TABLE OF CONTENTS

- INDUSTRY CHALLENGE
- AKSELOS SOLUTION
- AKSELOS BENEFITS
- AKSELOS WORKFLOW
  - Structural Modelling
  - Environmental loading
  - Structural analysis
  - Strength capacity check (ULS)
  - Fatigue analysis
- AKSELOS UNIQUE VALUE PROPOSITION
  - One holistic Digital Twin model merges all analysis in one workflow
  - Fully-coupled Mesh-based fatigue analysis made easy and accurate
  - Structural properties calibrated by sensors
  - Condition-based models
  - Perfect for distributed Engineering Teams
- HOW YOU CAN WORK WITH AKSELOS

TARGET AUDIENCE
- Asset Managers
- Operations
- Projects Engineering
- Technical Authorities
- Asset Integrity
- HSE
- Innovation and Digitisation
INDUSTRY CHALLENGE

Oil and gas platforms operate in demanding conditions requiring a real time assessment of risk and cost to operate efficiently. In addition, during the life of a platform it may be assessed for:

- Modifications for remedial work/ or extensions.
- Licence to operate and/or operations beyond original design life; requiring an engagement with regulators/ Safety executive.
- Assessment of integrity and/or structural design life.
- Assessment of operational issues or incidents.
- Requirements related to inspection and maintenance programs.

Using traditional industry approaches the assessment of Integrity, for each of these examples, is both time consuming and costly. OPEX for Offshore platform range typical between 20 and 100 million $ (but can be higher especially for those structures over 30 years old).

Traditional approaches to structural analysis need a combination of tools that need manual configuration and parameterization for each iteration that:

- Does not support global system models at a level that accurately reflects physical models.
- Either use a coarse FEA model, which simplifies the structural detail considerably, or partial fine FEA models, which can’t accurately capture cumulative effects in the global structural model.
- Are computationally infeasible for large-scale jacket platforms.

The challenges facing operators today are not only for the Asset Life Extension (ALE) but also the increasing standards with the accompanying regulatory scrutiny.

Akselos is offering a new approach based on leading-edge technology to allow a full-cycle approach with a predictive Digital Guardian that offers a step change in Asset Management.

AKSELOS SOLUTION

Akselos Integra™, the world’s most advanced and fastest engineering simulation platform, has pushed the boundaries of modern engineering to a new level with:

- Fully supported condition-based, physics-driven Digital Twin for an entire asset.
- Optimal design achieved with fast parametrized simulations that handle hundreds of iterations with 1000’s of load cases in minutes.

ULS with ISO 19902 in a fixed offshore jacket.

- Given the fast process many engineering options may be considered easily in short cycles to identify the best solution. This offers a step change in the engineering approach with better business outcomes.
- High resolution diagnostics of integrity issues, yield a better quality result with diagnosis for business critical engineering inputs.
- Full 3D fatigue assessments with meshing to industry standards are covered 1000 times faster than with de-facto standard tools.

Potential for significant increase in computed fatigue lives, applying DNV Fatigue standards on joint meshes (shell elements).

A traditional asset integrity assessment, from model generation to diagnostic will take weeks or months to complete while in Akselos Integra; a fixed structural platform can be completed within hours.

Companies in the offshore, power generation, mining and wind energy industries are using Akselos Integra; to solve their most demanding engineering problems, reduce cost and inefficiencies and gain competitive advantage.

Akselos Integra supports structural analysis applications that cover the entire life-cycle, from design through operation to late life asset and decommissioning.
AKSELOS WORFKLOW

**STRUCTURAL MODELLING**
- Beam elements
- Mesh modelling for the joints
- Shell elements, DNV RP
- Topside loads
- Point masses + footprint
- Pile/Soil interactions
- Non-linear springs
- Foundation linearisation for spectral fatigue

**ENVIRONMENTAL LOADING**
- Wind
- Wave
- Current

**STRUCTURAL ANALYSIS**
- Non-linear quasi-static (ULS)
- Linear harmonic (FLS, spectral fatigue)
- Modal (natural frequencies)

**STRENGTH CAPACITY CHECK (ULS)**
- Standard base check

**FATIGUE ANALYSIS**
- Operations reporting
- Technical reporting

---

**WORFKLOW DETAILS**

**Structural modelling**

We can help you do more with Akselos: any part of the structure can be modelled using shell or solid elements, and fully coupled within a global model.

