



SOFTWARE

Sesam™ – 45 years of success

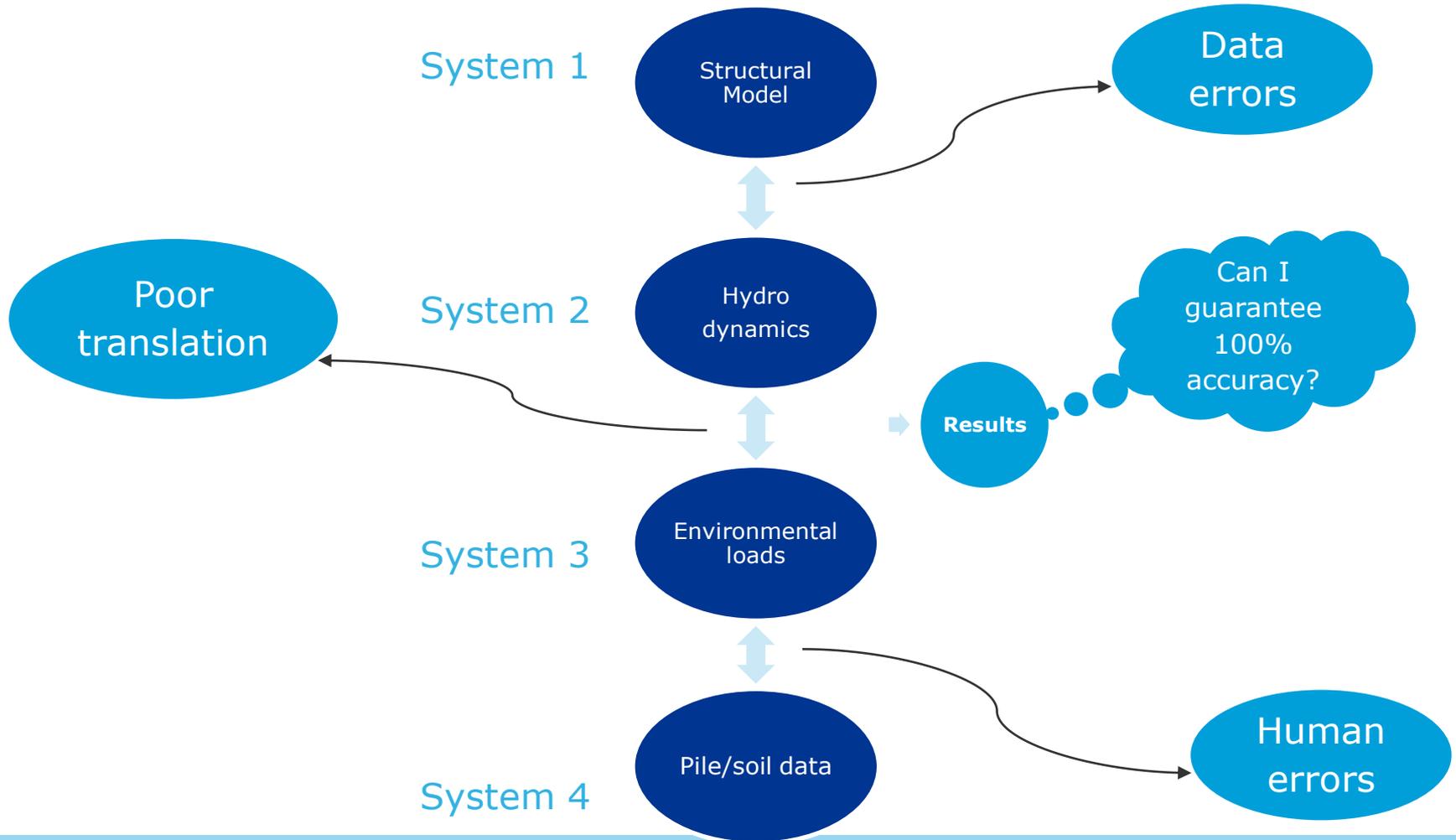
Be data smart in strength assessment of ship and offshore structures

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04 May 2017

Industry Perspectives

- Time wasted in modelling errors or poor data translation is costly



Poll 1

Do you have software tools that cause inefficiencies due to lack of integration?

