ProteusDS Software Validation and Quality

ProteusDS Solver v2.18.2784

January 22, 2016

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DYNAMIC SYSTEMS ANALYSIS

Contents

1 Introduction

This document outlines the quality management principles that Dynamic Systems Analysis Ltd. (DSA) uses in the development of its software. This document also presents the software validation and testing efforts DSA undertakes as a part of its development efforts. Several key validation cases that have been completed are briefly presented along with a list of ongoing automated validation and verification tests used as an integral part of the development process.

2 Quality Assurance

DSA's software quality policy guides all software development and releases. This policy is in place to ensure that developed software is robust and meets customer needs. It provides a systematic basis for development that ensures that focuses on meeting key objectives first.

2.1 Software development quality policy

General
DSA is committed to delivering quality software to customers. Consistent customer and client satisfaction is critical to our business.

Planning
Software is developed according to plans which are developed to meet the needs of DSA's customers in a timely and effective manner.

Monitoring and controlling
Software product managers are assigned for each product; they ensure that the development software meets DSA objectives and quality policy.

Documenting requirements
All software products are documented to levels that are deemed sufficient by the software product manager; they are documented in such a way so as to allow for continual improvement of documentation and the software products.

Architectural design
All software is to be designed according to software requirements that are customer focused and clearly specified by the software product manager. Requirements should be unambiguous and possess sufficient quality to support the development of a software product.

Coding
Projects shall develop software in compliance with predefined coding standards to ensure consistency, reliability, and efficient maintenance.

Testing
Software product managers are required to ensure that sufficient software testing is performed and documented to the degree which is appropriate for the complexity and scope of the project.

Managing quality
All product managers shall plan and perform the software quality management activities required to ensure customer satisfaction and that meet DSA's general quality policy.

Managing people
Product managers are responsible for ensuring that team members are aware of their quality responsibilities and appropriately trained to perform their assigned tasks.

2.2 Version control and backup

Careful revision control is maintained on all codes using a central software repository.

DSA software and repositories are redundantly backed-up daily, both on and off site.

Version change logs are provided with all software. All key features and bug fixes are listed in the change logs.

2.3 Procedures

Software development follows a documented procedure based on industry best-practices and team experience.

Software releases follow release protocols to ensure consistent output and suitable release documentation.

2.4 Redundancy

DSA software, such as ProteusDS and ShipMo3D, are typically used by highly trained scientific and technical personnel. Maintenance of the application source code requires advanced knowledge of many areas including:

- finite-element analysis
- hydrodynamics
- robotics and mechanisms dynamics
- environmental modelling

Whenever possible, DSA source code is reviewed and developed by multiple employees to ensure that code fixes and improvements do not rely on a single person. As with many small companies, it is important to be efficient, but DSA also recognizes that customers rely on software to maintained and improved over many years.

2.5 Software validation and testing

Prior to releasing software, DSA ensures that the released version passes the tests described in the table in Appendix A on page 9. These tests ensure that every build of ProteusDS passes critical validation cases which have been developed through the course of feature development and consulting projects. These tests ensure accuracy of the software and assist in preventing software bugs due to changes in the software between releases. Verification and validation is an ongoing effort and the bank of tests is constantly refined and updated with additional tests.

An automated testing facility is used to ensure that all functionality added does not affect the software accuracy or capability, unless intended.

The DSA software development team is notified via email if internal software release candidates do not pass the validation tests.

3 Validation cases

This section provides an overview of key validation tests of the software. In many cases, validation information is published through peer reviewed conference papers or engineering journals.

3.1 Validation of low tension finite-element cable model

Early development of the nonlinear beam model used by ProteusDS were validated through physical tests completed at the University of Victoria. In a low tension condition, bending and torsion loads dominate the motion of umbilical and this is an important factor in understanding the dynamics of a remotely operated vehicle (ROV). Controlled movements of ROV umbilical cables were captured with video and used to verify the same operations reconstructed in numerical simulation [3]. Additional verification and validation work on the early developments of the cable modelling through comparison of beam deflection and tow body maneuvering are documented in [4].

- B. Buckham, M. Nahon, and G. Cote. Validation of a finite element model for slack ROV tethers. In *OCEANS 2000 MTS/IEEE Conference and Exhibition*, volume 2, pages 1129–1136 vol.2, 2000
- B. J. Buckham. *Dynamics modelling of low-tension tethers for submerged remotely operated vehicles*. PhD thesis, University of Victoria, 2003
- B. J. Buckham, F. R. Driscoll, and M. Nahon. Development of a finite element cable model for use in low tension dynamics simulation. *Journal of Applied Mechanics*, 71(4):476–485, 2004

3.2 Aquaculture mooring loads

The finite element net model is used primarily for aquaculture system analysis. Hydrodynamic loads on the nets and the resulting net deformation play a significant role in establishing the loads on the mooring structures used to keep farms on station in a range of wind, current, and wave loads. Sensors were developed to measure the dynamic tension in the mooring lines of a fish farm located in Nova Scotia, Canada. Data was obtained on the dynamic loading in hurricane conditions on two of the mooring lines in a farm and this was used to validate the results of the same system reconstructed in ProteusDS [11].

- R. S. Nicoll, D. M. Steinke, J. Attia, A. Roy, and B. J. Buckham. Simulation of a high-energy finfish aquaculture site using a finite element net model. In *Proceedings of the ASME 2011 30th international conference on ocean, offshore and arctic engineering OMAE 2011*, 2011

3.3 Wave energy converter hydrodynamic motion and power capture

Devices that capture energy from tidal currents and ocean waves are difficult to validate due to the complexity of hydrodynamic loading and mechanical system operation. In partnership with Seawood Designs, Inc., analysis was completed on a floating ocean wave energy converter with piston-cylinder power take off system. Model scale data produced from wave tank tests of an ocean wave energy converter was used to validate the same system reconstructed in ProteusDS by comparison of the motion and power capture response of the device [13].

Additional work has been carried out by the West Coast Wave Initiative using ProteusDS to validate rigid body hydrodynamics of a moored self-reacting point absorber. Tank tests were conducted and compared to ProteusDS simulations [1].

- R. S. Nicoll and C. F. Wood. Nonlinear parametric analysis of a wave energy converter. In *Proceedings of the 2010 CSME Forum, Victoria, British Columbia*, June 2010
- R. S. Nicoll, C. F. Wood, and A. R. Roy. Comparison of physical model tests with a time domain simulation model of a wave energy converter. In *Proceedings of the ASME 2012 31th international conference on offshore mechanics and arctic engineering OMAE 2012*. OMAE, July 1-6 2012
- S. Beatty, A. Roy, K. Bubbar, J. Ortiz, B. Buckham, D. Steinke, and R. Nicoll. Experimental and numerical simulations of moored self-reacting point absorber wave energy converters,. In *Proceedings of the Twenty-fifth (2015) International Ocean and Polar Engineering Conference, Kona, Big Island, Hawaii, USA, June 21-26, 2015*, 2015

3.4 Subsea pipeline repair operations

Pipeline and riser analysis is a key area of interest for analysis work completed in the oil and gas industry. Several major projects completed by DSA have incorporated validation and verification work as part of the planned project work. Due to the complexity of these systems and there operation, often validation is completed by comparison to other numerical modelling packages with varying degrees of complexity. In this particular instance, the operation to prepare a span of damanged subsea pipe for repair was analysed. The process involved lifting a subsea pipe at different locations until a specific span was ready to be cut and replaced with undamanged pipe. The focus of the analysis was to monitor the stresses in the nearby region of pipe to ensure no new damage was introduced. Verification was completed through comparison with other commercially available software packages [18].

- D. M. Steinke, R. S. Nicoll, and A. R. Roy. Real-time finite element analysis of a remotely operated pipeline repair system. In *Proceedings of the ASME 2013 32th international conference on offshore mechanics and arctic engineering OMAE 2013*. OMAE, June 2013

3.5 Rigid Body motion in a tank

Validation between test tank data of a moored surface-piercing rigid body and ProteusDS simulations was carried out as part of a blind modeling study conducted as part of OMAE 2015. Direct comparison of surge and heave time history was used to gauge accuracy amongst submissions from six teams. Excellent agreement between the surge response and good agreement with the heave response was predicted and ProteusDS results were 2nd in overall accuracy. Some disagreement in heave response was attributed to depth-dependant added mass effects that were not represented in the model.

- Roy et al. Comparison of numerical simulations with experimental measurements for the response of a modified submerged horizontal cylinder moored in waves. In *Proceedings of the ASME 2015 34th International Conference on Ocean, Offshore and Arctic Engineering*, 2015
- Garcia-Rosa. Hydrodynamic modelling competition - overview and approaches. In *Proceedings of the ASME 2015 34th International Conference on Ocean Offshore and Arctic Engineering*, St. Johns, NL, 2015

3.6 Cable ferry motions verification

A recent significant project that was completed by DSA was the dynamic analysis of a cable ferry. A frequency domain hydrodynamics analysis was completed in ShipMo3D to determine the hydrodynamic loads on the ferry hull. Time domain analysis of the ferry crossing was completed using ProteusDS and the hydrodynamic database produced by ShipMo3D. Validation of the numerical models played an extensive role in the project and a range of scale model tank tests was completed and used to verify accuracy of the ShipMo3D and ProteusDS models. ProteusDS was then used to analyse the dynamic tensions and ferry motions during crossings in a range of weather conditions. The results of the verification and design process were presented at the SNAME annual meeting in 2013 and published in SNAME transactions [19].

- D. M. Steinke, R. S. Nicoll, T. Thompson, and B. Paterson. Design methodology and numerical analysis of a cable ferry. *SNAME transactions*, 2013

3.7 Code to code comparisons - software benchmarking

The paper cited below outlines the Wave Energy Converter Code Comparison (WEC3) project and present preliminary results from this effort. The objectives of WEC3 are to verify and validate numerical modelling tools that have been developed specifically to simulate wave energy conversion devices and to inform the upcoming IEA OES Annex VI Ocean Energy Modelling Verification and Validation project. WEC3 is divided into two phases. Phase 1 consists of a code-to-code verification and Phase II entails code-to-experiment validation. WEC3 focuses on mid-fidelity codes that simulate WECs using time-domain multibody dynamics methods to model device motions and hydrodynamic coefficients to model hydrodynamic forces. Consequently, high-fidelity numerical modelling tools, such as Navier-Stokes computational fluid dynamics simulation, and simple frequency domain modelling tools were not included in the WEC3 project.

- A. Combourieu, M. Lawson, A. Babarit, K. Ruehl, A. Roy, Costello R, P. Weywada, and H. Bailey. Wec3: Wave energy converter code comparison project. In *Proceedings of the 11th European Wave and Tidal Energy Conference 6-11th Sept 2015, Nantes, France*, 2015

3.8 Full scale Frigate motion validation

The hydrodynamics analysis package ShipMo3D is used extensively by DSA to determine hydrodynamic loading on floating vessel hulls. However, while ProteusDS is developed by DSA, ShipMo3D is developed and also validated by the Canadian Navy. ShipMo3D was recently validated against measured full scale Frigate motions in the open ocean [10].

- K A McTaggart. Verification and validation of ShipMo3D ship motion predictions in the time and frequency domains. *International Journal of Naval Architecture and Ocean Engineering*, 3:86–94, 2011

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[5] B. J. Buckham, F. R. Driscoll, and M. Nahon. Development of a finite element cable model for use in low tension dynamics simulation. *Journal of Applied Mechanics*, 71(4):476–485, 2004.

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A Automated Verification and Validation Tests

As testing and validation tests mature, some tests are removed and others added to the following list. A gap in test numbering should not be interpreted as a missing test.

Test ID	Name	Test Summary	Test Details
AT000	Bridle tension distribution 1	This is a test of the bridle capability of the Cable DObject.	Three Cables are connected together in a Y configuration. The nodes of the free ends of the two-leg bridle cables are kinematically fixed in space. The two-leg bridle cables are separated by 90 degrees and are each 45 degrees from the remaining free ended cable. The remaining cable free end is subjected to a large horizontal load. The resulting tension values in each bridle leg must be equal and their magnitude can be anticipated from analytical statics. In this permutation, the bridle cable's node N is attached to the trunk cable's Node 0.
AT001	Bridle tension distribution 2	This is a permutation of the bridle capability test of the Cable DObject.	Three Cables are connected together in a Y configuration. The nodes of the free ends of the two-leg bridle cables are kinematically fixed in space. The two-leg bridle cables are separated by 90 degrees and are each 45 degrees from the remaining free ended cable. The remaining cable free end is subjected to a large horizontal load. The resulting tension values in each bridle leg must be equal and their magnitude can be anticipated from analytical statics. In this permutation, the bridle cable's node 0 is attached to the trunk cable's Node 0.
AT002	Bridle tension distribution 3	This is a permutation of the bridle capability test of the Cable DObject.	Three Cables are connected together in a Y configuration. The nodes of the free ends of the two-leg bridle cables are kinematically fixed in space. The two-leg bridle cables are separated by 90 degrees and are each 45 degrees from the remaining free ended cable. The remaining cable free end is subjected to a large horizontal load. The resulting tension values in each bridle leg must be equal and their magnitude can be anticipated from analytical statics. In this permutation, the bridle cable's node N is attached to the trunk cable's Node N.
AT003	Bridle tension distribution 4	This is a permutation of the bridle capability test of the Cable DObject.	Three Cables are connected together in a Y configuration. The nodes of the free ends of the two-leg bridle cables are kinematically fixed in space. The two-leg bridle cables are separated by 90 degrees and are each 45 degrees from the remaining free ended cable. The remaining cable free end is subjected to a large horizontal load. The resulting tension values in each bridle leg must be equal and their magnitude can be anticipated from analytical statics. In this permutation, the bridle cable's node 0 is attached to the trunk cable's Node N.
AT004	Bridle tension distribution 5	This is a permutation of the bridle capability test of the Cable DObject.	Three Cables are connected together in a Y configuration. The nodes of the free ends of the two-leg bridle cables are kinematically fixed in space. The two-leg bridle cables are separated by 90 degrees and are each 45 degrees from the remaining free ended cable. The remaining cable free end is subjected to a large horizontal load. The resulting tension values in each bridle leg must be equal and their magnitude can be anticipated from analytical statics. In this permutation, the bridle cable's node N, and the trunk cable's Node 0, are attached together using a central point mass DObject.
AT005	Bridle tension distribution 6	This is a permutation of the bridle capability test of the Cable DObject.	Three Cables are connected together in a Y configuration. The nodes of the free ends of the two-leg bridle cables are kinematically fixed in space. The two-leg bridle cables are separated by 90 degrees and are each 45 degrees from the remaining free ended cable. The remaining cable free end is subjected to a large horizontal load. The resulting tension values in each bridle leg must be equal and their magnitude can be anticipated from analytical statics. In this permutation, the bridle cable's node 0, and the trunk cable's Node 0, are attached together using a central point mass DObject.
AT006	Bridle tension distribution 7	This is a permutation of the bridle capability test of the Cable DObject.	Three Cables are connected together in a Y configuration. The nodes of the free ends of the two-leg bridle cables are kinematically fixed in space. The two-leg bridle cables are separated by 90 degrees and are each 45 degrees from the remaining free ended cable. The remaining cable free end is subjected to a large horizontal load. The resulting tension values in each bridle leg must be equal and their magnitude can be anticipated from analytical statics. In this permutation, the bridle cable's node N, and the trunk cable's Node N, are attached together using a central point mass DObject.