This is a very important feature when it comes to joint modelling:

- Using shell elements for the jacket joints improves significantly the hotspot stresses accuracy.
- Akselos solver is not limited by the mesh size.
- All the joints in the global model can be meshed according to DNVGL-RP-C203.

Topside load modelling is done by creating pyramids of rigid links that connect a point mass to the four corners of the footprint.

The soil-pile interaction is modelled via non-linear “springs attached to the piles. The user can provide a table of soil properties and the software will convert it automatically into soil springs.

---

**BENEFITS**

Akselos is the only real-time structural integrity tool providing holistic, detailed models that help you:

- Extend field operational life by unlocking spare structural capacity in your assets
- Build confidence around life extension decisions with key stakeholders
- Reduce OpEx costs by optimizing inspection and maintenance plans
- Give confidence to HSE/regulators on the safe operation of the platforms by using the Akselos Digital Guardian features

Developed through a joint industry project with LIC Engineering, a leading engineering company with over 30 years EPC experience in Oil & Gas, Renewable Energy and Marine and Civil Engineering.
Environmental loading

Wave loading on beam elements is modelled via the Morison equation. For joints modelled with shell elements, the joint is automatically decomposed in its chord and brace sub-domains, and each mesh sub-domain is assigned an equivalent Morison load.

Akselos offers three wave theories via a plug-in implemented by LIC Engineering:

- Linear harmonic (Airy)
- Stokes 5th order
- Dean Stream

Current can be specified and will contribute to the Morison drag component.

Buoyancy is included, with or without flooding of the members.

Stationary wind loading is supported for deterministic analysis.

Added mass is taken into account for modal or dynamic spectral analysis.

---

Structural analysis

For the “100 year” return wave - ULS analysis, Akselos provides a quasi-static non-linear solver.

Waves can be specified from any heading, using any theory, also including current, wind, buoyancy. The wave can be stepped through a complete cycle in order to identify the steps giving maximum overturning moment and base shear. For a given step, the response of the structure can be calculated using Akselos quasi-static non-linear solver, including the fully detailed non-linear foundation.

For spectral fatigue analysis, Akselos provides a linear frequency-domain solver. Unit waves are specified by headings and frequencies. The wave theory is linear (Airy), and the Morison drag term is linearised around a centre of damage chosen by the user. The foundation is also linearised around the centre of damage. Current, wind and buoyancy do not contribute to loads. The response of the structure can be chosen to be quasi-static or dynamic, depending on the natural frequencies of the structure with respect to the wave environment.

Akselos also provides a modal solver, suitable after foundation linearisation, in order to identify the natural frequencies of the structure.

---

Three modes of Natural Frequencies Analysis on a jacket.

Developed jointly with a major Oil & Gas Energy operator with the goal of allowing the operators to monitor the health of their offshore fixed asset in real time and predict its future condition.
Strength capacity check - ULS

Strength capacity checks can be run after the response of the structure to a deterministic wave has been calculated. Akselos supports code checks via an open platform for plug-ins. Anyone can develop their own Akselos plug-in for code check. Akselos also offers its own in-house implementation for the following standards: ISO 19902, API RP 2A. Other standards can also be added upon customer request.

Fatigue analysis

The stress transfer functions of the hotspots are obtained after calculating the frequency domain response of the structure to various unit wave headings and frequencies. The fatigue life is obtained after further processing by combining the stress transfer functions with data provided by the user: wave scatter diagram, wave spectrum model, SN curves.