- 1) Yes, but it's manageable
- 2) Yes, and it requires too much manual rework
- 3) No

Sesam – a complete system for engineering of marine and offshore structures

Sesam is owned, developed and maintained by DNV GL – Software, a division in DNV GL



Sesam – a 45 years success story – the most complete system

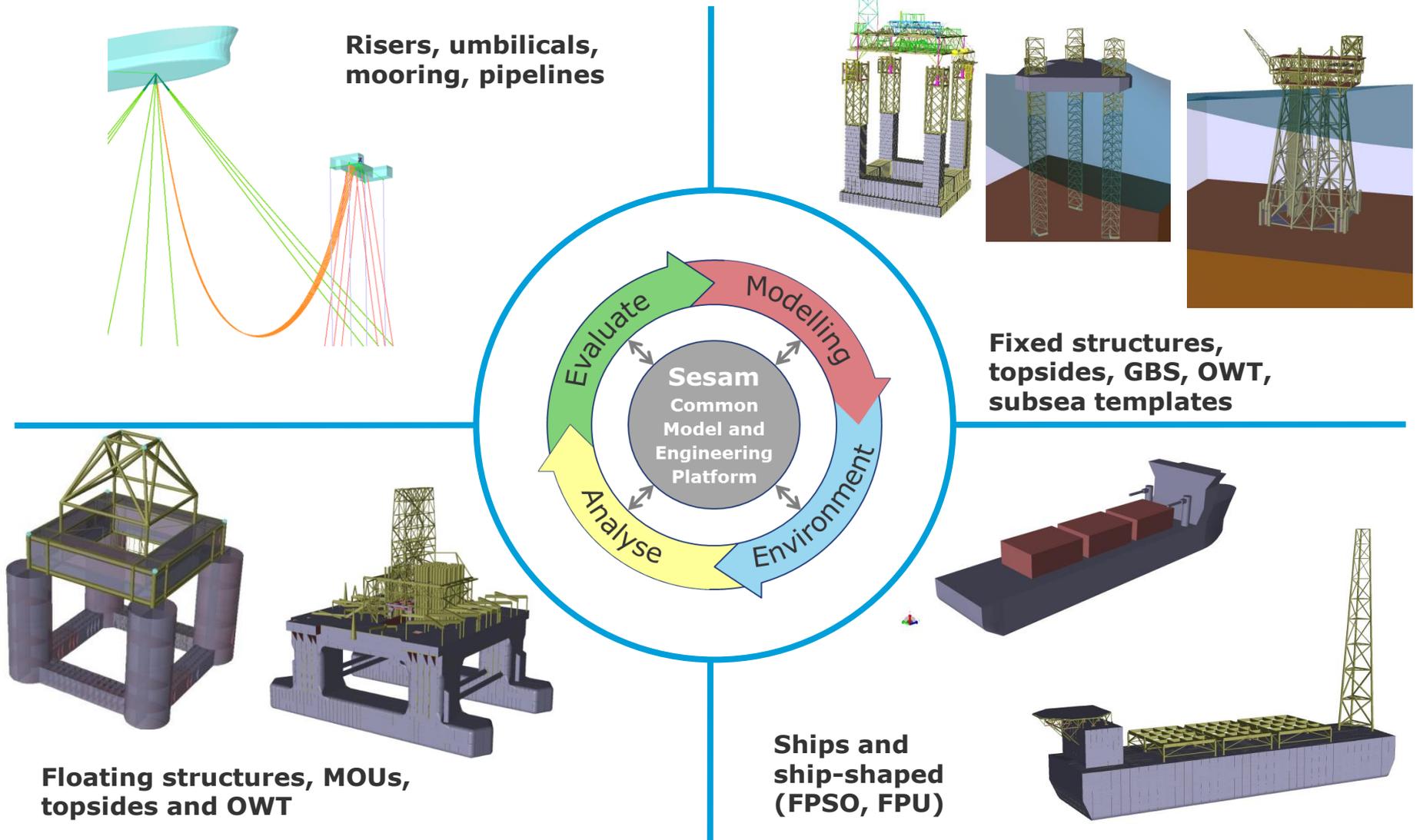
- Strength assessment and sea-keeping analysis
 - Combining the best from finite element, radiation/diffraction & Morison theories and pair it with engineering expertise
- Used to design ships, offshore floaters, offshore fixed installations, offshore wind turbine foundations and marine systems
 - API, AISC, NORSOK, EUROCODE, ISO, DNV GL, CSR-H, ORS
- Covers all engineering tasks and marine operations during the lifetime of the e.g. structure, risers, umbilicals and pipe lines
 - Design, modification & life extension
- More than 250 organizations use Sesam – thousand of users rely on it's efficiency, quality & support every day



The Oseberg Field designed with Sesam

GBS, Topside, Jacket, Living Quarter, Heli-deck, Bridge, Flareboom, Subsea template, Riser, Pipeline
Construction, transportation, marine operation, installation, in-place, modification, life extension