AT007	Bridle tension distribution 8	This is a permutation of the bridle capability test of the Cable DObject.	Three Cables are connected together in a Y configuration. The nodes of the free ends of the two-leg bridle cables are kinematically fixed in space. The two-leg bridle cables are separated by 90 degrees and are each 45 degrees from the remaining free ended cable. The remaining cable free end is subjected to a large horizontal load. The resulting tension values in each bridle leg must be equal and their magnitude can be anticipated from analytical statics. In this permutation, the bridle cable's node 0, and the trunk cable's Node N, are attached together using a central point mass DObject.
AT008	Bridle tension distribution 9	This is a permutation of the bridle capability test of the Cable DObject.	Three Cables are connected together in a Y configuration. The nodes of the free ends of the two-leg bridle cables are kinematically fixed in space. The two-leg bridle cables are separated by 90 degrees and are each 45 degrees from the remaining free ended cable. The remaining cable free end is subjected to a large horizontal load. The resulting tension values in each bridle leg must be equal and their magnitude can be anticipated from analytical statics. In this permutation, the bridle cable's node N, and the trunk cable's Node 0, are attached together using a central rigid body DObject.
AT009	Bridle tension distribution 10	This is a permutation of the bridle capability test of the Cable DObject.	Three Cables are connected together in a Y configuration. The nodes of the free ends of the two-leg bridle cables are kinematically fixed in space. The two-leg bridle cables are separated by 90 degrees and are each 45 degrees from the remaining free ended cable. The remaining cable free end is subjected to a large horizontal load. The resulting tension values in each bridle leg must be equal and their magnitude can be anticipated from analytical statics. In this permutation, the bridle cable's node 0, and the trunk cable's Node 0, are attached together using a central rigid body DObject.
AT010	Cable with RigidBody torsion pendulum 1	This is a dynamic torsional oscillation test of the Cable coupled to a RigidBody at Node 0. An analytical solution to the oscillation period is known.	A torsional oscillator is produced by coupling a Cable to a RigidBody; the torsional stiffness is provided by the Cable and the torsional inertia is provided by the RigidBody. The oscillation period of free vibration, which is the natural frequency of the system, is known from the equation of a mass spring damper that can be derived in a straightforward manner from Newtonian mechanics.
AT011	Cable with RigidBody torsion pendulum 2	This is a permutation of the dynamic torsional oscillation tests of the Cable coupled to a RigidBody at Node N. An analytical solution to the oscillation period is known.	A torsional oscillator is produced by coupling a Cable to a RigidBody; the torsional stiffness is provided by the Cable and the torsional inertia is provided by the RigidBody. The oscillation period of free vibration, which is the natural frequency of the system, is known from the equation of a mass spring damper that can be derived in a straightforward manner from Newtonian mechanics.
AT012	Cable pendulum 1	Pendulum in air with solid rod and with lumped or rigid body mass.	This gravity pendulum test verifies the physical behaviour of the cables with mass distributed in some configuration. In this permutation, a cable is fixed at one end and another free cable is attached to the other end. Both cables are given significant mass. The analytical solution for the period of oscillation in this setup is known.
AT013	Cable pendulum 2	Pendulum in air with solid rod and with lumped or rigid body mass.	This gravity pendulum test verifies the physical behaviour of the cables with mass distributed in some configuration. In this permutation, a cable is fixed at one end and another free cable is attached to the other end. Both cables have insignificant mass compared to the additional applied mass. A large ExtMass is added to the free end of the cables to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known.
AT014	Cable pendulum 3	Pendulum in air with solid rod and with lumped or rigid body mass.	This gravity pendulum test verifies the physical behaviour of the cables with mass distributed in some configuration. In this permutation, a cable is fixed at one end with a large ExtMass added to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known.
AT015	Cable pendulum 4	Pendulum in air with solid rod and with lumped or rigid body mass.	This gravity pendulum test verifies the physical behaviour of the cables with mass distributed in some configuration. In this permutation, a 2 element cable is fixed at one end with a heavy Rigid Body attached to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known.
AT016	Cable pendulum 5	Pendulum in air with solid rod and with lumped or rigid body mass.	This gravity pendulum test verifies the physical behaviour of the cables with mass distributed in some configuration. In this permutation, a 4 element cable is fixed at one end with a heavy Rigid Body attached to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known.
AT017	Cantilever beam 1	Clamped beam deflection test with applied point load	A tip load is applied to a cable in the P1 mechanical frame direction. This models a clamped beam. Both the first mode of vibration is checked as well as the tip displacement against expected results from the analytical solutions. The cable has different bending stiffnesses in either direction of the mechanical frame.
AT018	Cantilever beam 2	Clamped beam deflection test with applied point load	A tip load is applied to a cable in the P2 mechanical frame direction. This models a clamped beam. Both the first mode of vibration is checked as well as the tip displacement against expected results from the analytical solutions. The cable has different bending stiffnesses in either direction of the mechanical frame.
AT019	Net tensions 1	Net Stretch test with Edge N,j Kinematically Fixed in Space.	In these tests, the net object which lies in the X-Z plane has one edge kinematically fixed in space with a distributed load pulling on the opposite edge. In this permutation, the net edge N,j is kinematically fixed in space with a distributed load applied in the -X direction on the opposite edge. The simulated tensions in the horizontal filaments are compared with expected tensions to validate.

AT020	Net tensions 2	Net Stretch test with Edge 0,j Kinematically Fixed in Space.	In these tests, the net object which lies in the X-Z plane has one edge kinematically fixed in space with a distributed load pulling on the opposite edge. In this permutation, the net edge 0,j is kinematically fixed in space with a distributed load applied in the X direction on the opposite edge. The simulated tensions in the horizontal filaments are compared with expected tensions to validate.
AT021	Net tensions 3	Net Stretch test with Edge i,N Kinematically Fixed in Space.	In these tests, the net object which lies in the X-Z plane has one edge kinematically fixed in space with a distributed load pulling on the opposite edge. In this permutation, the net edge i,N is kinematically fixed in space with a distributed load applied in the -Z direction on the opposite edge. The simulated tensions in the horizontal filaments are compared with expected tensions to validate.
AT022	Net tensions 4	DNet Static	In these tests, the net object which lies in the X-Z plane has one edge kinematically fixed in space with a distributed load pulling on the opposite edge. In this permutation, the net edge i,0 is kinematically fixed in space with a distributed load applied in the +Z direction on the opposite edge. The simulated tensions in the horizontal filaments are compared with expected tensions to validate.
AT023	Net tensions 5	DNet Static	In these tests, the net object which lies in the X-Z plane has the nodes of an edge individually kinematically fixed in space with a distributed load pulling on the opposite edge. In this permutation, the Nodes N,0 and N,N are kinematically fixed in space with a distributed load applied in the -X direction on the opposite edge. The simulated tensions in the horizontal filaments are compared with expected tensions to validate.
AT024	Net tensions 6	DNet Static	In these tests, the net object which lies in the X-Z plane has the nodes of an edge individually kinematically fixed in space with a distributed load pulling on the opposite edge. In this permutation, the Nodes 0,0 and 0,N are kinematically fixed in space with a distributed load applied in the +X direction on the opposite edge. The simulated tensions in the horizontal filaments are compared with expected tensions to validate.
AT025	Net tensions 7	DNet Static	In these tests, the net object which lies in the X-Z plane has the nodes of an edge individually kinematically fixed in space with a distributed load pulling on the opposite edge. In this permutation, the Nodes 0,N and N,N are kinematically fixed in space with a distributed load applied in the -Z direction on the opposite edge. The simulated tensions in the horizontal filaments are compared with expected tensions to validate.
AT026	Net tensions 8	DNet Static	In these tests, the net object which lies in the X-Z plane has the nodes of an edge individually kinematically fixed in space with a distributed load pulling on the opposite edge. In this permutation, the Nodes 0,0 and N,0 are kinematically fixed in space with a distributed load applied in the +Z direction on the opposite edge. The simulated tensions in the horizontal filaments are compared with expected tensions to validate.
AT027	Net steady drag 1	Steady drag loading on a square net panel	This test compares the total horizontal drag loading applied to a square net against experimental results presented in Figure 9 of (Balash,2009). The area of the net is 1m$\hat{2}$, solidity is 0.17, and it is in a uniform 0.5m/s current.
AT028	Net steady drag 2	Steady drag loading on a square net panel	This test compares the total horizontal drag loading applied to a square net against experimental results presented in Figure 9 of (Balash,2009). The area of the net is 1m$\hat{2}$, solidity is 0.17, and it is in a uniform 1.0m/s current.
AT029	Net steady drag 3	Steady drag loading on a square net panel	This test compares the total horizontal drag loading applied to a square net against experimental results presented in Figure 9 of (Balash,2009). The area of the net is 1m$\hat{2}$, solidity is 0.17, and it is in a uniform 1.5m/s current.
AT030	Net steady drag 4	Steady drag loading on a square net panel	This test compares the total horizontal drag loading applied to a square net against experimental results presented in Figure 9 of (Balash,2009). The area of the net is 1m$\hat{2}$, solidity is 0.17, and it is in a uniform 2.0m/s current.
AT031	Net wave loading 1	A square net panel is subjected to monofrequency wave loading	This test compares the maximum total horizontal loading applied to a net against the experimental results presented in Figure 11 of (Balash,2009). The area of the net is 1m$\hat{2}$, solidity is 0.17, and it is in 0.22m, 4.91s stokes 2nd order waves.
AT032	Net wave loading 2	A square net panel is subjected to monofrequency wave loading	This test compares the maximum total horizontal loading applied to a net against the experimental results presented in Figure 11 of (Balash,2009). The area of the net is 1m$\hat{2}$, solidity is 0.17, and it is in 0.26m, 3.83s stokes 2nd order waves.
AT033	Net wave loading 3	A square net panel is subjected to monofrequency wave loading	This test compares the maximum total horizontal loading applied to a net against the experimental results presented in Figure 11 of (Balash,2009). presented in Figure 11 of (Balash,2009). The area of the net is 1m$\hat{2}$, solidity is 0.17, and it is in 0.30m, 3.21s stokes 2nd order waves.
AT034	Net wave loading 4	A square net panel is subjected to monofrequency wave loading	This test compares the maximum total horizontal loading applied to a net against the experimental results presented in Figure 11 of (Balash,2009). The area of the net is 1m$\hat{2}$, solidity is 0.17, and it is in 0.36m, 2.78s stokes 2nd order waves.
AT035	RigidBody ABA buoyant pendulum 1 (3ds)	A buoyancy pendulum is formed with an ABA configuration	This test validates the response of a buoyant pendulum formed with a sphere (MeshFeature) and two revolute joints. The redundant joints have high stiffness to emulate a solid rod so as to validate the ABA algorithm works properly over different joints in combination with different hydrodynamic models. The period of oscillation is checked against analytical expected results. The analytical equation is analogous to a regular pendulum, though in this case added mass plays an important role and augments the inertia of the system: T = 2*pi*sqrt((I + Ia)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, inertia I is about the pivot, and Ia is the added mass inertia about the pivot. More complex validation cases can be found in (Radharishnan, 2007).

AT036	RigidBody ABA buoyant pendulum 2	A buoyancy pendulum is formed with an ABA configuration	This test validates the response of a buoyant pendulum formed with a cylinder rod (PrismFeature) and a single revolute joint. This checks that the ABA algorithm works properly over different joints in combination with different hydrodynamic models. The period of oscillation is checked against analytical expected results. The analytical equation is analogous to a regular pendulum, though in this case added mass plays an important role and augments the inertia of the system: T = 2*pi*sqrt((I + Ia)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, inertia I is about the pivot, and Ia is the added mass inertia about the pivot. More complex validation cases can be found in (Radharishnan, 2007).
AT037	RigidBody ABA buoyant pendulum 3 (3ds)	A buoyancy pendulum is formed with an ABA configuration	This test validates the response of a buoyant pendulum formed with a cylinder rod (MeshFeature) and two revolute joints. The redundant joints have high stiffness to emulate a solid rod so as to validate the ABA algorithm works properly over different joints in combination with different hydrodynamic models. The period of oscillation is checked against analytical expected results. The analytical equation is analogous to a regular pendulum, though in this case added mass plays an important role and augments the inertia of the system: T = 2*pi*sqrt((I + Ia)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, inertia I is about the pivot, and Ia is the added mass inertia about the pivot. More complex validation cases can be found in (Radharishnan, 2007).
AT038	RigidBody ABA buoyant pendulum 4	A buoyancy pendulum is formed with an ABA configuration	This test validates the response of a buoyant pendulum formed with a sphere and two revolute joints. The redundant joints have high stiffness to emulate a solid rod so as to validate the ABA algorithm works properly over different joints in combination with different hydrodynamic models. The period of oscillation is checked against analytical expected results. The analytical equation is analogous to a regular pendulum, though in this case added mass plays an important role and augments the inertia of the system: T = 2*pi*sqrt((I + Ia)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, inertia I is about the pivot, and Ia is the added mass inertia about the pivot. More complex validation cases can be found in (Radharishnan, 2007).
AT039	RigidBody ABA buoyant pendulum 5 (3ds)	A buoyancy pendulum is formed with several joints in ABA configuration	This test validates the response of a buoyant pendulum formed with sphere and a single revolute joint. This test validates the response of a buoyant pendulum formed with a sphere (MeshFeature) and a single revolute joint. This checks that the ABA algorithm works properly over different joints in combination with different hydrodynamic models. The period of oscillation is checked against analytical expected results. The analytical equation is analogous to a regular pendulum, though in this case added mass plays an important role and augments the inertia of the system: T = 2*pi*sqrt((I + Ia)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, inertia I is about the pivot, and Ia is the added mass inertia about the pivot. More complex validation cases can be found in (Radharishnan, 2007).
AT040	RigidBody ABA buoyant pendulum 6 (3ds)	A buoyancy pendulum is formed with several joints in ABA configuration	This test validates the response of a buoyant pendulum formed with a sphere (MeshFeature) and universal joint. This checks the ABA algorithm works properly over different joints in combination with different hydrodynamic models. The period of oscillation is checked against analytical expected results. The analytical equation is analogous to a regular pendulum, though in this case added mass plays an important role and augments the inertia of the system: T = 2*pi*sqrt((I + Ia)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, inertia I is about the pivot, and Ia is the added mass inertia about the pivot. More complex validation cases can be found in (Radharishnan, 2007).
AT041	RigidBody ABA buoyant pendulum 7 (3ds)	A buoyancy pendulum is formed with several joints in ABA configuration	This test validates the response of a buoyant double pendulum formed with two spheres (MeshFeature) and two rod segments each with revolute joints. This checks the ABA algorithm works properly over different joints in combination with different hydrodynamic models. The response peaks of the system are compared against the vibration eigenvalues of the system in order to validate the system response.
AT042	RigidBody ABA gravity pendulum 1	A gravity pendulum is formed with several joints in ABA configuration in air	This test validates the response of a point mass (MeshFeature) gravity pendulum formed with a revolute joint and a stiff prismatic joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.
AT043	RigidBody ABA gravity pendulum 2	A gravity pendulum is formed with a single joint in ABA configuration in air	This test validates the response of a cylinder rod (PrismFeature) gravity pendulum formed with a revolute joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.
AT044	RigidBody ABA gravity cylinder pendulum 3	A gravity pendulum is formed with several joints in ABA configuration in air	This test validates the response of a cylinder gravity pendulum formed with a revolute joint and a stiff prismatic joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.
AT045	RigidBody ABA gravity pendulum 4 (3ds)	A gravity pendulum is formed with several joints in ABA configuration in air	This test validates the response of a point mass (MeshFeature) gravity pendulum formed with a revolute joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.

AT046	RigidBody ABA gravity pendulum 5 (3ds)	A gravity pendulum is formed with several joints in ABA configuration in air	This test validates the response of a point mass (MeshFeature) gravity pendulum formed with a spherical joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.
AT047	RigidBody ABA gravity pendulum 6 (3ds)	A gravity pendulum is formed with several joints in ABA configuration in air	This test validates the response of a point mass (MeshFeature) gravity pendulum formed with a universal joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.
AT048	RigidBody ABA centripedal acceleration	The centripetal acceleration of an ABA system is tested	An ABA with prismatic joint is subjected to pure rotation to check that centripetal forces are resolved correctly. A prismatic joint is used and a constant contraction force that is equal and opposite to the centripetal acceleration on the rotating mass prevents joint extension: zero joint extension velocity is maintained.
AT049	RigidBody ABA Coriolis acceleration	Coriolis acceleration on a rotating and extending joint is checked	An ABA with prismatic joint is subjected to pure rotation as well as an initial extension velocity. This checks that the Coriolis acceleration is resolved correctly.
AT050	Seabed contact 1	A cable is towed along the seabed	A zero drag and neutrally buoyant cable is towed at steady state at constant depth. A heavy ExtMass on the end of the cable contacts the seabed with friction present at the interface. The inclination angle and tension is checked against analytical expected results from the net forces acting on the mass.
AT051	Seabed contact 2	A cable is towed along the seabed	A zero drag and neutrally buoyant cable is towed at steady state at constant depth. A heavy PointMass is attached to the end of the cable and contacts the seabed with friction present at the interface. The inclination angle and tension is checked against analytical expected results from the net forces acting on the mass.
AT052	Net cable connection tension distribution test (one net)	This is a test of the tension distribution through net to cable connections	A panel net with a kinematic rigid body connected to edge 0 and cables connected to each other edge. The cable connected to edge 3 has extloads at each node and the tensions are measured throughout the net to match the extloads.
AT053	Net cable connection tension distribution test (two nets)	This is a test of the tension distribution through net to cable connections	Two net panels with a kinematic rigid body connected to edge 0 of the bottom net and edge 3 of the top net and cables connected to each other edge. The cable connected to edge 3 of the bottom net has extloads at each node and the tensions are measured throughout the top net to match the extloads.
AT059	FoilFeature lift and drag load validation	FoilFeatures are tested in a variety of orientations and positions in a steady current.	Four different foils used: two positive 30 degree attack angle (NACA 0012 and NACA 0021), one negative 30 degrees attack angle (NACA 0015), and one tangentially oriented to the current (NACA 0018). The resulting steady state lift and drag values are compared against expected values.
AT060	Seabed contact 3	A cable on a sloped seabed is tested.	A cable in water falls on to a sloped seabed. The steady state inclination angle of the cable is checked against the seabed inclination angle.
AT061	MeshFeature variable buoyancy (3ds)	A box floats on water	A 10x10x1 box with 3/8 density of water floats in still water. The Z position of the box is tracked and the mean value is compared against the expected static draft value.
AT062	Wind loading 1	A cube is subjected to wind loading and compared to analytical force results.	A 10kg 2x2x2 cube is exposed to a 10m/s air current in a zero gravity environment. This test validates the drag force experienced by the cube: Fd = 0.5*rho*V*A*Cd Where rho = fluid density, V = velocity of fluid, A = Area of surface seen by fluid, Cd = drag coefficient. This is analogous to the loading equations provided by DNV RP C205.
AT063	Added mass moment of inertia of a spherical mesh feature	Testing the added mass moment of inertia for a sphere spinning underwater	A sphere is attached with a 1DOF yaw joint at the centroid of the sphere, which is used to facilitate applying a torque. A mesh feature is applied to the sphere in order to establish the error in acceleration induced by inaccuracy in the added mass moment of inertia calculation. Since acceleration is measured, only a short simulation execution is required. Added mass moment of inertia for a sphere is expected to be approximately zero.
AT064	Submerged sphere on a cable in a current (3ds)	This is a test of the drag force capability on a spherical rigidbody.	A spherical mesh feature is provided to a RigidBody which is tethered to the ground via a Cable. A water current flows across the sphere. Under drag forces, the angle of the cable with the vertical will be nonzero as an equilibrium is reached between the vertical buoyancy/gravity force and the horizontal drag force. The steady state angle of the cable with the vertical as well as the tension in the cable are found by performing a force balance calculation (weight, buoyancy, drag, cable tension) on the RigidBody. The analytical inclination angle and tension in the cable is compared to the angle and tension from the simulation results.
AT065	ABA resistive force test 1	Nonlinear resistive force test is completed with a prismatic joint.	An ABA is constructed from two RigidBodies. One body is kinematically held in place while a constant joint actuation force is applied. The nonlinear resistive joint stiffness force ramps up to a value that is equal and opposite to the actuation force and the resulting static condition is checked.
AT066	ABA resistive force test 2	Nonlinear resistive force test is completed with a prismatic joint.	An ABA is constructed from two RigidBodies. One body is kinematically held in place while a constant negative joint actuation force is applied. The nonlinear resistive joint stiffness force ramps up to a value that is equal and opposite to the actuation force and the resulting static condition is checked.
AT067	Von Mises Stress in a beam	A 10 m long cylinder is fixed and Clamped an one end, loading in various ways, and the Von Mises stress verified	A 10 m long horizontal cylinder is fixed and clamped at one end. 3 tests are run simultaneously: 1. Axial loading only, 2. Transverse point load (bending+shear) 3. Axial+Transverse+Torsional loading simultaneously. For each test, the Von Mises stress is compared to expected analytical results.