Akselos’ ability to model joints with shell elements is a big advantage when considering fatigue:

- **Remove headaches with SCF formulas**: which to choose, range of application, non-tubular joints, etc.
- **Joint mesh modelling within a global model**
  - No need to juggle between a global beam model and several local joint models (e.g. FE based SCF)
  - Boundary conditions of the joints are properly and automatically accounted for
- **Local joint flexibility inherently included**
- **Hotspot stresses are more accurate**

**AKSELOS UNIQUE VALUE PROPOSITION**

One holistic model merges all analysis in one workflow

Akselos includes powerful next-generation technology that allows to run all analysis within one model, without incurring the computation cost of traditional systems. This means: Beam members and 3D joints fully coupled in the model. All joints represented in 3D, if necessary, yielding longer estimated fatigue life (with DNV GL recommended practice DNVGL-RP-C203).

**Fully-coupled Mesh-based fatigue analysis made easy and accurate**

Akselos provides by far the best workflow for fatigue analysis, yielding a much easier simulation of joints over the entire jacket, based on 3D meshes of joints, and at the same speed as beam software. This is made possible by the inclusion of RB-FEA to power the analysis of meshed joints.

**Simulation at the speed of thought ©**

**Beam model with SCF**

- Not able to calculate stress directly for fatigue
- Overly Conservative Results

Akselos model with 3D joint mesh (DNV-RP-C203 fatigue standard)

- More accurate results
- Get stress data directly from the large global model in one solve
- Reuse the results for further analysis (buckling, fatigue, etc.)
- With RB-FEA, 3D Shell as fast as beams
Structural properties calibrated by sensors

• Akselos provides unique capabilities to refine further the understanding of the asset by taking in data feeds in real time from a range of operational and environmental data sources.

• Akselos has also calibrated soil stiffness via a sensor system (accelerometers) deployed on the platform which in some cases have contributed significantly to the understanding of the asset aging.

Condition-based models

Akselos RB-FEA technology is a powerful evolution of FEA and enables to include all details related to structural integrity:

• Section losses can be represented in 3D

• Deformed members can be represented in 3D.

• Very easy to impact current state of platform and re-run all load cases.

Perfect for distributed Engineering Teams

• Cloud-based software for ultimate scalability.

• Easy collaboration between remotely located teams of engineers, including operations.

The calibrated displacements and stresses enable measurement-based analysis of the entire structure (e.g. fatigue and buckling code checks such as ISO 19902, API, AISC, DNVGL, etc., soil/pile monitoring, failure mode analysis, anomaly detection).
Akselos is a digital technology company headquartered in Switzerland, with operations in Europe, the USA and South East Asia. The company has created the world’s most advanced engineering modelling, and fastest simulation technology, to protect the world’s critical infrastructure today and tomorrow. The technology has the power to revolutionize how we build and manage our critical infrastructure, and pushes the boundaries of what modern engineering and data analytic can achieve. Developed by some of the world’s best minds, the MIT-licensed technology builds something far beyond the capability of a conventional digital twin – a digital guardian that allows operators to not only monitor an asset’s condition in real time, but helps them to see the future.

About Akselos

Our Akselos Integra platform is a leading engineering simulation platform that revolutionizes asset management and enables you to understand and manage structural safety risk for your entire asset more effectively than anything else on the market.

How can you work with Akselos?

**Service Level Agreement**
- Option for project initiation; digital twin set-up with a starter pack of support/services.
- We can help you to get your digital twin up and running quickly.

**Training Centre**
- Training for your engineers to help and manage digital twins.
- Online knowledge base with detailed information.
- Fully documented self training centre.

**Fully Cloud-Based**
- Accessible from anywhere on the internet.
- Promoting teamwork between geographies and companies.

**Software as a Service**
- Akselos’ main offering is a SaaS software (Software as a Service) with a license-based subscription.
- Other licensing options are available on request.
- Please contact us on: info@akselos.com.

North America
Akselos, Inc
210 Broadway, #201
Cambridge, MA | 02139, USA

Europe/Middle East/Africa
Akselos S.A.
EPFL Innovation Park,
Building D
1015 Lausanne, Switzerland

Asia-Pacific
Akselos Vietnam
125/167 Dinh Tien Hoang street, Binh Thanh Dist.
Ho Chi Minh city, Vietnam