The uniqueness of Sesam – one system for all



Sesam helps you to increase your engineering efficiency

- **Best practice workflows with integrated data flow**

- One data model and seamless data flow
- Pre-defined and custom built workflows

- **Modelling and analysis**

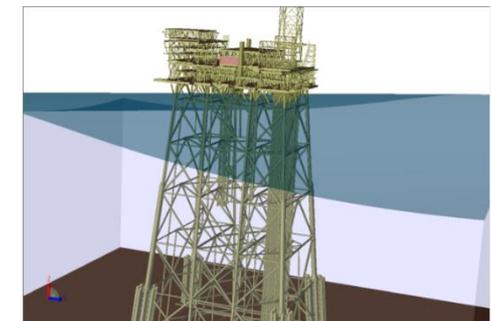
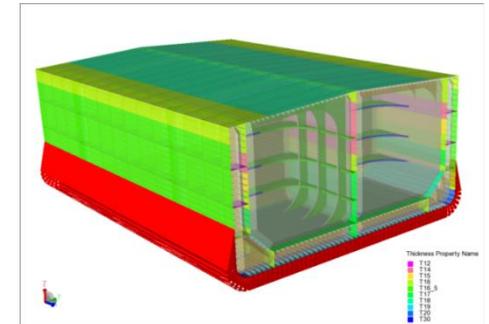
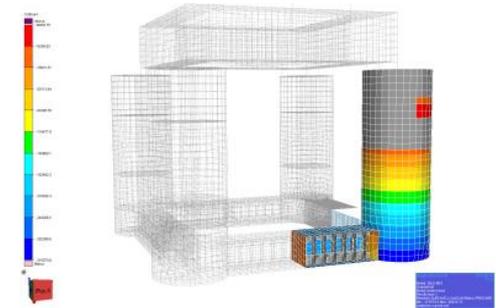
- Faster and intuitive modelling, re-use other data
- Mesh control and faster analysis

- **Complete for fixed and floating structures**

- Code checking and design iterations
- Earthquake analysis of fixed structures
- Fatigue analysis – screening and detailed
- Accidents and pushover analysis

- **Quality, verification and documentation**

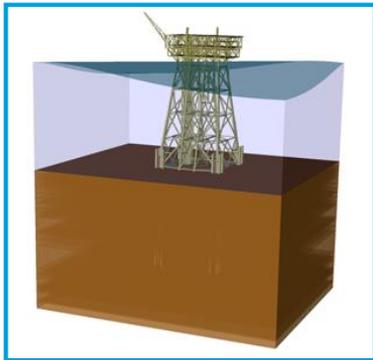
- Own verification and documentation of project
- Verification done by others



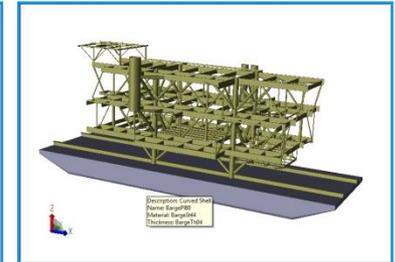
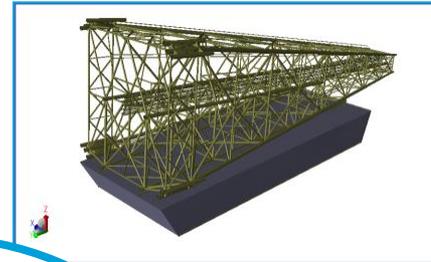
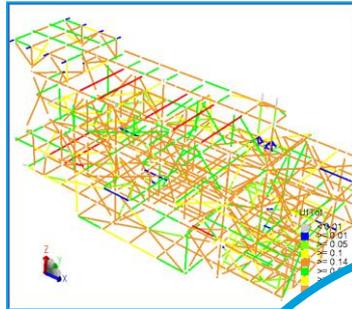
Gain engineering efficiency by using one data model for your hydrodynamic and strength assessment analyses:

How can workflows and the Sesam design loop help you?