AT068	Ochi-Shin Wind Spectrum Analysis	An Ochi-Shin wind spectrum is simulated and compared against expected.	An Ochi-Shin wind spectrum is generated with a 10m average wind speed of 10m/s and discretised using 5000 individual wind waves. The validation script performs a spectrum analysis on the wind speed at [0,0,-10m] (above water). The area under the power density distribution for the simulated wind speed is compared against the area under the analytical Ochi-Shin spectrum power density distribution that generated the 5000 waves.
AT069	Froya Wind Spectrum Analysis	An Froya wind spectrum is simulated and compared against expected.	An Froya wind spectrum is generated with a 10m average wind speed of 10m/s and discretised using 5000 individual wind waves. The validation script performs a spectrum analysis on the wind speed at [0,0,-10m] (above water). The area under the power density distribution for the simulated wind speed is compared against the area under the analytical Froya spectrum power density distribution that generated the 5000 waves.
AT070	PointMass and Cable with variable soil layer effects	Several PointMasses with varying densities fall to different depths in soil due to variation in soil reaction stiffness with depth.	Four pointmasses and two cables are dropped in to soil. The soil has 4 different stiffness layers with increasing stiffness toward the bottom. The densities of the pointmasses are set such that they fall to the halfway point of the layers: 150m, 250m, 350m, 450m. A cable is also tested to ensure that both velocity and stiffness apply in the anticipated manner.
AT071	Single Airy wave	A single airy wave is generated and checked against theoretical values.	A single Airy wave is generated. The maximum current and acceleration generated is checked against analytical values.
AT072	Wind Loading on a mesh feature 1 (3ds)	Confirming wind speeds and drags for the mesh feature with the Logarithmic Wind Profile	A cylinder shaped mesh feature aligned vertically is in air in a zero gravity environment and experiences wind loading across its axis at a 50m height. The wind is modelled using a constant wind speed and the logarithmic wind profile. The drag force acting on the mesh feature is compared to the analytical solution for constant wind at the simulated mean wind speed at 50m.
AT073	Wind Loading on a mesh feature 2 (3ds)	Confirming wind speeds and drags for the mesh feature using the Power Wind Profile	A cylinder shaped mesh feature aligned vertically is in air in a zero gravity environment and experiences wind loading across its axis at a 50m height. The wind is modelled using a constant wind speed and the power law wind profile. The drag force acting on the mesh feature is compared to the analytical solution for constant wind at the simulated mean wind speed at 50m.
AT074	Wind Loading on a mesh feature 3 (3ds)	Confirming wind speeds and drags on the NPD Wind Profile	A cylinder shaped mesh feature aligned vertically is in air in a zero gravity environment and experiences wind loading across its axis at a 50m height. The wind is modelled using a constant wind speed and the NPD wind profile. The drag force acting on the mesh feature is compared to the analytical solution for constant wind at the simulated mean wind speed at 50m.
AT075	Wind Loading on a mesh feature 4 (3ds)	Confirming wind speeds and drags on the Ochi-Shin Wind Spectrum	A cylinder shaped mesh feature aligned vertically is in air in a zero gravity environment and experiences wind loading across its axis at 50m height. The wind is modelled using the Ochi-Shin wind spectrum with a uniform wind profile. The average drag force acting on the mesh feature is compared to the analytical solution for constant wind at the simulated mean wind speed.
AT076	Wind Loading on a mesh feature 5 (3ds)	Confirming wind speeds and drags on the Froya Wind Spectrum	A cylinder shaped mesh feature aligned vertically is in air in a zero gravity environment and experiences wind loading across its axis at 50m height. The wind is modelled using the Froya/NPD wind spectrum with a uniform wind profile. The average drag force acting on the mesh feature is compared to the analytical solution for constant wind at the simulated mean wind speed.
AT082	Pierson-Moskowitz Wave Spectrum Analysis	The Pierson-Moskowitz wave spectrum is simulated and compared against expected.	The Pierson-Moskowitz wave spectrum is generated with a significant wave height of 4m, period of 8s with 1000 individual waves. The validation script performs a spectrum analysis on the ocean surface displacement at [0,0]. The area under the Power Spectral Density for the simulated wind speed is compared against the area under the analytical Pierce-Moskowitz wave spectrum power spectral density that generated the 1000 waves.
AT083	JONSWAP Wave Spectrum Analysis	An JONSWAP Wave spectrum is simulated and compared against expected.	An JONSWAP wave spectrum is generated with a significant wave height of 4m, period of 8s, a gamma of 3.3 and with 1000 individual waves. The validation script performs a spectrum analysis on the ocean surface displacement at [0,0]. The area under the Power Density Distribution for the simulated wind speed is compared against the area under the analytical JONSWAP wave spectrum power spectral density that generated the 1000 waves.
AT084	Wave Direction Spreading Function Check	An irregular sea state is simulated with a wave spread of 90 degrees. Directional spreading function results are checked against expected.	An irregular sea state is produced with 500 wave segments with a spreading of 90 degrees. A wave spreading function with a spreading function constant of 2 is used. The wave spreading function for each wave segment computed by ProteusDS is checked against the expected wave spreading function.
AT085	RigidBody gravity pendulum 1 (force constraint)	A gravity pendulum is formed with several joints using force constraints (FC) in air	This test validates the response of a point mass gravity pendulum formed with different stiff force constraint connection configurations. A lumped point mass is tested. The analytical period of oscillation is T = 2*pi*sqrt((I)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, I is inertia about the pivot, and m is the mass of the system.
AT086	RigidBody gravity pendulum 1 (force constraint)	A gravity pendulum is formed with several joints using force constraints (FC) in air	This test validates the response of a cylinder rod gravity pendulum formed with three RigidBodies and several stiff force constraint connection configurations. A lumped point mass is tested. The analytical period of oscillation is T = 2*pi*sqrt((I)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, I is inertia about the pivot, and m is the mass of the system.
AT087	RigidBody centripetal 1 (force constraint)	A RigidBody subjected to centripetal acceleration via a force constraint (FC) joint.	A base rigid body is kinematically rotated. A force constraint (FC) connection is made to a second body, which then undergoes centripetal motion. After one revolution, the position of the connected body is checked against its initial position.

AT088	GeomLib Unit Tests	The GeomLib unit test suite is executed which outputs its results to file. If any of the tests fail, a failure is reported.	The GeomLib unit test suite is executed which outputs its results to file. If any of the tests fail, a failure is reported.
AT096	Cable buoyant pendulum 1	Pendulum in water with rigid body 3DS mesh feature float.	This buoyancy pendulum test verifies the physical behaviour of the cables with mass distributed in some configuration and buoyancy loading from mesh feature. In this permutation, a 4 element cable is fixed at one end with a heavy Rigid Body attached to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known.
AT097	Cable buoyant pendulum 1	Pendulum in water with rigid body OBJ mesh feature float.	This buoyancy pendulum test verifies the physical behaviour of the cables with mass distributed in some configuration and buoyancy loading from mesh feature. In this permutation, a 4 element cable is fixed at one end with a heavy Rigid Body attached to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known.
AT098	WEC 1	An ocean Wave Energy Converter (WEC) is formed using only an ABA and compared to tank data.	A point-absorber WEC is formed using ABA components and hydrodynamic meshes. This is then subjected to Airy waves and compared with test tank data. The energy capture over 3 waves is compared to measured captured values in a wave tank.
AT099	Air gap tests on a 10 sec 1 m wave	The air gap is measured between a static rigidbody and the sea surface	A cube rigidbody is suspended in the air 2 meters off the water surface. As the wave pass underneath it, the air gap between the rigid body and the water is measured.
AT100	Morison 1	A static flexible cable cylinder is subjected to wave loading and compared to the Morison force.	This test evaluates Morison loading due to a fixed cylinder (Cable) held fixed at one end. Two cables are tested using the different hydrodynamic and surface-mesh fluid-dynamic loading modeling techniques. The Morison approximation for hydrodynamic loading has terms for acceleration and velocity. This test compares the moment acting on a slender cylinder submerged near the wave surface. An analytical expression for the moment is used for deepwater waves. The cylinder is 1m in diameter, 10m long, and is subjected to 10 second, 1m high Airy waves.
AT101	Morison 2	A static ABA cylinder is subjected to wave loading and compared to the Morison force.	This test evaluates Morison loading due to a fixed cylinder (MeshFeature 3ds file) held fixed with an ABA revolute joint. The Morison approximation for hydrodynamic loading has terms for acceleration and velocity. This test compares the moment acting on a slender cylinder submerged near the wave surface. An analytical expression for the moment is used for deepwater waves. The cylinder is 1m in diameter, 10m long, and is subjected to 10 second, 1m high Airy waves.
AT102	Morison 3	A static ABA cylinder is subjected to wave loading and compared to the Morison force.	This test evaluates Morison loading due to a fixed cylinder (PrismFeature) held fixed with an ABA revolute joint. The Morison approximation for hydrodynamic loading has terms for acceleration and velocity. This test compares the moment acting on a slender cylinder submerged near the wave surface. An analytical expression for the moment is used for deepwater waves. The cylinder is 1m in diameter, 10m long, and is subjected to 10 second, 1m high Airy waves.
AT103	Morison 4	A static ABA cylinder is subjected to wave loading and compared to the Morison force.	This test evaluates Morison loading due to a fixed cylinder (MeshFeature obj file) held fixed with an ABA revolute joint. The Morison approximation for hydrodynamic loading has terms for acceleration and velocity. This test compares the moment acting on a slender cylinder submerged near the wave surface. An analytical expression for the moment is used for deepwater waves. The cylinder is 1m in diameter, 10m long, and is subjected to 10 second, 1m high Airy waves.
AT104	Comparing Tensions from Low and Langley paper for a catenary riser	Comparing Tensions from Low and Langley paper for a catenary riser	A catenary riser was created with the same characteristics of the one in low_2006_taf. The theoretical tensions are compared at the ends of the riser NOTE: our own catenary theory still needs to be compared to the results.
AT105	RigidBody ABA buoyant pendulum 1 (obj)	A buoyancy pendulum is formed with an ABA configuration	NOTE: reference test AT035 with the use of an obj MeshFeature rather than 3ds. This test validates the response of a buoyant pendulum formed with a sphere (MeshFeature) and two revolute joints. The redundant joints have high stiffness to emulate a solid rod so as to validate the ABA algorithm works properly over different joints in combination with different hydrodynamic models. The period of oscillation is checked against analytical expected results. The analytical equation is analogous to a regular pendulum, though in this case added mass plays an important role and augments the inertia of the system: T = 2*pi*sqrt((I + Ia)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, inertia I is about the pivot, and Ia is the added mass inertia about the pivot. More complex validation cases can be found in (Radharishnan, 2007).

AT106	RigidBody ABA buoyant pendulum 3 (obj)	A buoyancy pendulum is formed with an ABA configuration	NOTE: reference test AT037 with the use of an obj MeshFeature rather than 3ds. This test validates the response of a buoyant pendulum formed with a cylinder rod (MeshFeature) and two revolute joints. The redundant joints have high stiffness to emulate a solid rod so as to validate the ABA algorithm works properly over different joints in combination with different hydrodynamic models. The period of oscillation is checked against analytical expected results. The analytical equation is analogous to a regular pendulum, though in this case added mass plays an important role and augments the inertia of the system: T = 2*pi*sqrt((I + Ia)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, inertia I is about the pivot, and Ia is the added mass inertia about the pivot. More complex validation cases can be found in (Radharishnan, 2007).
AT107	RigidBody ABA buoyant pendulum 5 (obj)	A buoyancy pendulum is formed with several joints in ABA configuration	NOTE: reference test AT039 with the use of an obj MeshFeature rather than 3ds. This test validates the response of a buoyant pendulum formed with sphere and a single revolute joint. This test validates the response of a buoyant pendulum formed with a sphere (MeshFeature) and a single revolute joint. This checks that the ABA algorithm works properly over different joints in combination with different hydrodynamic models. The period of oscillation is checked against analytical expected results. The analytical equation is analogous to a regular pendulum, though in this case added mass plays an important role and augments the inertia of the system: T = 2*pi*sqrt((I + Ia)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, inertia I is about the pivot, and Ia is the added mass inertia about the pivot. More complex validation cases can be found in (Radharishnan, 2007).
AT108	RigidBody ABA buoyant pendulum 6 (obj)	A buoyancy pendulum is formed with several joints in ABA configuration	NOTE: reference test AT040 with the use of an obj MeshFeature rather than 3ds. This test validates the response of a buoyant pendulum formed with a sphere (MeshFeature) and universal joint. This checks the ABA algorithm works properly over different joints in combination with different hydrodynamic models. The period of oscillation is checked against analytical expected results. The analytical equation is analogous to a regular pendulum, though in this case added mass plays an important role and augments the inertia of the system: T = 2*pi*sqrt((I + Ia)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, inertia I is about the pivot, and Ia is the added mass inertia about the pivot. More complex validation cases can be found in (Radharishnan, 2007).
AT109	RigidBody ABA buoyant pendulum 7 (obj)	A buoyancy pendulum is formed with several joints in ABA configuration	NOTE: reference test AT041 with the use of an obj MeshFeature rather than 3ds. This test validates the response of a buoyant double pendulum formed with two spheres (MeshFeature) and two rod segments each with revolute joints. This checks the ABA algorithm works properly over different joints in combination with different hydrodynamic models. The response peaks of the system are compared against the vibration eigenvalues of the system in order to validate the system response.
AT110	RigidBody ABA gravity pendulum 1 (obj)	A gravity pendulum is formed with several joints in ABA configuration in air	NOTE: reference test AT042 with the use of an obj MeshFeature rather than 3ds. This test validates the response of a point mass (MeshFeature) gravity pendulum formed with a revolute joint and a stiff prismatic joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.
AT111	RigidBody ABA gravity pendulum 4 (obj)	A gravity pendulum is formed with several joints in ABA configuration in air	NOTE: reference test AT045 with the use of an obj MeshFeature rather than 3ds. This test validates the response of a point mass (MeshFeature) gravity pendulum formed with a revolute joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.
AT112	RigidBody ABA gravity pendulum 5 (obj)	A gravity pendulum is formed with several joints in ABA configuration in air	NOTE: reference test AT046 with the use of an obj MeshFeature rather than 3ds. This test validates the response of a point mass (MeshFeature) gravity pendulum formed with a spherical joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.
AT113	RigidBody ABA gravity pendulum 6 (obj)	A gravity pendulum is formed with several joints in ABA configuration in air	NOTE: reference test AT047 with the use of an obj MeshFeature rather than 3ds. This test validates the response of a point mass (MeshFeature) gravity pendulum formed with a universal joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.
AT114	MeshFeature variable buoyancy (obj)	A box floats on water	NOTE: reference test AT061 with the use of an obj MeshFeature rather than 3ds. A 10x10x1 box with 3/8 density of water floats in still water. The Z position of the box is tracked and the mean value is compared against the expected static draft value.
AT115	Submerged sphere on a cable in a current (obj)	This is a test of the drag force capability on a spherical rigidbody.	NOTE: reference test AT064 with the use of an obj MeshFeature rather than 3ds. A spherical mesh feature is provided to a RigidBody which is tethered to the ground via a Cable. A water current flows across the sphere. Under drag forces, the angle of the cable with the vertical will be nonzero as an equilibrium is reached between the vertical buoyancy/gravity force and the horizontal drag force. The steady state angle of the cable with the vertical as well as the tension in the cable are found by performing a force balance calculation (weight, buoyancy, drag, cable tension) on the RigidBody. The analytical inclination angle and tension in the cable is compared to the angle and tension from the simulation results.

