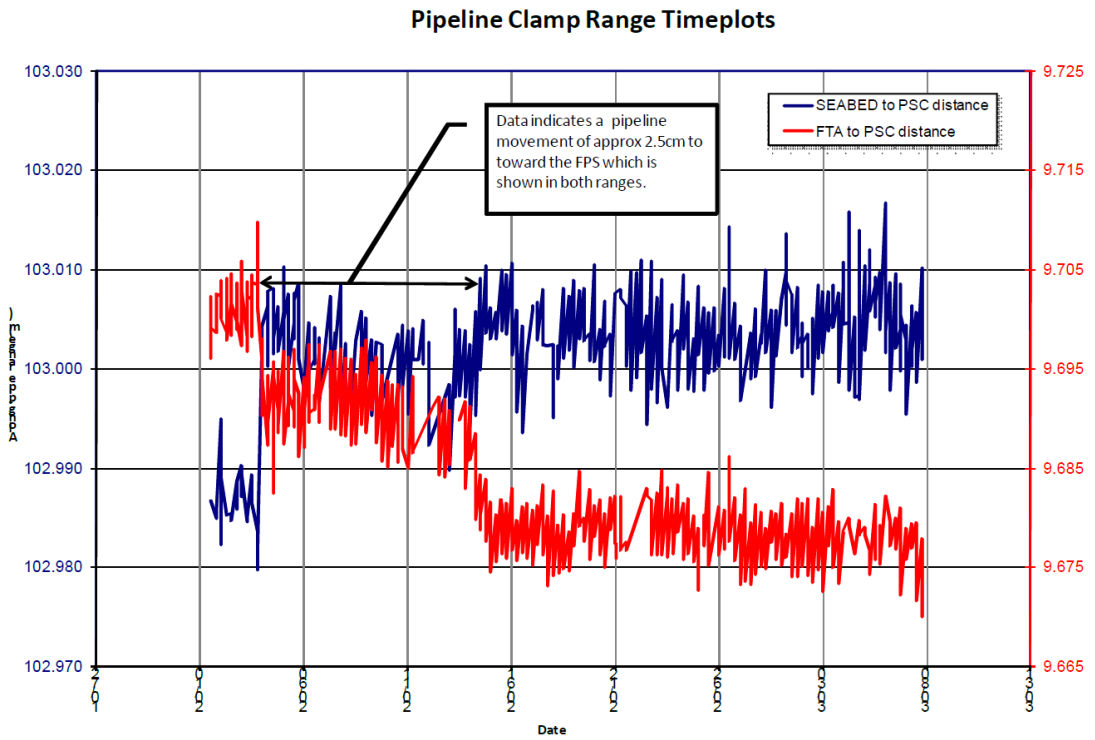
- Range and sensor data processed topside to produce movement information
- Plot shows a 25mm movement over 3 days – validated as change seen to two fixed transponders
- Compare to control distance (5mm divisions – some offset and noise but very stable

Field Data Results



- Range and sensor data processed topside to produce movement information
- Plot shows a 25mm movement over 3 days – validated as change seen to two fixed transponders
- Compare to control distance (5mm divisions – some offset and noise but very stable
- Known variations – such as tide cycle variations can be resolved and addressed in processing