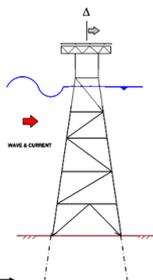
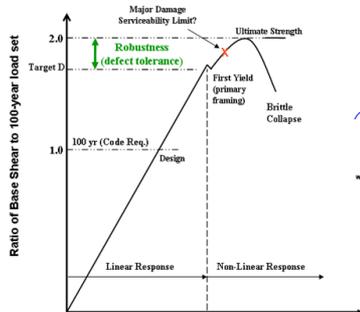
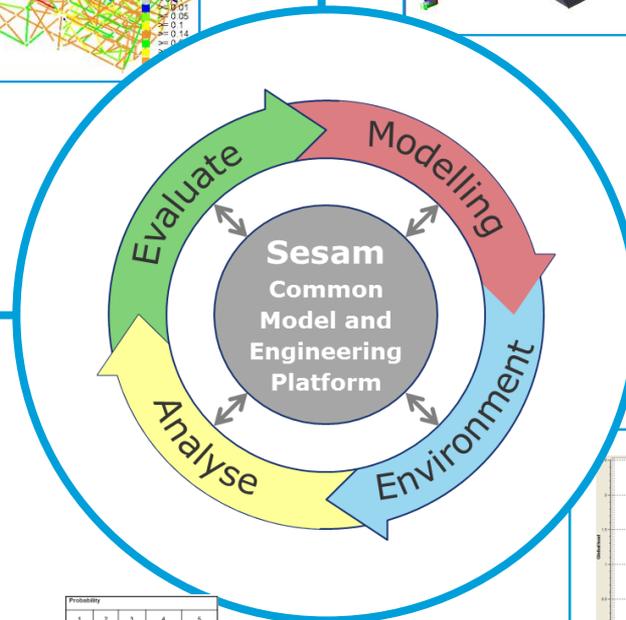
Engineering efficiency drives the development of Sesam



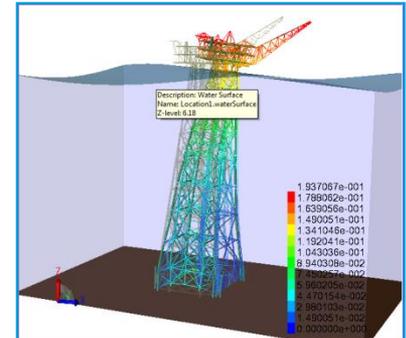
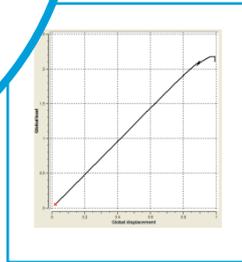
In-place and construction
Deflections, stresses,
code-check, fatigue, earthquake



Transportation, lifting, launching
Deflections, stresses,
code-check, fatigue



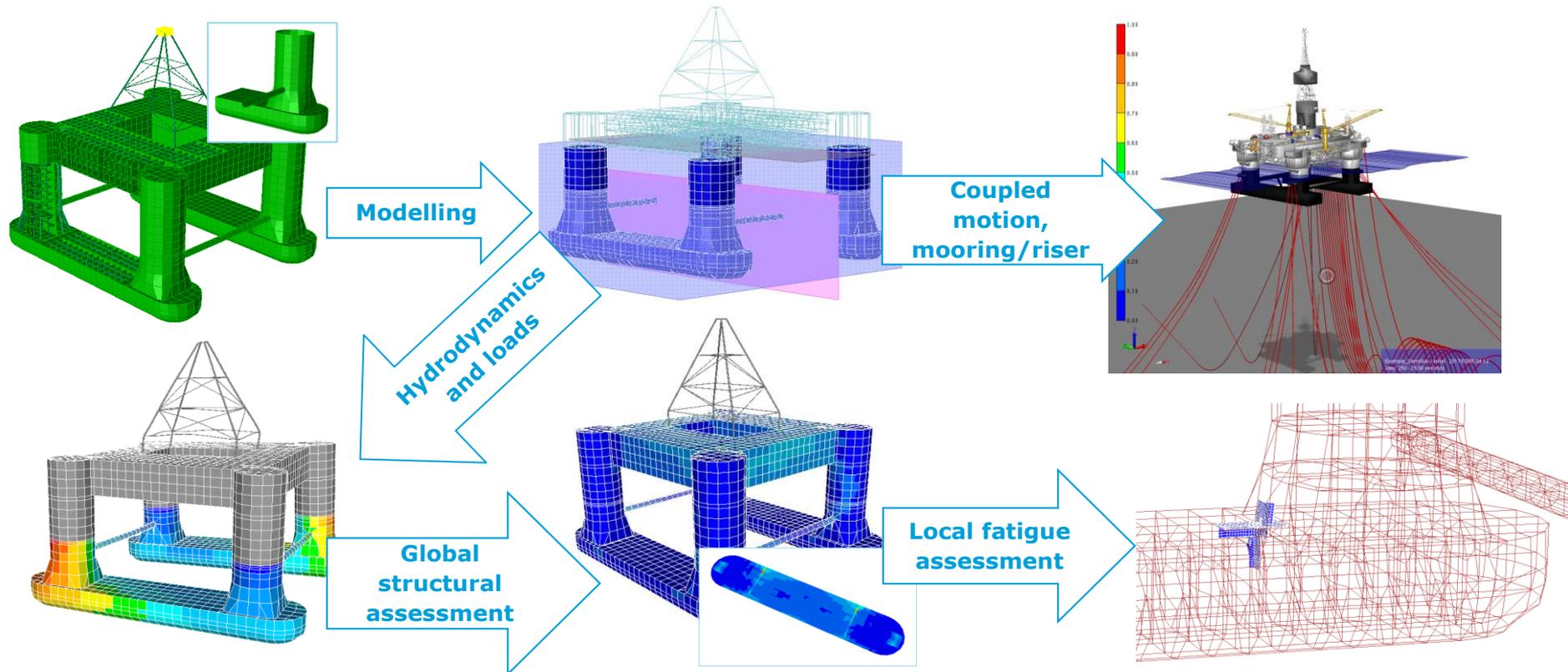
Consequence	Probability				
	1	2	3	4	5
A	10	10	10	10	10
B	10	10	10	10	10
C	10	10	10	10	10
D	10	10	10	10	10
E	10	10	10	10	10