AT116	Wind Loading on a mesh feature 1 (obj)	Confirming wind speeds and drags for the mesh feature with the Logarithmic Wind Profile	NOTE: reference test AT072 with the use of an obj MeshFeature rather than 3ds. A cylinder shaped mesh feature aligned vertically is in air in a zero gravity environment and experiences wind loading across its axis at a 50m height. The wind is modelled using a constant wind speed and the logarithmic wind profile. The drag force acting on the mesh feature is compared to the analytical solution for constant wind at the simulated mean wind speed at 50m.
AT117	Wind Loading on a mesh feature 2 (obj)	Confirming wind speeds and drags for the mesh feature using the Power Wind Profile	NOTE: reference test AT072 with the use of an obj MeshFeature rather than 3ds. A cylinder shaped mesh feature aligned vertically is in air in a zero gravity environment and experiences wind loading across its axis at a 50m height. The wind is modelled using a constant wind speed and the power law wind profile. The drag force acting on the mesh feature is compared to the analytical solution for constant wind at the simulated mean wind speed at 50m.
AT118	Wind Loading on a mesh feature 3 (3ds)	Confirming wind speeds and drags on the NPD Wind Profile	NOTE: reference test AT074 with the use of an obj MeshFeature rather than 3ds. A cylinder shaped mesh feature aligned vertically is in air in a zero gravity environment and experiences wind loading across its axis at a 50m height. The wind is modelled using a constant wind speed and the NPD wind profile. The drag force acting on the mesh feature is compared to the analytical solution for constant wind at the simulated mean wind speed at 50m.
AT119	Wind Loading on a mesh feature 4 (obj)	Confirming wind speeds and drags on the Ochi-Shin Wind Spectrum	NOTE: reference test AT075 with the use of an obj MeshFeature rather than 3ds. A cylinder shaped mesh feature aligned vertically is in air in a zero gravity environment and experiences wind loading across its axis at 50m height. The wind is modelled using the Ochi-Shin wind spectrum with a uniform wind profile. The average drag force acting on the mesh feature is compared to the analytical solution for constant wind at the simulated mean wind speed.
AT120	Wind Loading on a mesh feature 5 (obj)	Confirming wind speeds and drags on the Froya Wind Spectrum	NOTE: reference test AT076 with the use of an obj MeshFeature rather than 3ds. A cylinder shaped mesh feature aligned vertically is in air in a zero gravity environment and experiences wind loading across its axis at 50m height. The wind is modelled using the Froya/NPD wind spectrum with a uniform wind profile. The average drag force acting on the mesh feature is compared to the analytical solution for constant wind at the simulated mean wind speed.
AT121	RigidBody ABA gravity pendulum 1 (3ds) offset CG	A gravity pendulum is formed with several joints in ABA configuration in air using offset CG	This test validates the response of a point mass (MeshFeature) gravity pendulum formed with a revolute joint and a stiff prismatic joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.
AT122	RigidBody ABA gravity pendulum 2 offset CG	A gravity pendulum is formed with a single joint in ABA configuration in air using offset CG	This test validates the response of a cylinder rod (PrismFeature) gravity pendulum formed with a revolute joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.
AT123	RigidBody ABA gravity pendulum 4 (3ds) offset CG	A gravity pendulum is formed with several joints in ABA configuration in air with offset CG	This test validates the response of a point mass (MeshFeature) gravity pendulum formed with a revolute joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.
AT124	Non-Linear Randolph Soil-Pipeline Contact Model	A 2 element cable is pushed in and out of the soil a few times. Contact forces are compared against literature.	A 2 element cable has its end nodes kinematically controlled. The cable is pushed into the soil by 1 Dia then pulled out to 0.5 Dia, then pushed back in to a penetration of 1.5 Dia, pulled out to 0.6 Dia and finally pushed back in to 1.8 Dia. The contact force is compared against that presented in [Mark Randolph, Peter Quiggin, Non-Linear Hysteretic Seabed Model for Catenary Pipeline Contact, Proceedings of the ASME 2009 28th International conference on Ocean, Offshore and Arctic Engineering]
AT125	Bowden and Leben Stick-Slip Experiment (LuGre Friction Model)	Performs the Bowden and Leben Stick-Slip experiment and compares results to the literature.	Performs the Bowden and Leben stick-slip experiment which consists of a mass on a threadmill held by a spring. This experiment is replicated with a SCable which is towed by Node 0 along X at a constant velocity. A PointMass is attached to Node N, and is initially at rest in contact with a flat floor. The friction between the floor and the pointmass is modelled using the LuGre friction model.
AT126	Soil damping test	Checks the influence of soil damping	Several point masses and rigid bodies are placed at various depths and soil penetration positions. The oscillation through time in the vertical direction is measured and the log-decrement technique is used to check the damping ratio.
AT127	Net tensions with ExtMasses	Net Stretch test with Edge 0 Kinematically Fixed in Space.	In this test, the net object which lies in the X-Z plane has one edge kinematically fixed in space with a distributed load pulling on the opposite edge. In this permutation, the net edge 0 is kinematically fixed in space with 3 distributed extmasses applied in the Z direction on the opposite edge. The simulated tensions in the horizontal filaments are compared with expected tensions to validate.
AT128	Cable pendulum using Quaternions	Pendulum in air with solid rod and with lumped or rigid body mass using Quaternions.	This gravity pendulum test verifies the physical behaviour of the cables with mass distributed in some configuration. In this permutation, a 4 element cable is fixed at one end with a heavy Rigid Body attached to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known. Quaternions are used instead of Euler Angles
AT129	Munk moment 1	Munk moment is quantified in a translating body in calm water	A rigid body with forward velocity and some yaw angle in calm water with known added mass values is checked for the correct Munk moment in yaw and pitch.
AT130	Cable variable drag and buoyancy 1	Combined wind and current loading is tested in the variable drag and buoyancy model	The variable drag model of several cables is tested. All have lengths of 50m and 1m diameter and all are neutrally are in neutrally buoyant states. Two pipes are 50% submerged and subjected to wind and current loading, with one pipe at an initial translation velocity and the resulting environmental loads are checked. The last pipe is fully submerged with a sinking velocity to check the orthogonal direction. In all cases, the resulting loads are tested against expected values.

AT131	Submerged sphere on a cable in a current	This is a test of the variable drag force capability on a cable ExtMass.	NOTE: reference test AT064 and AT115 with the use of a RigidBody MeshFeature. A sphere ExtMass is provided to a cable that is tethered to the ground via a Cable. A water current flows across the sphere. Under drag forces, the angle of the cable with the vertical will be nonzero as an equilibrium is reached between the vertical buoyancy/gravity force and the horizontal drag force. The steady state angle of the cable with the vertical as well as the tension in the cable are found by performing a force balance calculation (weight, buoyancy, drag, cable tension) on the sphere. The analytical inclination angle and tension in the cable is compared to the angle and tension from the simulation results.
AT132	Cable variable drag and buoyancy 2	Combined wind and current loading is tested in the variable drag and buoyancy model	A 2m diameter 50% submerged ExtMass sphere is subjected to water and wind loading. Net buoyancy and resulting wind and water loads are tested against expected values. Two cables with different orientations are checked to ensure the orientation of the ExtMass does not affect the results.
AT133	Linear quadratic drag	Test of speed-dependent hydrodynamic parameter coefficients is completed	Three identical rigid bodies with significantly different forward speeds are checked for the correct forcing values according to the speed-dependent hydrodynamic coefficients. The hydrodynamic coefficients should be automatically sorted by increasing speed and this is tested as well as coefficients are specified in no particular order with respect to speed.
AT134	Cable buoyant pendulum 3	Pendulum in water with ExtMass variable drag feature float.	This buoyancy pendulum test verifies the physical behaviour of the cables with an ExtMass distributed in some configuration and buoyancy loading from mesh feature. In this permutation, a 4 element cable is fixed at one end with a heavy ExtMass attached to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known.
AT135	Cable buckle 1	A slender cable is used to test the Euler buckling criterion	A 10m long, 0.1m diameter steel rod is clamped at the base with the other end free to move laterally. The euler buckling criterion indicates a critical axial load above which the system will buckle. Two cables are used with a load 2% lower and higher than the critical buckling load and both with a 10N lateral force halfway along the cable span. Both cables are checked for buckling.
AT136	Cable buoyant pendulum 4 - Variable drag / buoyancy on	A buoyancy pendulum is formed with a cable and variable drag on.	This test validates the response of a buoyant pendulum formed with a cable cylinder rod pinned about its base. Due to the low physical mass of the system a longer rod is used to test the response (50m, 1m diameter). This test uses the variable drag model. The period of oscillation is checked against analytical expected. results. The analytical equation is analogous to a regular pendulum, though in this case added mass plays an important role and augments the inertia of the system: T = 2*pi*sqrt((I + Ia)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, inertia I is about the pivot, and Ia is the added mass inertia about the pivot. More complex validation cases can be found in (Radharishnan, 2007).
AT137	Cable buoyant pendulum 5 - Variable drag / buoyancy off	A buoyancy pendulum is formed with a cable and variable buoyancy and drag off.	This test validates the response of a buoyant pendulum formed with a cable cylinder rod pinned about its base. Due to the low physical mass of the system a longer rod is used to test the response (50m, 1m diameter). This test uses the classic lumped drag model. The period of oscillation is checked against analytical expected. results. The analytical equation is analogous to a regular pendulum, though in this case added mass plays an important role and augments the inertia of the system: T = 2*pi*sqrt((I + Ia)/m/g/L) where L is the distance from the CG of the pendulum rod to the pivot, inertia I is about the pivot, and Ia is the added mass inertia about the pivot. More complex validation cases can be found in (Radharishnan, 2007).
AT138	Morison 1 with variable drag	A static flexible cable cylinder is subjected to wave loading and compared to the Morison force.	This test differs from AT100 by using the variable discrete drag algorithm. This test evaluates Morison loading due to a fixed cylinder (Cable) held fixed at one end. Two cables are tested using the different hydrodynamic and surface-mesh fluid-dynamic loading modeling techniques. The Morison approximation for hydrodynamic loading has terms for acceleration and velocity. This test compares the moment acting on a slender cylinder submerged near the wave surface. An analytical expression for the moment is used for deepwater waves. The cylinder is 1m in diameter, 10m long, and is subjected to 10 second, 1m high Airy waves.
AT139	Cable buoyant pendulum 6 - ExtCylinder	Pendulum in water with ExtCylinder variable drag and buoyancy feature float.	This buoyancy pendulum test verifies the physical behaviour of the cables with an ExtMass cylinder distributed in some configuration and buoyancy loading with a meshed feature. In this permutation, a 4 element cable is fixed at one end with a heavy ExtMass cylinder attached to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known.
AT140	DCable payout tests	Several cable model payout capabilities are tested	A Cable and SCable are both run with payout scheduling set to contract and then expand at both ends for a specific amount of time. The validation script checks to make sure the element lengths are changing the appropriate amount for constant velocity effects. Note payout thrust forces are not checked.
AT145	Time varying current test	Verifies that the water particle velocities output from ProteusDS are as expected based on the inputs.	A time varying current with 3 time stamps, and 2 depths are used to model the currents. This test checks that the time and spatial interpolation is as expected. Also tested are whether the velocity sampled outside the defined bounds of the time varying current are those of the bounds. Currents are defined at times steps of 0s, 1s and 2s, and at depths of 0m and 60m. The fluid particle velocities are sampled at 30m, and 90m at times of
AT150	Custom current profile 1	Checks custom current profile is interpolated correctly	A custom current profile is provided. The current sample points are checked to ensure interpolation between depth data points is completed correctly.

AT151	Internal pressure stress test	A 100 m long hollow pipeline is suspended by and given an internal pressure at node 0. Hydro static pressure build up along the length of the pipe. Von Mises stress at node N is compared against expected.	A 100m long hollow pipeline is modeled with a cable as having an external diameter of 0.01m and an internal diameter of 0.008m is provided an internal density of 2000kg/m$\hat{3}$ and an internal pressure of 500kPa at node 0. The pipeline hangs vertically and gravity will cause the internal pressure the pipeline to rise along its length. The only stresses experienced by node N should be due to internal pressure with a component of stress due to hoop stress and a radial component too. The Von Mises stress from the simulation is compared against expected at Node N.
AT152	Beam deflection test (clamped-clamped with self weight load)	A 50m long hollow pipe has clamped-clamped boundary conditions and is supended in shallow water. Deflection is caused by the beam weight. The maximum beam deflection at the center of the cable and pipe stresses are compared against an analytical solution.	A 50m long, straight, hollow and empty steel pipe is clamped in shallow water at both ends. The distributed load acting on it is from self weight and buoyancy. The pipe has an outer diameter of 1.22 m, inner diameter of 1.05m, density of 7778 kg/m$\hat{3}$, and flexural rigidity of 2.175e10 Nm$\hat{2}$ and an axial stiffness EA is 2.334e11. The maximum deflection at the center of the pipe, the stress at the clamped boundary and at span span, the vertical reaction load, the reaction moment, and the stress reported by the probes at the clamped boundary and half-span are all compared against analytical solution.
AT153	Internal pressure stress test	A 1 m long hollow pipeline is given an internal pressure at node 0. The stresses acting on the pipeline are assuming to be solely due to the internal pressure. The Von Mises stress in the cable is compared against expected.	A 1m long hollow pipeline is modeled with a cable as having an external diameter of 1.22m and an internal diameter of 1.05m. It is provided an internal pressure of 579 kPa at node 0. The only stresses experienced by node N are due to internal pressure with a component of stress due to hoop stress and a radial component too. The Von Mises stress from the simulation is compared against expected from thick-walled pressure vessel formulas.
AT159	Cable pendulum (SCable, Extmass)	Pendulum in air with solid rod and with lumped extmass.	This gravity pendulum test verifies the physical behaviour of the cables with mass distributed in some configuration. In this permutation, a 1 element SCable is fixed at one end with a heavy extmass attached to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known.
AT160	Cable pendulum 5 (SCable)	Pendulum in air with solid rod and with lumped or rigid body mass.	This gravity pendulum test verifies the physical behaviour of the cables with mass distributed in some configuration. In this permutation, a 1 element SCable is fixed at one end with a heavy Rigid Body attached to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known.
AT161	Single Airy wave in altered water level	A single airy wave is generated and checked against theoretical values when the water level is raised 20m.	A single Airy wave is generated. The maximum current and acceleration generated is checked against analytical values.
AT162	Single Airy wave in altered water level	A single airy wave is generated and checked against theoretical values when the water level is lowered by 20m.	A single Airy wave is generated. The maximum current and acceleration generated is checked against analytical values.
AT163	Morison 1 water elevation	A static flexible cable cylinder is subjected to wave loading and compared to the Morison force with a water level raised by 10m.	This test evaluates Morison loading due to a fixed cylinder (Cable) held fixed at one end. Two cables are tested using the different hydrodynamic and surface-mesh fluid-dynamic loading modeling techniques. The Morison approximation for hydrodynamic loading has terms for acceleration and velocity. This test compares the moment acting on a slender cylinder submerged near the wave surface. An analytical expression for the moment is used for deepwater waves. The cylinder is 1m in diameter, 10m long, and is subjected to 10 second, 1m high Airy waves.
AT164	Morison 1 water elevation	A static flexible cable cylinder is subjected to wave loading and compared to the Morison force with a water level lowered by 10m.	This test evaluates Morison loading due to a fixed cylinder (Cable) held fixed at one end. Two cables are tested using the different hydrodynamic and surface-mesh fluid-dynamic loading modeling techniques. The Morison approximation for hydrodynamic loading has terms for acceleration and velocity. This test compares the moment acting on a slender cylinder submerged near the wave surface. An analytical expression for the moment is used for deepwater waves. The cylinder is 1m in diameter, 10m long, and is subjected to 10 second, 1m high Airy waves.
AT165	Transition of water elevation and current magnitude change	Environment conditions are ramped from nonzero current and water elevation values and results compared against expected values.	A uniform current with low water elevation starts the simulation. This is ramped to a high water elevation with reversed current. The start, midpoint, and final state current, water elevation, and hydrostatic pressures are checked against expected values.
AT166	MeshFeature variable buoyancy (obj) Water Levels	A box floats on changing water level	NOTE: reference test AT061 with the use of an obj MeshFeature rather than 3ds. A 10x10x1 box with 3/8 density of water floats in still water. The Z position of the box is tracked and the mean value is compared against the expected falling draft value.
AT167	Von Mises Stress in a beam (Modulus override)	A 10 m long cylinder is fixed and Clamped an one end, loading in various ways, and the Von Mises stress verified	A 10 m long horizontal cylinder is fixed and clamped at one end. 3 tests are run simultaneously: 1. Axial loading only, 2. Transverse point load (bending+shear) 3. Axial+Transverse+Torsional loading simultaneously. For each test, the Von Mises stress is compared to expected analytical result. This test is identical to AT067, except that it has the elastic, flexural and torsional modulii modified.