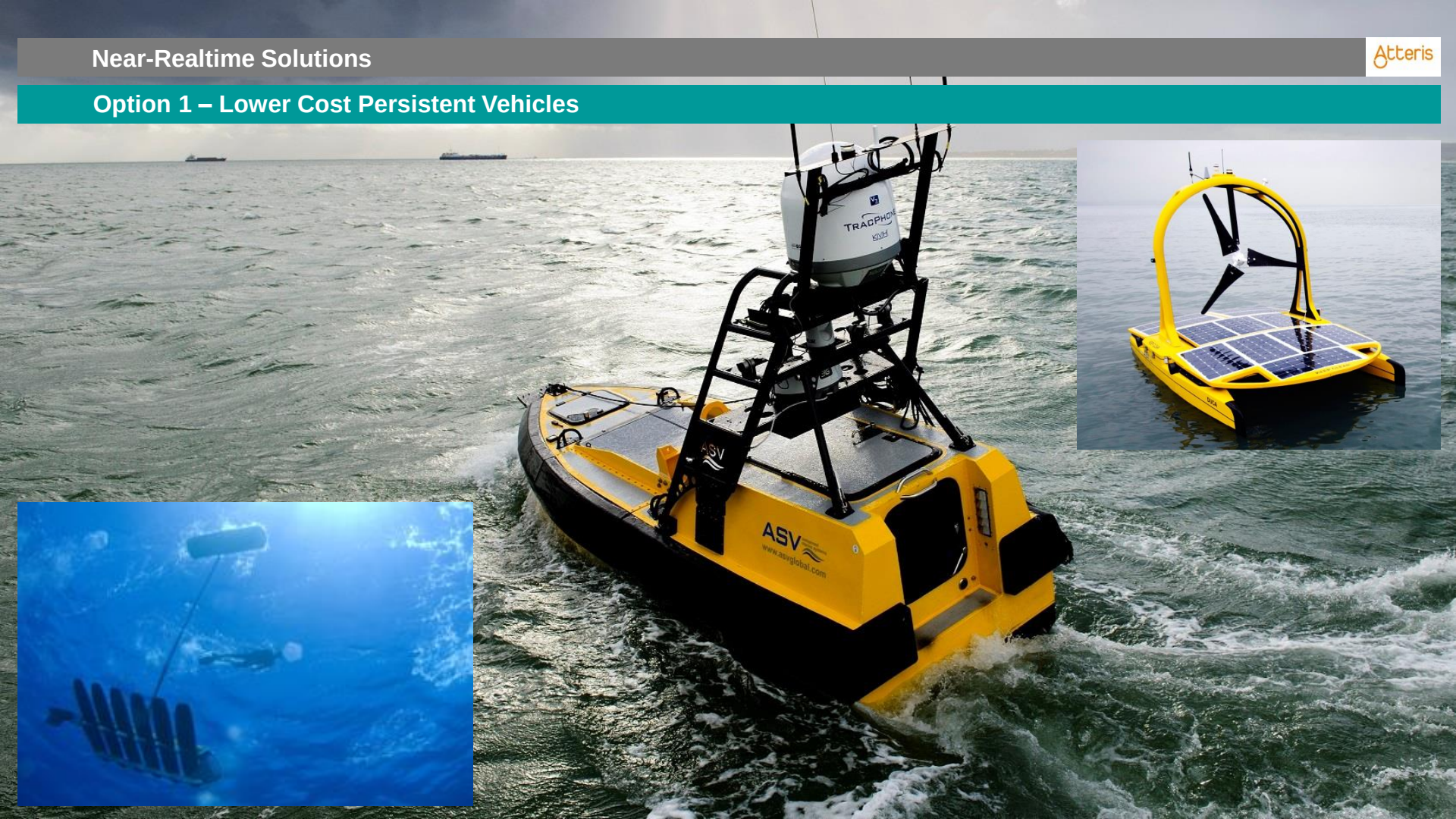
Field Data Results

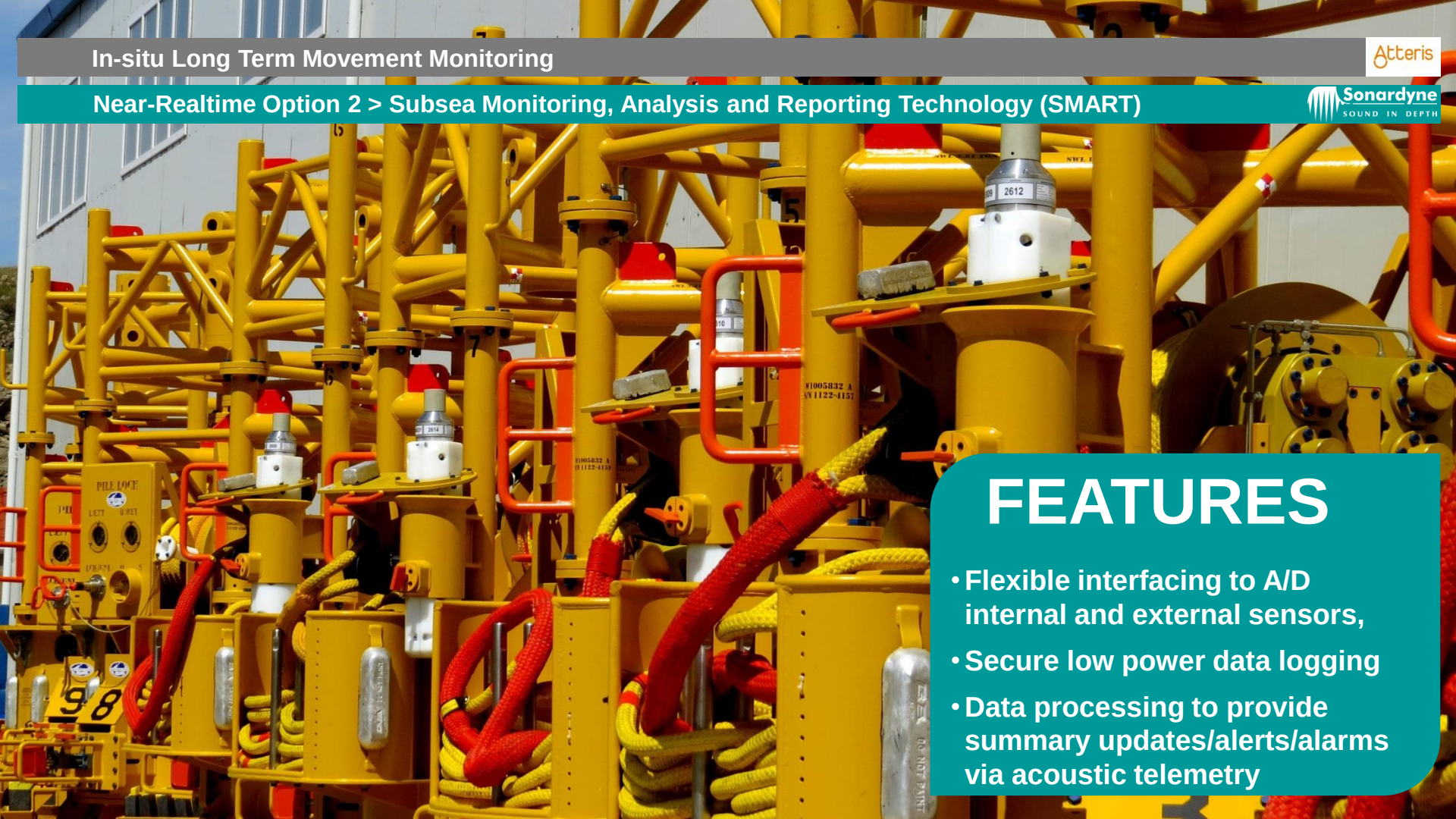


- Range and sensor data processed topside to produce movement information
- Plot shows a 25mm movement over 3 days – validated as change seen to two fixed transponders
- Compare to control distance (5mm divisions – some offset and noise but very stable
- Known variations – such as tide cycle variations can be resolved and addressed in processing

PROBLEM – Surface Vessel Required for Data Retrieval – Irregular and expensive

Option 1 – Lower Cost Persistent Vehicles





In-situ Long Term Movement Monitoring

Near-Realtime Option 2 > Subsea Monitoring, Analysis and Reporting Technology (SMART)