AT168	RigidBody zipline	RigidBody traverses high tension cables via sliding connection.	Three cables are set up with inclination angles from the seabed of 0, 30, and 45 degrees. A rigid body is constrained to each cable by two sliding force connections, which results in a zipline effect. Two sliding connections per rigid body results in the pitch angle matching that of the slope of the cable. Friction is neglected so the acceleration is known based on the component of acceleration due to gravity down the slope. The last 50% of the data sampled is compared with known values in order to neglect any transient effects.
AT169	RigidBody cable force connection	RigidBody sticks to a cable mid-span using a force connection	A single rigid body is connected to the mid-span of a cable via force connection.
AT170	Straight tow test	Test of the DCable end node straight tow controller	An SCable with connected point mass moves with straight tow. The acceleration and velocity both have maximum limits and are enforced in this simulation.
AT171	Straight tow test	Test of the DCable end node combined straight tow and heave controller	An SCable with connected point mass moves with straight tow. The acceleration and velocity both have maximum limits and are enforced in this simulation. Heave motion is toggled after a period of time and this span of time is checked for correct oscillation period as well as amplitude.
AT172	RigidBody Simple Controller	A simple controller applies a force to keep a rigid body on station	A single rigid body in water will sink and trim nose down without any additional forces applied. The simple controller applies a pitch and heave force to keep it level and at a depth of 50m.
AT173	RigidBody cable traction controller	RigidBody uses a traction controller to prevent sliding down a cable	A single rigid body is connected to the mid-span of a 45 degree sloped cable via sliding force connection. A traction controller is used to prevent the rigid body from sliding down due to self-weight.
AT174	Sliding connection damping test	RigidBody sliding connection on a horizontal high tension cables via sliding connection. Checks lateral oscillatory behaviour of underdamped system and overdamped system.	A 1000kg rigidbody is attached midspan of a taut horizontal cable. There are two sets of cables and rigidbodies, one with an underdamped connection and one with an over damped connection. The damped frequency of oscillation of the underdamped system is compared against analytical, while the over damped system is checked to ensure there is no overshoot.
AT175	RB-DCable force connection damping test	RigidBody connected on a horizontal high tension cables via force connection. Checks oscillatory behaviour of underdamped system and overdamped system.	A 1000kg rigidbody is attached midspan of a taut horizontal cable with a Z offset of 2 m. There are two sets of cables and rigidbodies, one with an underdamped connection and one with an over damped connection. The damped frequency of oscillation of the underdamped system is compared against analytical, while the over damped system is checked to ensure there is no overshoot.
AT176	Time varying current profile	Simulation of environment with custom current profile read from current_data.dat file. Current profile changes throughout the simulation.	The 5 second simulation starts with a current profile oriented in the X-direction only. 10m/s at the surface, 5m/s at 5m and 0m/s at 0m. It transitions to having a current of 0m/s at 2.5 seconds. Next, the current transitions to a uniform current of 1m/s in the Y-direction.
AT177	RigidBody zipline with friction	RigidBody traverses high tension cables via sliding connection with friction.	Three cables are set up with inclination angles from the seabed of 0, 30, and 45 degrees. A rigid body is contrained to each cable by down sliding force connections, which results in a zipline effect. Two sliding connections per rigid body results in the pitch angle matching that of the slope of the cable. Friction on the sliding joint is incorporated and the acceleration is known based on the component of acceleration due to gravity down the slope less the expected friction load. The last half of the data sampled is compared with known values in order to neglect any transient effects.
AT178	independent hydrodynamics and aerodynamics load check	Three identical rigid bodies with cube mesh features are half submerged. One has only hydrodynamics computations, one has only aerodynamics computations and the last has both.	Three 10kg 2x2x2 cube is half exposed to a 10m/s air current and half exposed to a 1m/s water current in a zero gravity environment. One block has only hydrodynamics computations enable, the second has only aerodynamics computations enabled while the 3rd has both computations enabled. This tests checks to make sure that the switches that turn the hydrodynamics and aerodyanmics computations for the MeshFeature are functioning correctly by comparing the forces acting on the rigid bodies against analytical expect results.
AT179	Rigidbody Corilis acceleration test	The RigidBody model computes forces about its body-fixed frame with is rotating. To account for the rotating frame of reference, Coriolis forces must be accounted for to ensure Newtons 2nd law is not violated.	A rigidbody starts the simulation at the origin and is given a velocity of [1,1,1] m/s. The body is also given Euler rotation rates of 1 rad/s for each rotation axis also. This validation test verifies that after 50 seconds of simulation time, the body is located at [50,50,50] as expected.
AT180	Rigidbody Corilis acceleration test (quaternion)	The RigidBody model computes forces about its body-fixed frame with is rotating. To account for the rotating frame of reference, Coriolis forces must be accounted for to ensure Newtons 2nd law is not violated.	A rigidbody starts the simulation at the origin and is given a velocity of [1,1,1] m/s. The body is also given equivalent Euler rotation rates of 1 rad/s for each rotation axis though the body fixed frame is oriented using quaternions. This validation test verifies that after 50 seconds of simulation time, the body is located at [50,50,50] as expected.
AT181	Rigidbody base with ABA Corilis acceleration test (quaternion)	A RigidBody with coupled ABA attached is tested to ensure coriolis loads are accounted for correctly.	A rigidbody connected to another body via ABA with equal inertia properties is set in motion with constant angular velocity and no external forces applied. A second rigid body with ABA joint is also in motion with the same angular velocity but with the rigid body and ABA joint positions reversed. The time history of position of the rigid body floating base one system and the constrained body (ABA end effector) of the other system are directly compared and are expected to be identical.
AT182	RBSimpleController max force and max moment test	Checks the limit of the rbcontoller loads	A simple cylinder is half submerged. A depth controller is trying to sink it and and a pitch controller is trying to pitch the bow up. The P coefficent is such that the control force is greater than the limit imposed within each controller.

AT185	RB force connection damping test	Damping and natural frequency of rb force connection is tested.	A 1000kg rigidbody is connected to a kinematically fixed rigidbody with a force connection. There are two sets of rigidbodies, one with an underdamped connection and one with an over damped connection. The damped frequency of oscillation of the underdamped system is compared against analytical, while the over damped system is checked to ensure there is no overshoot.
AT186	RB force negative bimodal connection damping test	Damping and natural frequency of rb force connection is tested.	A 1000kg rigidbody is connected to a kinematically fixed rigidbody with a force connection. There are two sets of rigidbodies, one with an underdamped connection and one with an over damped connection. The damped frequency of oscillation of the underdamped system is compared against analytical, while the over damped system is checked to ensure there is no overshoot.
AT187	RB force positive bimodal connection damping test	Damping and natural frequency of rb force connection is tested.	A 1000kg rigidbody is connected to a kinematically fixed rigidbody with a force connection. There are two sets of rigidbodies, one with an underdamped connection and one with an over damped connection. The damped frequency of oscillation of the underdamped system is compared against analytical, while the over damped system is checked to ensure there is no overshoot.
AT190	Acceleration probe tests	Fixed probes on a rigid body that measure acceleration are tested	A rigid body has known torques, forces, and initial angular velocity such that the total acceleration at any point on the body is known. The acceleration probes are checked that they provide the correct values as expected.
AT191	Acceleration probe tests on ABA link	Fixed probes on a rigid body ABA link that measure acceleration are tested	A rigid body ABA link has known torques, forces, and initial angular velocity such that the total acceleration at any point on the body is known. The acceleration probes are checked that they provide the correct values as expected.
AT192	Acceleration probe tests on ABA link with accelerating base	Fixed probes on a rigid body ABA link that measure acceleration are tested	A rigid body ABA link has known torques, forces, and initial angular velocity such that the total acceleration at any point on the body is known. The base is floating and also accelerating. The acceleration probes are checked that they provide the correct values as expected.
AT193	Acceleration probe tests on multiple ABA links with accelerating base	Fixed probes on a rigid body ABA link that measure acceleration are tested	A rigid body ABA link has known torques, forces, and initial angular velocity such that the total acceleration at any point on the body is known. The base is floating and also accelerating. The acceleration probes are checked that they provide the correct values as expected.
AT196	RigidBody ABA centripedal acceleration 1	The centripetal acceleration of a dual link ABA system is tested	A dual prismatic link ABA system is subjected to pure rotation to check that centripetal forces are resolved correctly. A prismatic joint is used and a constant contraction force that is equal and opposite to the centripetal acceleration on the rotating mass prevents joint extension: zero joint extension velocity is maintained.
AT200	Morison 5	A static flexible cable cylinder is subjected to wave loading and compared to the Morison force.	This test differs from AT100 by wave heading of +90 degrees. This test evaluates Morison loading due to a fixed cylinder (Cable) held fixed at one end. Two cables are tested using the different hydrodynamic and surface-mesh fluid-dynamic loading modeling techniques. The Morison approximation for hydrodynamic loading has terms for acceleration and velocity. This test compares the moment acting on a slender cylinder submerged near the wave surface. An analytical expression for the moment is used for deepwater waves. The cylinder is 1m in diameter, 10m long, and is subjected to 10 second, 1m high Airy waves.
AT201	Morison 6	A static ABA cylinder is subjected to wave loading and compared to the Morison force.	This test differs from AT101 by wave heading of +90 degrees. This test evaluates Morison loading due to a fixed cylinder (MeshFeature 3ds file) held fixed with an ABA revolute joint. The Morison approximation for hydrodynamic loading has terms for acceleration and velocity. This test compares the moment acting on a slender cylinder submerged near the wave surface. An analytical expression for the moment is used for deepwater waves. The cylinder is 1m in diameter, 10m long, and is subjected to 10 second, 1m high Airy waves.
AT202	Morison 7	A static ABA cylinder is subjected to wave loading and compared to the Morison force.	This test differs from AT102 by wave heading of +90 degrees. This test evaluates Morison loading due to a fixed cylinder (PrismFeature) held fixed with an ABA revolute joint. The Morison approximation for hydrodynamic loading has terms for acceleration and velocity. This test compares the moment acting on a slender cylinder submerged near the wave surface. An analytical expression for the moment is used for deepwater waves. The cylinder is 1m in diameter, 10m long, and is subjected to 10 second, 1m high Airy waves.
AT203	Morison 8	A static ABA cylinder is subjected to wave loading and compared to the Morison force.	This test differs from AT103 by wave heading of +90 degrees. This test evaluates Morison loading due to a fixed cylinder (MeshFeature obj file) held fixed with an ABA revolute joint. The Morison approximation for hydrodynamic loading has terms for acceleration and velocity. This test compares the moment acting on a slender cylinder submerged near the wave surface. An analytical expression for the moment is used for deepwater waves. The cylinder is 1m in diameter, 10m long, and is subjected to 10 second, 1m high Airy waves.
AT204	Cable pendulum PointMass	Pendulum in air with solid rod and with lumped PointMass.	This gravity pendulum test verifies the physical behaviour of the cables with mass distributed in some configuration. In this permutation, a cable is fixed at one end with a large PointMass added to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known.

AT205	Cable pendulum PointMass	Pendulum in air with solid rod and with lumped PointMass.	This gravity pendulum test verifies the physical behaviour of the cables with mass distributed in some configuration. In this permutation, a cable is fixed at one end with a large PointMass added to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known. DIFFERENCE FROM 204: NODES O and N SWAPPED
AT206	Cable buoyant pendulum with PointMass	Pendulum in water with PointMass variable drag feature float.	This buoyancy pendulum test verifies the physical behaviour of the cables with an PointMass distributed in some configuration and buoyancy loading from mesh feature. In this permutation, a 4 element cable is fixed at one end with a heavy ExtMass attached to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known.
AT207	Cable buoyant pendulum with PointMass	Pendulum in water with PointMass variable drag feature float.	This buoyancy pendulum test verifies the physical behaviour of the cables with an PointMass distributed in some configuration and buoyancy loading from mesh feature. In this permutation, a 4 element cable is fixed at one end with a heavy ExtMass attached to the free end to model a pendulum with a massless rod. The analytical solution for the period of oscillation in this setup is known. NOTE: SAME AS 206 BUT CABLE NODES SWAPPED
AT208	RigidBody-RigidBody Force Constraint Friction 1	Force constraints are used to generate a friction moment.	In this test, rigid body 0 is kinematically fixed in place. Rigid body 1 is free to move and an external force pushes it into 0. Two RB-RB force constraints are used to hold them apart. Each of them have friction coefficients set to apply friction loads in the linear directions orthogonal to the RB-RB force constraint direction. An external moment is applied to body 1 that is below the maximum possible friction moment that could be resolved by the constraint points. As a result, body 1 has no rotation about the RB-RB force constraint axis direction in spite of the external moment application. Another body 2, also pushed into body 0, has an external moment applied that exceeds the friction moment capacity. The expected angular velocity and angular deflection based on the net moment applied to body 2 after the simulation time is completed is checked.
AT209	RigidBody-RigidBody Force Constraint Friction 2	Force constraints are used to generate a friction moment.	In this test, rigid body 0 is kinematically rotated in roll at a constant velocity. Rigid body 1 is free to move and an external force pushes it into 0. Two RB-RB force constraints are used to hold them apart. Each of them have friction coefficients set to apply friction loads in the linear directions orthogonal to the RB-RB force constraint direction. No other external forces are applied. The resulting roll friction moment ensures the roll velocity of body 1 matches body 0 in steady state.
AT210	RigidBody-RigidBody Force Constraint Friction 3	Force constraints are used to generate a friction force.	In this test, rigid body 0 is kinematically driven with a linear constant surge velocity. Rigid body 1 is free to move and an external force pushes it into 0 in heave. A single RB-RB force constraint is used to hold them apart. No other external forces are applied. Using a friction coefficient, the resulting surge velocity of body 1 reaches body 0 in steady state.
AT211	RigidBody DCableTractionController thurst and power limit test	Traction force and power limit features are checked	In this test, three rigid bodies are attached to a cable each with a sliding constraint. A constant force is applied to each body and no other forces are present. Each body has a traction controller set to resist the external force applied. One body has a traction limit in excess of the applied force, one body has a traction limit below the applied force, both of which are used to demonstrate the thrust load limit feature. The final body has a power limit set along with a forward speed that will require twice the power limit. With a power limit in place, the final body attains only attain a fraction the desired forward speed as a result.
AT212	RigidBody ShipMo3D hydrodynamic loading test 1	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT213	RigidBody ShipMo3D hydrodynamic loading test 2	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT214	RigidBody ShipMo3D hydrodynamic loading test 3	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT215	RigidBody ShipMo3D hydrodynamic and cable phase load test	The incident and diffraction load on a floating box and large connected cable are checked for coincident phase.	This test is comprised of a 20m x 20m floating box with an attached large diameter floating cable. The box and cable are subjected to loading from a long wavelength Airy wave and the motion of the cable and box are checked to ensure they are in phase.
AT216	RigidBody ShipMo3D hydrodynamic loading test 4	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT217	RigidBody ShipMo3D hydrodynamic loading test 5	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT218	RigidBody ShipMo3D hydrodynamic loading test 6	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT219	RigidBody ShipMo3D hydrodynamic and cable phase load test 2	The incident and diffraction load on a floating box and large connected cable are checked for coincident phase.	This test is comprised of a 20m x 20m floating box with an attached large diameter floating cable. The box and cable are subjected to loading from a long wavelength Airy wave and the motion of the cable and box are checked to ensure they are in phase.

AT220	Seabed contact block 1	A rigid body block on a sloped seabed is tested.	A block in water falls on to a sloped seabed. The steady state inclination angle of the block is checked against the seabed inclination angle.
AT221	Seabed contact Block 2	2 rigid body blocks on a flat surface have an extforce applied.	One will be just light enough to tip the other just heavy enough to not tip.
AT222	DCable pretension controller tests	DCable pretension controller is tested	Two cables are fixed to the water surface at both ends. For one cable, the pretension controller pays in cable at node 0 until the target tension is reached. For the other cable, the pretension controller pays out at node N until the target tension is reached. The validation script averages the last 3 seconds of cable tension at node 0 and checks to ensure that the tension is within 5% of expected
AT223	Seabed Boundary Layer Fluid Velocity Test 1	Seabed Boundary Layer is tested using default flat bathymetry	The SeabedBoudaryLayerFluidVelocity property is initialized and set to have a thickness of 10m in an environment with a water depth of 10m. The current is set as 10m/s constant in the +x direction. The SeacurrentX.dat file is compared with a calculated parabolic boundary layer approximation at two different times. The validation script ensures that the values are within 1% of expected.
AT224	Seabed Boundary Layer Fluid Velocity Test 2	Seabed Boundary Layer is tested using default custom sloped bathymetry	The SeabedBoudaryLayerFluidVelocity property is initialized and set to have a thickness of 10m in an environment with a water depth of 20m. The current is set as 10m/s constant in the +x direction. Fluid velocity probes are placed at 4 different locations. Each probe is is compared with a calculated parabolic boundary layer approximation. The validation script ensures that the values are within 1% of expected.
AT225	Seabed Boundary Layer Fluid Velocity Test 3	Seabed Boundary Layer - power law is tested using default flat bathymetry	The SeabedBoudaryLayerFluidVelocity property is initialized and set to have a thickness of 10m in an environment with a water depth of 10m. The profile 1 - power law curve is used. The current is set as 10m/s constant in the +x direction. Velocity probes are placed every 0.1m between the seabed and 2m above the seabed. The waterVelocityProbes.dat file is compared with a calculated power law boundary layer at two different times. The validation script ensures that the values are within 1% of expected.
AT226	Seabed Boundary Layer Fluid Velocity Test 4	Seabed Boundary Layer - Power law is tested using custom sloped bathymetry	The SeabedBoudaryLayerFluidVelocity property is initialized and set to have a thickness of 2m in an environment with a water depth of 10m. The profile 1 - power law curve is used. The current is set as 10m/s constant in the +x direction. Fluid velocity probes are placed at 4 different locations. Each probe is compared with a calculated power law boundary layer value. The validation script ensures that the values are within 1% of expected.
AT227	Floating base ABA Test 1 (DumbBell 1)	Dumbbell ABA test - Two 1000 kg mass 5 m apart rotates about cg of both	The base link has a mass of 1000 kg and the cg is at its body frame. The downstream joint is 5 m in X from body frame. The link is a 1000 kg mass with the cg at the body frame, the upstream joint location is at the body frame. The joint is a prismatic joint with actuation about the Z axis. The base is given a velocity of [0 -2.5 0 0 0 57.3]. The test passes if the articulated body rotates about a point half-way between both masses with zero average velocity.
AT228	Floating base ABA Test 2 (DumbBell 2)	Dumbbell ABA test - Two pairs of dumbbells, one with a massive base, one with a massive link. Tests propagation of forces and mass.	For this validation case, we compare two dumbbells, each with their masses 5m apart, and a joint that actuates prismatically in Z (i.e. unforced/unactuated). One dumbell has a massive base while the other has a massive link. The two dumbbells are mirror images of each other such that the massive link of one is in the same starting position as the massive link of the other (same with the light link/base). The dumbells are given an initial velocity such that they rotate about the massive base/link without any linear motion. The test passes if there is no linear motion of the massive base/link.
AT229	Floating base ABA Test 3 (DumbBell 3)	Two pairs of floating bases with 1 link with constant joint torque are tested with motion compared against one another.	Two pairs of floating bases and single links are mirror images of each other. For one pair, the base is massive, while in the other pair the link is massive. The joint is revolute aligned to the Z axis. A constant torque is applied to the joints and the position of the massive base of one pair and the massive link of the other pair is compared and checked for any divergence.
AT240	Munk moment 2	Munk moment is quantified in a stationary body in a current	A rigid body with zero forward velocity and some yaw angle in current with known added mass values is checked for the correct Munk moment in yaw and pitch.
AT241	Tangental Drag Test	Tangental drag is tested on a 1x1x1 moving cube in current	A rigid body with 1m/s forward velocity and in 1m/s current with zero normal drag coeffs and with a known tangental drag coeff is tested.
AT242	Hydrodynamic Feature Tangental Drag Test	Tangental drag is tested on a moving block in current	A rigid body with 1m/s forward velocity and in 1m/s current with a given hydrodynamic file.
AT243	Seabed friction tests	The coulomb friction model is tested	A box is sitting on a flat seabed and a force greater than the force of friction is applied. The friction force is calculated based on the velocity of the box. Due to the magnitude of the force, the velocity will fall within the coulomb friction zone. The calculated friction value is compared to the generated friction values.
AT244	KarnoppFrictionTest	The Karnopp friction model deadzone is tested	A box is sitting on a flat seabed and a force less than the force of friction is applied. The friction force is calculated based on the velocity of the box. Due to the magnitude of the force, the velocity will fall within the deadzone. The calculated friction value is compared to the generated friction value. The validation script takes a point at 0.4sec. The value is checked to within 15% of expected.
AT245	Coriolis Effect ABA Test 1	The coriolis effect is tested with a rigid body floating base and single link attached with a planar joint.	A planar joint with constant velocity moves with respect to a rigid body floating base that has constant angular velocity. The coriolis effect is tested by checking the absolute velocity of the link with planar joint to ensure it is constant in time with respect to the global inertial reference frame.
AT246	Coriolis Effect ABA Test 2	The coriolis effect is tested with a rigid body floating base and two links attached with a revolute and planar joint.	A planar joint with constant velocity moves with respect to a revolute link that rotates at a constant angular velocity. The revolute link is attached to a floating base with zero velocity. The coriolis effect is tested by checking the absolute velocity of the link with planar joint to ensure it is constant in time with respect to the global inertial reference frame.

AT247	Seabed Boundary Layer Fluid Velocity Test 5	Seabed Boundary Layer - Follow slope function is tested with Power law and custom sloped bathymetry	The SeabedBoudaryLayerFluidVelocity property is initialized and set to have a thickness of 2m in an environment with a water depth of 10m. The profile 1 - power law curve is used. The current is set as 10m/s constant in the +x direction. Fluid velocity probes are placed at 4 different locations. The BoudaryLayer FollowSlope is set to 1. Each probe is compared with a calculated power law boundary layer value. The validation script ensures that the values are within 1% of expected.
AT248	Cable Porosity Test 1	The buoyancy model of porous cables is tested	The buoyancy model of porous cables is tested. There are two cases tested. One is a hollow porous cable while the other is a solid porous cable. Both cables have a length of 50m and 1m diameter. Both cables should be semi-submerged to pass. The cables materials both have porosity of 50 percent, however, the cables densities differ while one is solid and the other is hollow with an internal fluid (internal fluid cannot be porous).
AT249	PointMass/PointMass connection test 1	The Pointmass/Pointmass connection force transfer is tested	A vertical cable has a pointmass hanging at the bottom node. That pointmass is connected to another pointmass that has 2 vertical cables hanging off of it. Each of the 2 bottom cables has a 10kN extmass at the bottom node.
AT250	PointMass/PointMass connection test 2	The Pointmass/Pointmass connection accelerations are tested	2 pointmasses are connected together with an initial downward velocity. The total masses and forces are added up and the resulting acceleration is compared with predicted values.
AT251	Pointmass with extmass feature	Extmass feature in a pointmass using the VDrag property	A pointmass is sitting at the surface with a density 3/4 of the surrounding water. Using an extmass feature and the VDrag property, the pointmass should rest with at a known elevation.
AT252	Extmasses in current	Extmass types are tested in uniform current	All three types of extmass are drag and buoyancy tested with and without VBuoy. Three cables each contain 4 extmasses (a sphere and cylinder with and without VBouy) and each cable reperesents a type of extmass. For types 1 and 2, the buoyancy diameter and mass in water are such that the extass is neutrally buoyant. Type 0: The extmass is defined by density and dimensions. Type 1: The extmass is defined by mass in air + water and fluid diameter (drag) Type 2: The extmass is defined by fluid diameter (drag), buoyancy diameter, and mass in water
AT255	NPD Wind Spectrum Analysis(runtime check	The NPD wind spectrum is used. No comparison completed.	The NPD wind spectrum is used. No comparison completed.
AT256	ArcPointProbe Test	The ArcPointProbe is tested and position values are compared with known initial condition	The ArcPointProbe is tested and position values are compared with known initial condition
AT259	ABA Spherical Joint 2	This test verifies that energy is conserved with a spherical joint pendulum.	A gravity pendulum is created from one kinematically constrained base rigid body and another rigid body connected by a spherical joint. 3 cases are considered, one where the pendulum pendulates in the global XZ plane, another in the YZ plane and another with a plane 45 degrees from both the YZ and XZ planes.The pendulum masses are given an initial twisting velocity about it's pendulum rod. The pendulums are allowed to pendulate and the conversion of potential energy to kinetic energy back to potential energy is verified. If always rises back to its initial height, the test passes. There are no modes of energy loss in the system.
AT260	ABA spherical joint 0	Test of relative rotation about an axis	A base rigid body is kinematically rotated at constant velocity. A second body is attached with a spherical joint. The test checks that the second body maintains vertical orientation in spite of the rotation of the base rigid body.
AT261	ABA spherical joint 1	Test of relative rotation about an axis	A base rigid body is kinematically rotated at constant velocity. A second body is attached with a spherical joint. The test checks that the second body maintains vertical orientation in spite of the rotation of the base rigid body.
AT262	ABA universal joint 0	Test of relative rotation about an axis	A base rigid body is kinematically rotated at constant velocity. A second body is attached with a universal joint. The test checks that the second body maintains vertical orientation in spite of the rotation of the base rigid body.
AT263	ABA universal joint 1	Test of relative rotation about an axis	A base rigid body is kinematically rotated at constant velocity. A second body is attached with a universal joint. The test checks that the second body rotates with the first body due to the locked universtal joint axis orientation.
AT264	ABA universal joint 2	Test of relative rotation about an axis	A base rigid body is kinematically rotated at constant 25deg/s velocity. A second body is attached with a universal joint with a 45 degree knee. This tests checks the expected maximum and minimum angular velocities expected from the 2nd output shaft in the UJoint. The UJoint equations of motion can be found here: https://en.wikipedia.org/wiki/Universal_joint
AT265	Submerged sphere on a cable in a current (Parameteric Ellipsoid)	This is a test of the drag force capability on a spherical rigidbody.	NOTE: reference test AT064 with the use of the Ellipsoid feature rather than a obj/3ds. A spherical mesh feature is provided to a RigidBody which is tethered to the ground via a Cable. A water current flows across the sphere. Under drag forces, the angle of the cable with the vertical will be nonzero as an equilibrium is reached between the vertical buoyancy/gravity force and the horizontal drag force. The steady state angle of the cable with the vertical as well as the tension in the cable are found by performing a force balance calculation (weight, buoyancy, drag, cable tension) on the RigidBody. The analytical inclination angle and tension in the cable is compared to the angle and tension from the simulation results.
AT266	Floating box test (parametric cuboid)	This is a simple test designed to ensure the proper functioning of the RigidBodys cuboid feature.	A 5x5x1 box was generated using the cuboid feature of the rigidbody. With the rigidbody in calm water, the steady state water line on the rigid body is compared against expected to ensure the proper functioning and loading of the cuboid feature.
AT267	Buoyancy, Drag and AM of an ellipsoid in a current	This is a test of the drag force capability on a ellipsoid rigidbody.	3 ellipsoids are held in place fully submerged in a uniform current with varying orientations. Buyancy, drag and added mass are compared against analytical.
AT268	Buoyancy, Drag and AM of Submerged cuboid in a current (Parameteric Ellipsoid)	This is a test of the drag force capability on a cuboid rigidbody.	3 cuboids are held in place fully submerged in a uniform current with varying orientations. Buyancy, drag and added mass are compared against analytical.

AT269	Cable end node following the sea surface using DCableEndNodeController	This is a test of the sea follower option in the DCableEndNodeController for both Node 0 and N.	2 cable are hanging in water with a Node 0 at the origin and a Node N at 5 0 0. A DCableEndNodeContoller is connected to each top node. The sea follower option is selected. A 1m - 5 second JONSWAP wave spectrum is used.The Z position of nodes are compared to the seaheight.
AT270	Foil feature PitchSlope and ChordSlope properties	This is a lift and drag test of the Pitch and Chord slope properties in the foil feature.	Two foils are created using a Pitch Slope of 4, one with a feature pitch of 30 degrees. The lift and drag are compared to calculated values. Another foil was created using a ChordSlope of 5 and a feature pitch of 30 degrees. The lift and drag are again compared to calculated values.
AT271	Towed body test	Towed body with super controllers	An arbitrary towed body with 3 control surfaces is towed and a depth and yaw are set in the super controller After 50s, the depth and yaw are checked. The control surfaces are a tail, port, and starboard foil.
AT275	Turbine feature coefficients based on hub vel (mode 4)	The turbine feature's coefficients are based on hub velocity instead of TSR for modelling blades with high speed power shedding	The thrust and torque coefficients are defined as a function of hub velocity rather than TSR. The turbine is exposed to a 5m/s current. The turbine's TSR is checked against prescribed and the torque and thrust loads output are compared against expected.
AT276	Turbine feature scheduling mode verification	Verifies that turbine feature's scheduling functionality is able to control the state of the turbine as expected.	The turbine feature is placed in ScheduleMode while in mode 3. The rotor TSR is prescribed when ON and when in FW. The turbine is placed in on, off and FW modes at various point during the simulation. The Turbine's behaviour and output are checked against expected.
AT279	Pipe boundary reaction force test	Roarks formula tested on pinned pipe	A HDPE water filled pipe is pinned on both ends and left to hang under its own weight. The reaction loads on the boundary nodes are compared against the formula for a uniformly distributed loaded pipe based on the formulas found in Roarks formulas for stress and strain.
AT280	Axial thermal expansion stress and strain	This verifies axial stress and strain from thermal stress in cables and pipes.	Two clamped cables are in the air and in the water. With known air and water temperature, expected internal tension (compression) is verified. A third cable with one end free changes its length and resulting strain is computed though without any internal stress.
AT281	Axial thermal expansion stress and strain from internal flow	This verifies axial stress and strain from thermal stress induced by internal flow in pipes.	Temperature distribution.
AT282	Loading of 90 degree elbows	This verifies the deflections of the tip of a 90 degree elbow clamped at one end and a tip load at the other.	Two 90 degree elbows are tested. Each is clamped at node 0 and free at node N. A tip load of 1000N in X and a 1000N in Z is applied at Node N. One elbow has a large radius of curvature in comparison with its diameter, which straight beam equations can approximate well. The other is a small elbow whose radius of curvature is small compared to its diameter. The analytical solutions for these two cases were taken from Roarks Formulas for Stress and Strain. The deflection of the tips are compared against expected.
AT283	Precurved pipe with normal loading perpendicular to curvature plane	This test verifies the center deflection of a clamped-clamped curved pipe under self-weight loading with a horizontal pipe curvature plane.	This test comes from Roarks Formulas for stress and strain. An S shaped steel pipe whose curvature plane is horizontal made up of two 45 degree elbows with parallel entrance and exit tangents is clamped at both ends. The pipe is filled with water.
AT284	Precurved 90 elbows with internal flow and nozzle at exit	This test verifies the tip deflection of a long and stubby 90 degree elbows with internal flow	This test comes from Roarks Formulas for stress and strain. The two 90 degree elbows from AT282 have had their horizontal tip loads removed and are subjected to internal flow loads instead. The pipe has a large internal diameter for most of its length and a small internal diameter at the tip to create a nozzle. The idea is to have low flow velocity through the pipe to remove distributed loads from momentum flux due to curvature while creating a jet at the tip that creates a thrust forces equal to those in AT282. Displacement is compared against expected.
AT285	Axial expansion strain from hydrostatic pressure	This verifies axial stress and strain from hydrostatic pressure on cables and pipes.	Two sets of a horizontal cable and pipe are located deep underwater. One set has both ends clamped and the other set has one end clamped and one end free. Pressure is not applied on the end faces. Analytical results for axial compression stress (for clamped-clamped) and strain expansion (for clamped-free) due to Poisson ratio from radial and circumferential stresses are compared with actual simulation values.
AT289	AOA on foil feature based turbines	This verifies that the angles of attack on the blades of foil feature based turbines are as expected.	Three permutations of the same turbine are run. The first turbine spins clockwise, the second spins counter clockwise with the blades mirrored. The 3rd turbine is the same as the first except the blades have the root at the tip and vice versa. Basically the foil feature frame is upside down. The turbine have an angular velocity of 60rpm. The AOA of the blades should match the blade pitch angles since there is no flow.
AT290	AOA on foil feature based turbines	This verifies that the angles of attack on the blades of foil feature based turbines are as expected.	Three permutations of the same turbine are run. The first turbine spins clockwise, the second spins counter clockwise with the blades mirrored. The 3rd turbine is the same as the first except the blades have the root at the tip and vice versa. Basically the foil feature frame is upside down. The turbine have an angular velocity of 60rpm. The AOA of the blades should match the blade pitch angles since there is no flow.
AT291	Cable boundary node kinematic control	Verifies the kinematic control of a cable boundary nodes	Both boundary nodes of a cable are kinematically constrained with a constant linear velocity. Node 0: 1m/s +x and Node N: 1m/s -x.
AT300	Stokes 2nd order wave test	Checks that Stokes 2nd order waves are functioning correctly.	A deep water wave is generated in the Stokes 2nd order region (see Figure 3.2 in DNV RP C205 (2010)). The wave height, pressure, velocity and acceleration is compared against Airy waves and ensure that the difference between the two is as expected. The peaks for all 6 signals (velocity and acceleration have 2 components) are checked to ensure Stokes waves have higher peaks where expected and lower peaks where expected.