Atteris

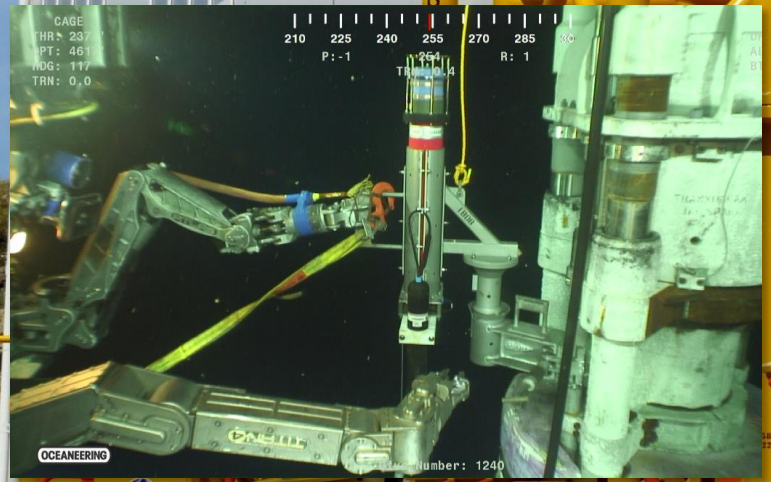
Sonardyne SOUND IN DEPTH

FEATURES

- Flexible interfacing to A/D internal and external sensors,
- Secure low power data logging
- Data processing to provide summary updates/alerts/alarms via acoustic telemetry

In-situ Long Term Movement Monitoring

Near-Realtime Option 2 > Subsea Monitoring, Analysis and Reporting Technology (SMART)

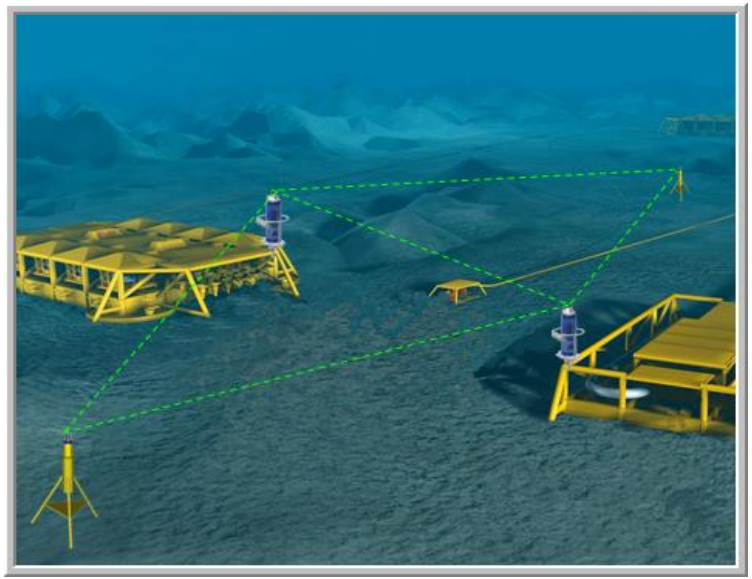


FEATURES

- Flexible interfacing to A/D internal and external sensors,
- Secure low power data logging
- Data processing to provide summary updates/alerts/alarms via acoustic telemetry

In-situ Long Term Movement Monitoring

Near-Realtime Option 2 > Subsea Monitoring, Analysis and Reporting Technology (SMART)



Data processing all done subsea by SMART unit

Typically SMART placed on movement risk point

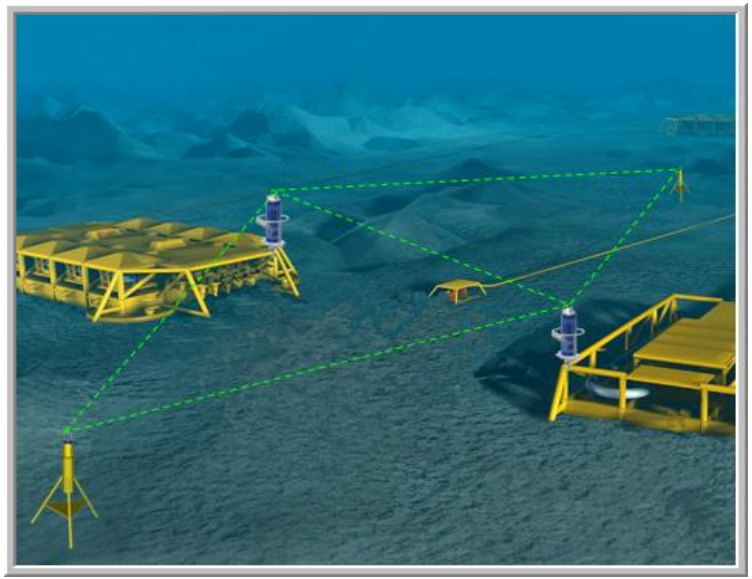
Fixed array simple Compatt (known baselines perform SV verification