AT301	Stokes 5th order wave test	Checks that Stokes 5th order waves are functioning correctly.	A deep water wave is generated in the Stokes 5th order region (see Figure 3.2 in DNV RP C205 (2010)). The wave height, pressure, velocity and acceleration is compared against Airy waves and ensure that the difference between the two is as expected. The peaks for all 6 signals (velocity and acceleration have 2 components) are checked to ensure Stokes waves have higher peaks where expected and lower peaks where expected.
AT310	Soil loading option test	Checks the effect of toggling soil loads on feature meshes	A set of identical cuboids and custom meshes are located at the seabed. One rigid body with cuboid and another with a custom mesh have soil contact dynamics loading turned off and this verifies the behavior.
AT311	Axial turbine feature test 0	Thrust and torque values from turbine features are verified	A rigid body with an axial flow turbine feature is set in a current with known speed. The thrust and torque are verified. Flow orthogonal to the turbine axis is also checked.
AT312	Cross flow turbine feature test	Thrust and torque values from turbine features are verified	A rigid body with an cross flow turbine feature is set in a current with known speed. The thrust and torque are verified. Flow orthogonal to the turbine axis is also checked.
AT313	Axial turbine feature with ABA rotor	Thrust and torque values from a turbine feature are verified	A rigid body with an ABA rotor that has a turbine feature is set in a current with known speed and offset heading. The thrust and torque are verified.
AT314	Cross flow turbine feature test with ABA rotor	Thrust and torque values from a turbine feature are verified with dynamic rotor	A rigid body with an ABA rotor with cross flow turbine feature is set in a current with known speed and offset heading. The thrust and torque are verified.
AT315	Turbine feature in Kinematic ABA mode	Torque from turbine is transmitted to base ABA Kinematicly controlled joint	A turbine feature is attached to a rotor. The rotor is attached to a static base via a revolute joint that is kinematically controlled to spin at a constant 360 deg/s rate. The fluid has a uniform flow of 0.5 along the turbine and joint's axis of rotation.
AT316	foil based turbine in Kinematic ABA mode	Torque from turbine is transmitted to base via kinematically controlled joint.	A foil based turbine is attached to a stator via a kinematically controlled ABA joint spinning at 360 deg/s. The turbine is exposed to a uniform current of 0.5m/s travelling along the turbine's axis of rotation. The simulated joint torque and thrust loads imparted onto the stator are compared against analytical solution.
AT317	Turbine feature in Kinematic ABA mode	2 Turbines, 1 pointing towards the flow, the other yawed 180 degrees from the first. Torque and thrust loads on stator are compared against expected.	Both turbine features are attached to their own rotor. Each rotor is attached to the stator via a kinematically controlled revolute joint spinning at 360 deg/s. One of the turbines is rotated 180 degrees away from the flow thus the turbines will be counter rotating due to the commanded RPM. The torque loads should cancel each other. The thrust loads should add.
AT318	foil based turbine in Kinematic ABA mode (prescribed TSR)	Turbine RPM controlled based on prescribed TSR.	A Turbine feature is attached to a rotor which is connected to the stator via a kinematically controlled revolute joint. The Turbine controls the rotor revolute joint speed based on a prescribed TSR variation with axial flow speed.
AT320	Cuboid, Cylinder, Ellipsoid feature variable drag	Comparison of prism and full combined loading results	The variable drag model of several fundamental loading features is tested. A cylinder, cuboid, and ellipsoid that is 50% submerged are tested with the simple prism drag model and with the full simplified hydrodynamics model mode. The prism drag model can only be used with cylinders and applies wind or current drag loading and the results verify this behavior.
AT321	Moving Cuboid, Cylinder, Ellipsoid feature variable drag	Comparison of prism and full combined loading results	The variable drag model of several fundamental loading features is tested. A cylinder, cuboid, and ellipsoid that is 50% submerged are tested with the simple prism drag model and with the full simplified hydrodynamics model mode. The prism drag model can only be used with cylinders and applies wind or current drag loading and the results verify this behavior.
AT325	Wave spectrum surface verification 0	Reconstructed sea state properties are verified	Surface displacement and velocities are checked to ensure expected values given sea state and heading. Results are also verified with PostPDS.
AT326	Wave spectrum surface verification 1	Reconstructed sea state properties are verified	Surface displacement and velocities are checked to ensure expected values given sea state and heading. Results are also verified with PostPDS.
AT327	Wave spectrum surface verification 2	Reconstructed sea state properties are verified	Surface displacement and velocities are checked to ensure expected values given sea state and heading. Results are also verified with PostPDS.
AT328	Wave spectrum surface verification 3	Reconstructed sea state properties are verified	Surface displacement and velocities are checked to ensure expected values given sea state and heading. Results are also verified with PostPDS.
AT329	Airy wave surface verification 0	Reconstructed sea state properties are verified	Surface displacement and velocities are checked to ensure expected values given sea state and heading. Results are also verified with PostPDS.
AT330	Airy wave surface verification 1	Reconstructed sea state properties are verified	Surface displacement and velocities are checked to ensure expected values given sea state and heading. Results are also verified with PostPDS.
AT331	airy wave surface verification 2	Reconstructed sea state properties are verified	Surface displacement and velocities are checked to ensure expected values given sea state and heading. Results are also verified with PostPDS.
AT332	airy wave surface verification 3	Reconstructed sea state properties are verified	Surface displacement and velocities are checked to ensure expected values given sea state and heading. Results are also verified with PostPDS.
AT333	Wind heading verification 0	Reconstructed wind state heading is verified	Mean wind heading is verified.
AT334	Wind heading verification 1	Reconstructed wind state heading is verified	Mean wind heading is verified.
AT335	Wind heading verification 2	Reconstructed wind state heading is verified	Mean wind heading is verified.
AT336	Wind heading verification 3	Reconstructed wind state heading is verified	Mean wind heading is verified.
AT337	Wind spectrum heading verification 0	Reconstructed wind state heading is verified	Mean wind heading of Froya/NPD wind spectrum is verified.
AT338	Wind spectrum heading verification 1	Reconstructed wind state heading is verified	Mean wind heading of Froya/NPD wind spectrum is verified.
AT339	Wind spectrum heading verification 2	Reconstructed wind state heading is verified	Mean wind heading of Froya/NPD wind spectrum is verified.
AT340	Wind spectrum heading verification 3	Reconstructed wind state heading is verified	Mean wind heading of Froya/NPD wind spectrum is verified.

AT341	Water current heading verification 0	Water current heading is verified	Water current heading is verified.
AT342	Water current heading verification 1	Water current heading is verified	Water current heading is verified.
AT343	Water current heading verification 2	Water current heading is verified	Water current heading is verified.
AT344	Water current heading verification 3	Water current heading is verified	Water current heading is verified.
AT345	Custom wave segments surface verification 0	Reconstructed sea state properties are verified	Surface displacement and velocities are checked to ensure expected values given sea state and heading. Results are also verified with PostPDS.
AT346	Custom wave segments surface verification 1	Reconstructed sea state properties are verified	Surface displacement and velocities are checked to ensure expected values given sea state and heading. Results are also verified with PostPDS.
AT347	Custom wave segments surface verification 2	Reconstructed sea state properties are verified	Surface displacement and velocities are checked to ensure expected values given sea state and heading. Results are also verified with PostPDS.
AT348	Custom wave segments surface verification 3	Reconstructed sea state properties are verified	Surface displacement and velocities are checked to ensure expected values given sea state and heading. Results are also verified with PostPDS.
AT349	Polar Circle Strain Test	Polar circle (hollow pipe) stretched in X by opposite point loads half circle apart.	A 100 m circumference (approx. 31m diameter) polar circle made of hollow HDPE pipe has two opposite point loads applied a half circle away on the polar circle. The circle is streched in X by the load. The max deflection of the polar circle in X is compared against analytical from Roarks Formulas for Stress and Strain. The analytical solution assumes the pipe is not pre-stressed, however due to the concept of superposition, this is not an issue. Validation test passes if deflection is less than 10% from expected.
AT350	Axial flow turbine feature test (constant speed/TSR)	Three identical turbines with identical thrust and torque values are simulated. One has rotor inertia and has constant speed control via ABA controller. One has no inertia and is constant speed while the last one has no inertia and is under constant TSR control.	A rigid body with 2 axial flow turbine features and an ABA rotor with an axial flow turbine feature is set in a slowly oscillating current of known speed and heading. One turbine is in mode 1 (constant RPM), one is in mode 2 (constant TSR) and the 3rd is in mode 0 (ABA controlled). All 3 turbines are subjected to the same flow. The turbine rpm, TSR and power output are compared against expect for all three turbines.
AT355	ABA Hydrodynamic Loading	Drag load and moment from a sphere on revolute joint is verified.	A revolute joint with 10m moment arm is revolving into a steady current. The drag force, moment, and revolute acceleration is verified.
AT360	Traction controller and clamped tension probe test 1	Traction controller used to pull on node N of a cable	A Traction controller is used to pull on node N of a cable with a clamped tension probe placed at node N. The tensions measured by the probe and cable are compared to the set value of 1kN. The loads on the traction controller are also compared to the set value.
AT361	Traction controller and clamped tension probe test 2	Traction controller used to pull on node 0 of a cable	A Traction controller is used to pull on node 0 of a cable with a clamped tension probe placed at node 0. The tensions measured by the probe and cable are compared to the set value of 1kN. The loads on the traction controller are also compared to the set value.
AT362	Sliding and Clamped Tension Probe test	Sliding and clamped tension probe placed on a moving cable	A sliding and clamped tension probe are placed 5m along a hanging heavy cable. The cable is paid out at 0.5m/s and after 5 seconds, the clamped tension probe should have the same tension and the sliding tension probe should see an additional 2.5m worth of cable tension.
AT366	Hydrodynamic model with offset CG orientation test	CG offset geven to a hydrodynamic model and the orientation is tested	A barge hydrodynamic model was created in ShipMo3D and submerged 20m below the water surface. The rigid body CG and hydrodynamic frame are offset by 10m in the x and y direction from the rigid body frame. At the barge rose in the water column the roll, pitch, and yaw were monitored. The barge should not change orientation and the results are compared to 0 degrees.
AT370	Cable Reynolds number hydrodynamics 0	Drag loads on cables with no Reynolds number dependence is tested for reference	A 0.1m diameter pipe in a range of water current and wind velocities at the start of a simulation is checked against expected values given a constant drag coefficient.
AT371	Cable Reynolds number hydrodynamics 1	Drag loads on cables with variable drag and no Reynolds number dependence is tested for reference	A 0.1m diameter pipe with variable drag in a range of water current and wind velocities at the start of a simulation is checked against expected values given a constant drag coefficient.
AT373	Pipe Reynolds number hydrodynamics 2	The effect of drag coefficient variation with Reynolds number is verified	A 0.1m diameter pipe in a range of water current and wind velocities at the start of a simulation is checked against expected values given Reynolds number variation of drag coefficient.
AT374	Pipe Reynolds number hydrodynamics 3	The effect of variable drag with drag coefficient variation with Reynolds number is verified	A 0.1m diameter pipe with variable drag activated in a range of water current and wind velocities at the start of a simulation is checked against expected values given Reynolds number variation of drag coefficient.
AT375	Pipe seabed proximity hydrodynamics 0	Lift effect from pipeline proximity to seabed is confirmed	A 0.1m diameter pipe adjacent to a seabed in a uniform current is used to verify expected lift forces at the start of the simulation.

AT376	Sliding connection brake mode verification test	The functionality of the 3 sliding connection brake modes is verified using 5 individual tests.	For each of the 5 test cases in this test, a 20 m horizontal cable is pinned (static) at both ends. The cable end nodes span from [-10m,0m,0m] to [10m,0m,0m]. Four 2mx2mx0.2m boxes with masses of 410 kg, are all floating at steady state at the origin. The 3 boxes are connected to their cable by a sliding connection. The boxes have external loads applied to them or in the 4th case have an initial velocity. For the first case, the box has an axial load of 410 N applied in the cable tangent direction. The brake mode for the sliding connection is set to 1 while the max brake load is set to 1000N. This box is checked that it does not move and that the average brake force applied matches the expected environmental load. For the second case, the box is identical to the first except that an axial load of 1300N is applied in the cable tangent direction. The max brake load is exceeded, causing the box to accelerate. The box is not expected to hold its position. The friction load applied is expected to max out at 1000N. For the 3rd case, the box is identical to the first except Brake Mode 2 is used. Regardless, the brake will match whatever the environmental load is. The brake force should average about 410 N, and the box is not expected to move. For the 4th case, the box buoyancy forces are disabled, and thus the cable is applying a load on the box equal to the boxes weight. The friction load is mu = 0.1 times the weight (Friction 410N). A force of 300N is trying to move the box. The box shouldn't move. The test verifies that the box has not moved and that the friction force applied is equal to 300N. The 5th case is identical to the 4th case except the load applied tot he box is greater than the max friction force (410N) hence the box is expected to move. the test checks that the box has moved and that the friction force applied is equal to 410N.
AT377	Polar Circle curvatures test	The shape and curvature of 3 different meshed and different sized polar circles are checekd	3 polar circles are made. 1) 5m diameter with 10 elements 2) 30m diameter with 20 elements 3) 50m diameter with 30 elements The curvature magnitudes along each cable are tested against the mean. The Frenet tangents at node 0 and N are compared Finally, the curvature vectors are complared at Node 0 and the Node midway along the span (directly across)
AT378	Linear ABA joint end stop test	Endstop property tested using a prismatic ABA connection	The final position of the piston will be 2m beyond endstop due to the external force of 10e3N applied and endstop stiffness of 5e3N
AT379	Revolute ABA joint end stop test	Endstop property tested using a revolving ABA connection	The final position of the piston will be 45 degrees beyond endstop (45 degrees)due to the external moment of 10e3N applied and endstop stiffness of 222.2N/m
AT380	Addition and removal of extmasses	An extmass is added and removed from nodes 0 and N	4 10m long cables are initialized. A 5kN wet weight is added at nodes 0 and N as well as removed. The test validates the change in tensions witnessed by the cable. There should be a 5kN change in tension for each cable be it a decrease or increase.
AT381	Addition and removal of extmass cylinders	An extmass is added and removed from nodes 0 and N	4 10m long cables are initialized. A 5kN wet weight is added at nodes 0 and N as well as removed. The test validates the change in tensions witnessed by the cable. There should be a 5kN change in tension for each cable be it a decrease or increase.
AT382	cylindrical extmasses in current	Two cylindrical extmasses exposed to 1m/s current to test normal and tangential drag	Two cylindrical extmasses are on two different cables. Once is oriented such that it will experience soley normal drag forces and the other tangential drag forces. The drag forces measured is compared to expected calculated values
AT383	Cable segment property Warnings	Cable segment property warnings are tested to ensure they are provided to the user and correct.	Two 30m long cables are used with multiple segment properties defined along its length. One cable pays out at Node 0, the other at Node N. Cable element definitions assigned by ProteusDS are checked to ensure their functionality matches expected. The warning messages provided by ProteusDS during Init and during Remesh about clipped off cable segment properties are checked to ensure their functionality matches expected.
AT384	Tensioner connection verification test	The functionality of the tensioner connection is tested by checking the tension in a cable on either side of the tensioner.	An unstretched horizontal 40m cable is pinned at both end. Gravity is off. A RigidBody is placed in the middle of the cable and attached to the cable using a tensioner connection with a commanded tension of 1000N. The tension on one side of the tensioner is checked to ensure tension is 1000N while the tension on the other side should be 0N.
AT385	Cable tension controller test	The functionality of the DCableTensionController is tested	A cable has a DCableTensionController on one end and a RB on the other. The RB is controlled with an external sinusoidal force of 1kN. The controller will pay out and pay in quick enough such that the tension in the cable remains 0.
AT390	RigidBody ABA kinematic revolute joints	Tests of revolute joints in kinematic mode	A floating base with two serial revolute connected rigid links is used to check the effect of kinematic mode. Several instances of the configuration are checked by confirming the expected angular acceleration based on an arbitrary known applied force at the tip of the system. In addition, tests of a kinematic joint with constant velocity and applied joint forces are checked.
AT391	RigidBody ABA kinematic prismatic joints	Tests of prismatic joints in kinematic mode	A floating base with two serial prismatic connected rigid links is used to check the effect of kinematic mode. Several instances of the configuration are checked by confirming the expected angular acceleration based on an arbitrary known applied force at the tip of the system. In addition, tests of a kinematic joint with constant velocity and applied joint forces are checked.
AT392	RigidBody ABA gravity pendulum 1 - kinematic	A gravity pendulum is formed with several joints in ABA configuration in air with some joints kinematic	This test validates the response of a point mass gravity pendulum formed with a revolute joint and a kinematic prismatic joint. The vibration period is checked against the analytical expected response period T = 2*pi*sqrt((I)/m/g/L), where L is the distance from the CG of the pendulum rod to the pivot, I is the inertia about the pivot, and m is the mass of the system.
AT400	RigidBody relative velocity probe check	The RigidBody relative velocity probe is tested for correct functioning	A RigidBody is placed halfway down a water column with a current velocity of 2.5m/s at that depth (shear current). The probe is positioned offset from the RB CG. The RB is given a linear velocity of 1m/s in the direction of the current and an angular rate which give the probe an instantaneous y velocity component. The probe reported relative fluid velocity is compared against expected.

AT401	Wind Driven Current verification 1	Environmental water velocity probe check of Wind Driven Current output	A set of 10 water velocity probes are placed along the water column to measure the water particle velocity. The environment is provided a uniform water current of 1m/s with a heading of -30Deg and a uniform wind speed of 7.5 m/s at a heading of 45Deg. The final water particle velocities from all 10 probes are compared against expected from water current and wind driven current. There are no waves in this test.
AT402	Wind Driven Current verification 2	Environmental water velocity probe check of Wind Driven Current output in waves	A set of 10 water velocity probes are placed along the water column to measure the water particle velocity. The environment is provided a uniform water current of 1m/s with a heading of -30Deg and a uniform wind speed of 7.5 m/s at a heading of 45Deg. The final water particle velocities from all 10 probes are compared against expected from water current and wind driven current. A single 8s-2m Airy wave travelling North is present in this validation case.
AT403	Custom Wave Spectrum 1	Checks the functioning of the custom wave spectrum as an input	A custom wave spectrum is supplied to PDS which was manually computed from a JONSWAP spectrum. The spectrum is recreated using ProteusDS JONSWAP wave spectrum. The resulting spectrum plots (power versus frequency) are compared to ensure a match.
AT404	Custom wave segments and spectrum input via file	This test ensures that custom wave segments and custom wave spectrum can be loaded via input file.	Two wave features are created, one is using custom wave segments defined via input file, the other is using custom wave spectrum also defined via input file. There are 4 custom waves being generated and the custom wave spectrum is reconstructed using 40 wave segments. The seastate should thus have a total of 44 wave segments. This test verifies that the simulation indeed has a sea state with 44 wave segments.
AT412	RigidBody ShipMo3D RAO test 1	Time domain response of a floating block in kinematic RAO mode is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT413	RigidBody ShipMo3D RAO test 2	Time domain response of a floating block in kinematic RAO mode is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT414	RigidBody ShipMo3D RAO test 3	Time domain response of a floating block in kinematic RAO mode is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT415	RigidBody ShipMo3D RAO and cable phase load test	The incident and diffraction load on a floating box and large connected cable are checked for coincident phase.	This test is comprised of a 20m x 20m floating box with an attached large diameter floating cable. The box and cable are subjected to loading from a long wavelength Airy wave and the motion of the cable and box are checked to ensure they are in phase.
AT416	RigidBody ShipMo3D RAO test 4	Time domain response of a floating block in kinematic RAO mode is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT417	RigidBody ShipMo3D RAO test 5	Time domain response of a floating block in kinematic RAO mode is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT418	RigidBody ShipMo3D RAO test 6	Time domain response of a floating block in kinematic RAO mode is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT419	RigidBody ShipMo3D RAO and cable phase load test 2	The incident and diffraction load on a floating box and large connected cable are checked for coincident phase.	This test is comprised of a 20m x 20m floating box with an attached large diameter floating cable. The box and cable are subjected to loading from a long wavelength Airy wave and the motion of the cable and box are checked to ensure they are in phase.
AT420	Rigidbody kinematic control waypoint feature	Tests use of the RigidBOy kinematic control feature	Six rigid bodies are start at the global origin with 0 degree pitch, roll and yaw. They are sent to 1 and -1 in each direction, and 360 and -360 in each direction, ending at 1m and 360 degrees in each DOF, respectively.
AT421	Current boundary layer auto adjustment	Checks that boundary layer is adjusted according to local bathymetry changes and time varying current input file.	Simulation is run with time varying current profile. Current profile is checked against expected powerlaw output at two locations using current velocity probes.
AT422	Current probe boundary layer check	Checks that boundary layer is adjusted according to local bathymetry changes and time varying current input file. Uses current probe.	Simulation is run with time varying current profile. Current profile is checked against expected powerlaw output at two locations using current velocity probes.
AT423	Current probe with mean water level	Checks that boundary layer is adjusted according to local bathymetry changes and time varying current input file. Checks that results are accurate when mean water level property is used.	Simulation is run with time varying current profile. Current profile is checked against expected powerlaw output at two locations using current velocity probes.
AT424	Power law current profile	Simulation is run with power law current profile option.	Simulation is run with power law current profile. The simulation is ramped from 5 meters per second current speed at the surface to 0 meters per second over 20 seconds. The output is checked.
AT425	Power law current profile with mean water level	Simulation is run with power law current profile option, mean water level is adjusted.	Simulation is run with power law current profile. The simulation is ramped from 5 meters per second current speed at the surface to 0 meters per second over 20 seconds. The output is checked.

AT430	Mooring line probe tests 0	Verifies uplift angle, grounded line length, touch down point, and altitude probe behavior	Several inclined cables are simulated and probe results against expected values are checked.
AT435	Helical joint test 0	A helical joint between two rigid bodies is used and the constant velocity response is verified	The position and velocity of a body under constant velocity is verified with expected response
AT436	Helical joint test 1	A helical joint between two rigid bodies is used and rotational spring stiffness is verified	A body with constant force applied is verified with expected response
AT440	RBDCableWinchController test 0	A barge with 4 point mooring is controlled to a surge and sway offset position with autotension constraint	A barge is commanded to winch position several meters from starting location and with a final target for pretension in one of the lines.
AT441	CustomWaveSegments Test	Comparing a custom wave to a known sea state	A JONSWAP spectrum simulation was completed and using known wave parameters at specific locations, the custom wave abilities are compared.
AT442	Buoyancy Froude-Krylov rigid body feature test	The FK flags 1 and 2 are tested using the rigid body cylinder feature	A cylinder is completely sumberged with the BFK flag set to 1 and another 51% submerged with the BFK flag set to 2. Since BFK = 2 calculates buoyancy based on complete submergance if more than 50% submerged, both cylinder buoyancies should be equal. NOTE: The ellipsoid and cuboid features are also included in the simulation files but are not validated (just comment back in the lines of code) since BFK = 2 is not implemented yet for those features.
AT443	Wind Loaded Net	A net is partially submerged and is wind loaded. The drag is compared to computated results	A net is half submerged in the water with 20m/s wind applied. The drag from the wind is measured on the 2 rigid bodies attached to the top and bottom of the net. A computed drag force is compared to the sum of the forces acting on the rigid body.
AT450	Spatially/Temporally varying currents (3D) - test 0	A current profile probe is placed to measure inside and outside of the spatially varying current domain. Spatial and temporal interpolation functionality is tested.	A current profile probe is placed in the scene such that is measures the current at a few locations inside and outside of the spatially varying current domain. The current domain is 10 m depth and the water is 20 m deep. At the water surface, the current in the domain starts at 1.0 and at the bottom of the domain, the current is always zero. The current is linearly interpolated between those boundaries. The current at the top increases by 1 m/s ever 0.1s to a maximum of 4.0 m/s. The current is measured at 0m, 5m, 10m and 15m depths and check to make sure the currents are as expected. The measurements are check for times of 0s, 0.2s and 0.7s.
AT451	Spatially/Temporally varying currents (3D) - test 1	A current profile probe is placed to measure the spatially varying current domain. The organisation of the spatially fluid domain data in a GridPartition3D is tested.	A current profile probe is placed in the scene such that is measures the current at 5 locations of varying depth at X,Y = 0,0. The current velocity in X varies from 0.0m/s at a depth of 0.0 to a current of 5m/s at a depth of 100m. The spatially varying current domain is centered at 0,0 and it 100mx100mx100m. The current is known at the points of a uniform grid that discretizes the fluid domain into 10 pieces. This test ensures that the current probes return the expected velocities ensuring that a) interpolation is functioning correctly, but also that the discretized data points of the spatially varying fluid domain are properly sorted and stored in a GridPartition2.5D for efficient queries to fluid currents.
AT452	Spatially/Temporally varying currents (2.5D)	A set of water velocity probes are placed to measure the current inside spatially varying current domain. Spatial and temporal interpolation functionality is tested.	Four water velocity probes are placed in the fluid domain such that they test the temporal and spatial interpolation capabilities of the spatially/temporally varying current profile. The current data set, features a large domain with 5 time stamps and 1361 2D sampling data set (faces). Each 2D sampling data set has 10 data point uniformly spaced between the surface and the soil. The first two probes compare the velocity at exact locations where data is provided by the dataset, requiring no interpolation. The 3rd probe tests spatial interpolation and the 4th probe tests temporal interpolation. The tests pass if probe results are within 1% of expected values.
AT453	Spatially/Temporally varying currents - Tide testing (2.5D)	The Spatially/Temporally varying current code is made to alter the tide over a short period of time. The water elevation is compared against expected.	The Spatially/Temporally varying current code is made to alter the calm water level for 2 cycles over the period of 200s. There are no waves present. The water level is checked at various times over the course of the simulation to ensure the spatially/temporally varying current code is correctly handling the tidal elevation.
AT460	Cable segment specified from Node N	Stress at the top of two identical cables are checked against expected values.	Stress at one end of two cables pretensioned with 500kN are checked against expected values. Cables are identical with the exception that material properties are specified from Node 0 and Node N. The difference in diameter accounts for the difference in expected tension values.
AT465	CustomMesh asymmetric drag loading check	This test ensures that asymmetric drag loading is functioning for custom mesh features.	Six rigidbodys with the same box shaped mesh feature are modelled. One body has its X axis aligned with the world X axis, the next has its X axis aligned opposite the world X axis, the next has its Y axis aligned with the world X axis, and so on and so forth. The rigid bodys are all subjected to the same current speed, however, a different drag coefficient is provided for flows in the same direction as the X, Y and Z axes as flows against the X, Y, and Z axes. The total drag load acting on each rigid body is compared against expected.
AT470	RigidBody tangential and normal soil friction	Normal, tangential friction, and normal friction forces are verified with slender box motion in the seabed	This test is comprised of several 20m x 1m x 1m box moving with constant velocity in the seabed. One set moves tangentially and one laterally. The expected normal, tangential friction, and normal friction forces from the soil are verified. Bodies with applied forces greater than friction capacity are checked to ensure they are still moving at the end of the test. Note that ABA joints are used to prevent the moving bodies from rotating to simplify the friction calculation tests.

AT471	Cable centerline soil penetration friction tests	Normal and tangential friction effects are tested with the cable centerline soil penetration model.	Several 20m x 1m diameter solid steel rods lay horizontally penetrated into the soil. Two cables have initial velocities in the tangential and normal directions above the friction deadzone value and the maximum expected friction loads are verified. These cables also have loads applied that exceed the friction values and at the end of the test the velocity is checked to ensure they are accelerating. Two additional cables have loads below the maximum friction thresholds and at the end of the test the velocity is checked to ensure they are static.
AT472	Cable discretized soil penetration friction tests	Normal and tangential friction effects are tested with the cable discretized surface soil penetration model.	Several 20m x 1m diameter solid steel rods lay horizontally penetrated into the soil. Two cables have initial velocities in the tangential and normal directions above the friction deadzone value and the maximum expected friction loads are verified. These cables also have loads applied that exceed the friction values and at the end of the test the velocity is checked to ensure they are accelerating. Two additional cables have loads below the maximum friction thresholds and at the end of the test the velocity is checked to ensure they are static.
AT473	RigidBody tangential and normal soil friction	Normal, tangential friction, and normal friction forces are verified with squat, thick box motion in the seabed	This test is comprised of several 20m x 20m x 1m box moving with constant velocity and applied loads in the seabed. One set has loads applied above and the other below friction and soil resistance capacity. The expected normal, tangential friction, and normal friction forces from the soil are verified. Bodies with applied forces greater than friction capacity are checked to ensure they are still moving at the end of the test.
AT512	RigidBody ShipMo3D hydrodynamic with non-linear buoyancy loading test 1	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m × 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency. The hydrostatic and incident wave loads have been disabled in the hydrodynamics database, instead a cuboid feature is used to model the Froude-Krylov forces.
AT513	RigidBody ShipMo3D hydrodynamic loading with non-linear buoyancy test 2	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m × 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.The hydrostatic and incident wave loads have been disabled in the hydrodynamics database, instead a cuboid feature is used to model the Froude-Krylov forces.
AT514	RigidBody ShipMo3D hydrodynamic with non-linear buoyancy loading test 3	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m × 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.The hydrostatic and incident wave loads have been disabled in the hydrodynamics database, instead a cuboid feature is used to model the Froude-Krylov forces.
AT515	RigidBody ShipMo3D hydrodynamic with non-linear buoyancy and cable phase load test	The incident and diffraction load on a floating box and large connected cable are checked for coincident phase.	This test is comprised of a 20m x 20m floating box with an attached large diameter floating cable. The box and cable are subjected to loading from a long wavelength Airy wave and the motion of the cable and box are checked to ensure they are in phase.The hydrostatic and incident wave loads have been disabled in the hydrodynamics database, instead a cuboid feature is used to model the Froude-Krylov forces.
AT516	RigidBody ShipMo3D hydrodynamic with non-linear buoyancy loading test 4	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m × 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.The hydrostatic and incident wave loads have been disabled in the hydrodynamics database, instead a cuboid feature is used to model the Froude-Krylov forces.
AT517	RigidBody ShipMo3D hydrodynamic with non-linear buoyancy loading test 5	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m × 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.The hydrostatic and incident wave loads have been disabled in the hydrodynamics database, instead a cuboid feature is used to model the Froude-Krylov forces.
AT518	RigidBody ShipMo3D hydrodynamic with non-linear buoyancy loading test 6	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m × 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.The hydrostatic and incident wave loads have been disabled in the hydrodynamics database, instead a cuboid feature is used to model the Froude-Krylov forces.
AT519	RigidBody ShipMo3D hydrodynamic with non-linear buoyancy and cable phase load test 2	The incident and diffraction load on a floating box and large connected cable are checked for coincident phase.	This test is comprised of a 20m x 20m floating box with an attached large diameter floating cable. The box and cable are subjected to loading from a long wavelength Airy wave and the motion of the cable and box are checked to ensure they are in phase.The hydrostatic and incident wave loads have been disabled in the hydrodynamics database, instead a cuboid feature is used to model the Froude-Krylov forces.
AT612	RigidBody WAMIT hydrodynamic loading test 1	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m × 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT613	RigidBody WAMIT hydrodynamic loading test 2	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m × 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.

AT614	RigidBody WAMIT hydrodynamic loading test 3	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT615	RigidBody WAMIT hydrodynamic and cable phase load test	The incident and diffraction load on a floating box and large connected cable are checked for coincident phase.	This test is comprised of a 20m x 20m floating box with an attached large diameter floating cable. The box and cable are subjected to loading from a long wavelength Airy wave and the motion of the cable and box are checked to ensure they are in phase.
AT616	RigidBody WAMIT hydrodynamic loading test 4	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT617	RigidBody WAMIT hydrodynamic loading test 5	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT618	RigidBody WAMIT hydrodynamic loading test 6	Time domain response of a floating block with wave radiation and diffraction is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the ShipMo3D frequency-domain predicted values are tested at a specific wave frequency.
AT619	RigidBody WAMIT hydrodynamic and cable phase load test 2	The incident and diffraction load on a floating box and large connected cable are checked for coincident phase.	This test is comprised of a 20m x 20m floating box with an attached large diameter floating cable. The box and cable are subjected to loading from a long wavelength Airy wave and the motion of the cable and box are checked to ensure they are in phase.
AT650	Test VRoller connection	Test VRoller connection	Checks Autostiffness and damping of VRoller connection. Ensures that cable maintains position. The support rolls 180 degrees and checks the release of the pipe.
AT660	Verify ABA connection transmitted load output	Verifies that the corrected forces transmitted across the ABA joints are reported.	Two separate single prismatic joint ABA configurations are used to verify transmitted loads through the joint. The systems are identical except the base rigid body is switched in the connection. An equivalent external load and moment is applied to both systems with the point of application on the outboard rigid body. The load is verified against the expected force and moment seen at the upstream joint connection point on the base rigid body and at the downstream joint connection point on the outboard rigid body.
AT680	Verify force connection and moment stiffness properties and deflections	Verifies moment stiffness response in a force connection.	Rigid bodies are connected with a force joint. A moment stiffness is used to connect them and deflection response in time is checked. A rigid body connected with initial rotational offset and another body with external moments applied are checked against a fixed reference rigid body.
AT681	Verify force connection internal forces and moments	A rigid body beam system is generated using a force and moment connection. Expected internal moment and forces at the connection are verified.	Rigid bodies are connected with a force and moment joint. A moment stiffness is used to connect them and the force connection loads are checked against expected values. A pair of rigid bodies are used to check pure moment loading and another with force and moment loads are checked with a connection to a fixed rigid body.
AT682	Verify force connection moment stiffness with frame rotation offset	Verifies moment stiffness connection response with joint frame rotation offset.	Rigid bodies are connected using a force connection with three different joint frame rotation angles. The final resulting orientation of the follower body is checked against the expected value.
AT683	Verify force connection moment stiffness with follower frame rotation offset	Verifies moment stiffness connection response with joint frame rotation offset.	Rigid bodies are connected using a force connection with three different joint frame rotation angles. The final resulting orientation of the follower body is checked against the expected value.
AT684	Verify force connection with rotation offset and moment stiffness properties and file output	Verifies force and moment stiffness response in a force connection.	Two separate rigid bodies are connected with a force joint with constraint only in the local X direction and with rotation offset. A moment stiffness is used to connect them and deflection response in time is checked. A rigid body connected with initial rotational offset and another body with external moments applied are checked.
AT712	RigidBody WAMIT RAO test 1	Time domain response of a floating block in kinematic RAO mode is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the WAMIT frequency-domain predicted values are tested at a specific wave frequency.
AT713	RigidBody WAMIT RAO test 2	Time domain response of a floating block in kinematic RAO mode is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the WAMIT frequency-domain predicted values are tested at a specific wave frequency.
AT714	RigidBody WAMIT RAO test 3	Time domain response of a floating block in kinematic RAO mode is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the WAMIT frequency-domain predicted values are tested at a specific wave frequency.
AT715	RigidBody WAMIT RAO and cable phase load test	The incident and diffraction load on a floating box and large connected cable are checked for coincident phase.	This test is comprised of a 20m x 20m floating box with an attached large diameter floating cable. The box and cable are subjected to loading from a long wavelength Airy wave and the motion of the cable and box are checked to ensure they are in phase.
AT716	RigidBody WAMIT RAO test 4	Time domain response of a floating block in kinematic RAO mode is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the WAMIT frequency-domain predicted values are tested at a specific wave frequency.
AT717	RigidBody WAMIT RAO test 5	Time domain response of a floating block in kinematic RAO mode is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the WAMIT frequency-domain predicted values are tested at a specific wave frequency.

AT718	RigidBody WAMIT RAO test 6	Time domain response of a floating block in kinematic RAO mode is tested at a specific wave frequency	This test is comprised of a 20m x 20m floating box. An extra linear stiffness and damping acts as a stiff mooring to prevent drift. The amplitude and phase of motion of the body with respect to the WAMIT frequency-domain predicted values are tested at a specific wave frequency.
AT719	RigidBody WAMIT RAO and cable phase load test 2	The incident and diffraction load on a floating box and large connected cable are checked for coincident phase.	This test is comprised of a 20m x 20m floating box with an attached large diameter floating cable. The box and cable are subjected to loading from a long wavelength Airy wave and the motion of the cable and box are checked to ensure they are in phase.
AT730	File output check	Checks that all of the expected output files are produced.	This test checks that all of the expected files are output. It does not check DObject output files but checks all other files.
AT740	BallastTank feature check	Checks that the change in weight and change in inertia are functioning correctly.	A 10mx10mx2m box naturally displaces 10mx10mx1m of water. A 10mx10m cross-sectional area ballast tank is provided that is initially empty. The ballast tank is slowly filled to a level of 0.5m over the first 25s. The final draft of the box after the ballast tank is filled should be 1.5m. A constant 1000N force is applied to the box in the surge degree off freedom. The initial acceleration should be approx. 0.01m/s2̂ slowly reducing as the box total inertia increases. When the ballast tank is filled, the surge acceleration should then be a constant 0.0065m/s2̂.
AT780	Cable tangential/normal drag loading	Checks that the tangential and normal drag loading model is outputing the expected drag loads	Two identical cables are fully submerged and exposed to a current of 1m/s. One cable is perpendicular to the flow while the other is parallel to the flow. Both cables have a diameter of 0.01m. The normal drag coefficient is set to 1.0 while the tangential drag coefficient is set to 0.01. This tests checks that the total drag load acting on the Cables in ProteusDS matches the expected total drag load.