3D Location (Latitude/Longitude/Depth) stored as 3 4byte packets

288 Bytes/day **25x Reduction from 7500 Bytes/day**

In-situ Long Term Movement Monitoring

Near-Realtime Option 2 > Subsea Monitoring, Analysis and Reporting Technology (SMART)



Data processing all done subsea by SMART unit

Typically SMART placed on movement risk point

Fixed array simple Compatt (known baselines perform SV verification

3D Location (Latitude/Longitude/Depth) stored as 3 4byte packets

288 Bytes/day **25x Reduction from 7500 Bytes/day**

On-board processing capability also enables movement data to be thresholded

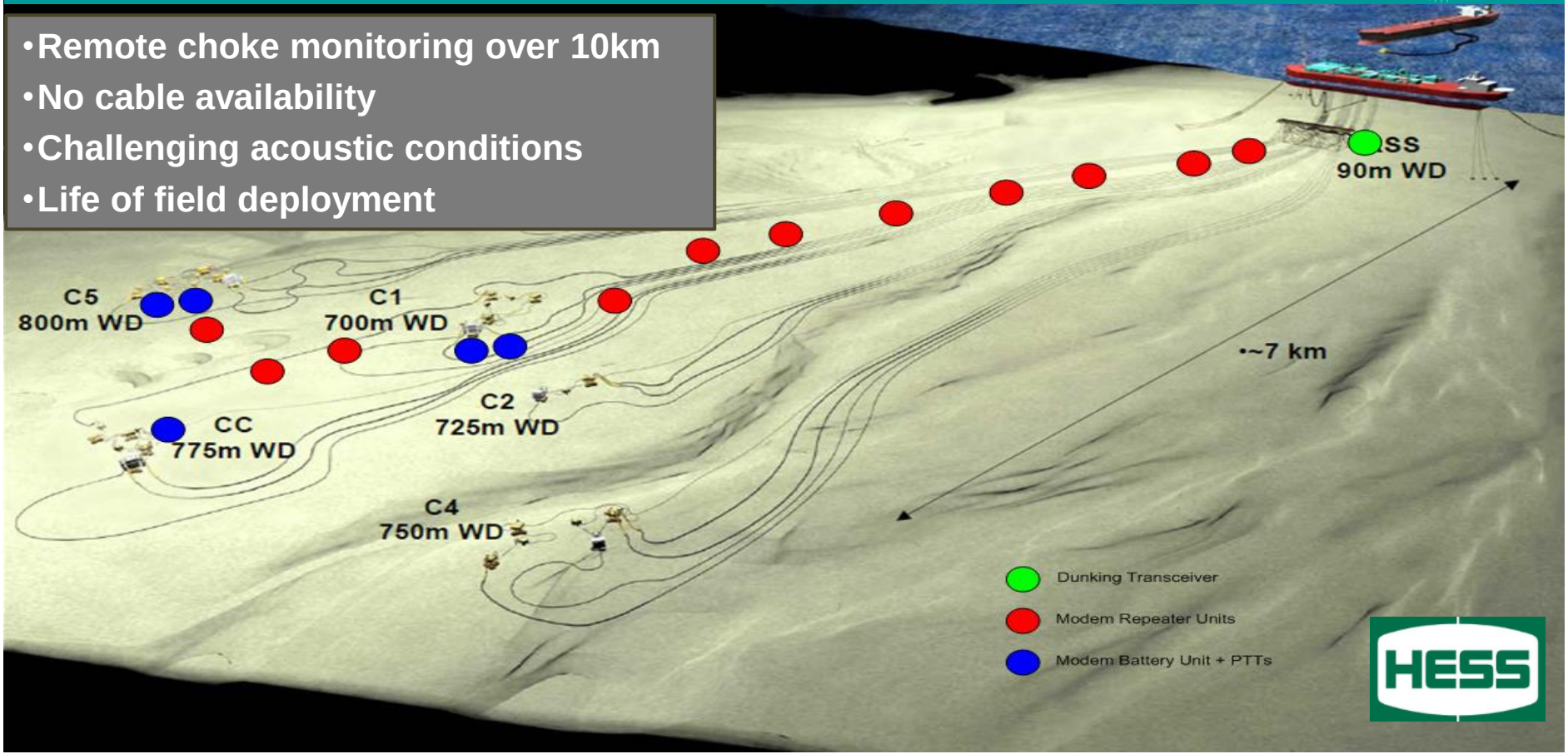
Movement < Defined Threshold = Device status Byte only to be transmitted

Data relayed to Transceiver connected at nearest field communications position

Reduced data packet means “multi-hop” relay to connection point >10km away is reasonable

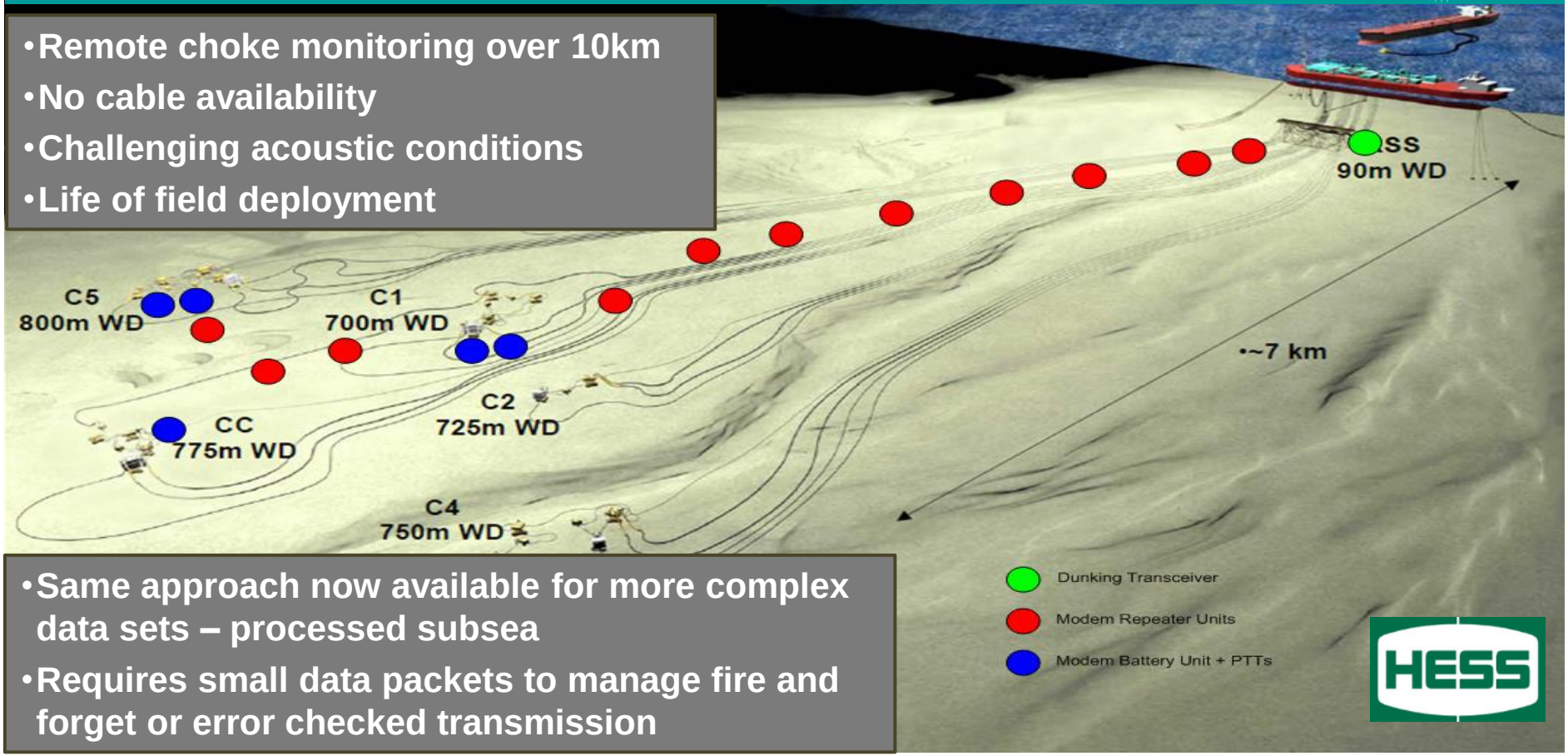
Relay Network Layout

- Remote choke monitoring over 10km
- No cable availability
- Challenging acoustic conditions
- Life of field deployment



Relay Network Layout

- Remote choke monitoring over 10km
- No cable availability
- Challenging acoustic conditions
- Life of field deployment



- Same approach now available for more complex data sets – processed subsea
- Requires small data packets to manage fire and forget or error checked transmission

Conclusions

Conclusions

Conclusions

- There is no substitute for good design!
- Tools (and accompanying experience) are available
  - Analytical Tools
  - FEA

Conclusions

- There is no substitute for good design!
- Tools (and accompanying experience) are available
  - Analytical Tools
  - FEA
- Need to account for all component contributions to buckling & walking
  - Some may have significant uncertainty

Conclusions

- There is no substitute for good design!
- Tools (and accompanying experience) are available
  - Analytical Tools
  - FEA
- Need to account for all component contributions to buckling & walking
  - Some may have significant uncertainty
- Addition of accurate position monitoring allows for validation of analysis

Conclusions

- There is no substitute for good design!
- Tools (and accompanying experience) are available
  - Analytical Tools
  - FEA
- Need to account for all component contributions to buckling & walking
  - Some may have significant uncertainty
- Addition of accurate position monitoring allows for validation of analysis and improved safety by identifying unplanned movement before catastrophic failure

Conclusions

- There is no substitute for good design!
- Tools (and accompanying experience) are available
  - Analytical Tools
  - FEA
- Need to account for all component contributions to buckling & walking
  - Some may have significant uncertainty
- Addition of accurate position monitoring allows for validation of analysis and improved safety by identifying unplanned movement before catastrophic failure
- Moving to SMART data processing allows for:
  - Lower cost system operation – through connection to existing infrastructure (“Vessel Free”)
  - Near-Realtime inputs to control systems to maximise operational efficiency
  - The possibility of tailoring operating parameters to “unwind” previous movement

Conclusions

- There is no substitute for good design!
- Tools (and accompanying experience) are available
  - Analytical Tools
  - FEA
- Need to account for all component contributions to buckling & walking
  - Some may have significant uncertainty
- Addition of accurate position monitoring allows for validation of analysis and improved safety by identifying unplanned movement before catastrophic failure
- Moving to SMART data processing allows for:
  - Lower cost system operation – through connection to existing infrastructure (“Vessel Free”)
  - Near-Realtime inputs to control systems to maximise operational efficiency
  - The possibility of tailoring operating parameters to “unwind” previous movement
- **Consideration of monitoring systems during design (or for existing) will remove uncertainty and conservatism of theoretical behaviour modelling.**
- **We have an opportunity to implement a truly evidence based behaviour model for reliable predictive modelling.**

Sonardyne
SOUND IN DEPTH

Atteris

Questions?

SUT
Society for Underwater Technology

Stephen Fasham
Global Business Manager – Sonardyne International
stephen.fasham@sonardyne.com

Derek Scales
Lead Engineer – Atteris Pty Ltd
derek.scales@atteris.com.au

Subsea Controls Down Under 2016
Enhancing Value Through Technology