Asset Integrity Management
API RP 2SIM compliance, structural redundancy,
Consequence and Probability of failure, RBUI

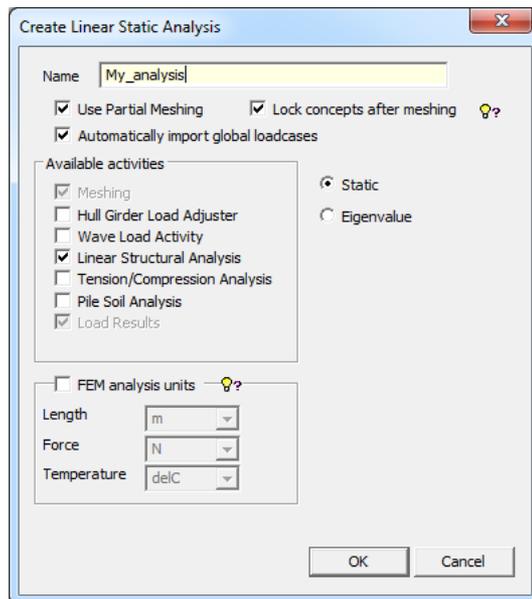
Modification, life extension, requalification
Corrosion allowance, weight control, deflections, stresses,
fatigue, push-over, collapse, accidents, boat impacts

Engineering efficiency drives the development of Sesam

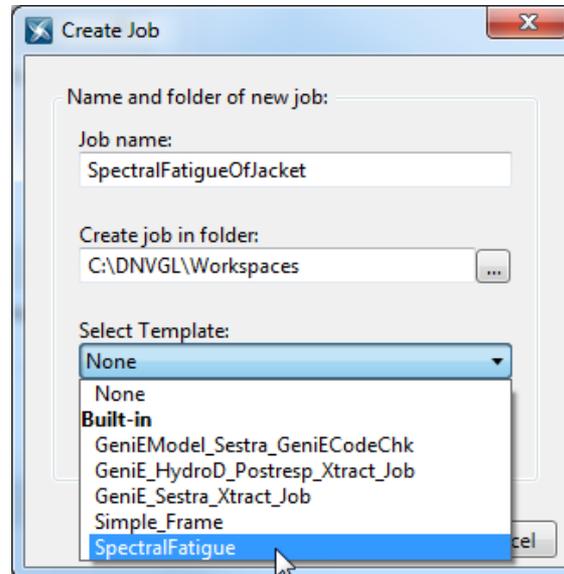


Workflows based on best practice

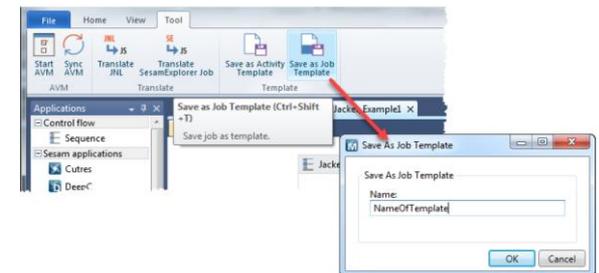
- Our tools for modelling, structural & hydrodynamic analysis include pre-defined analysis setups for the most frequent analysis you would run
 - Data flow is automatic



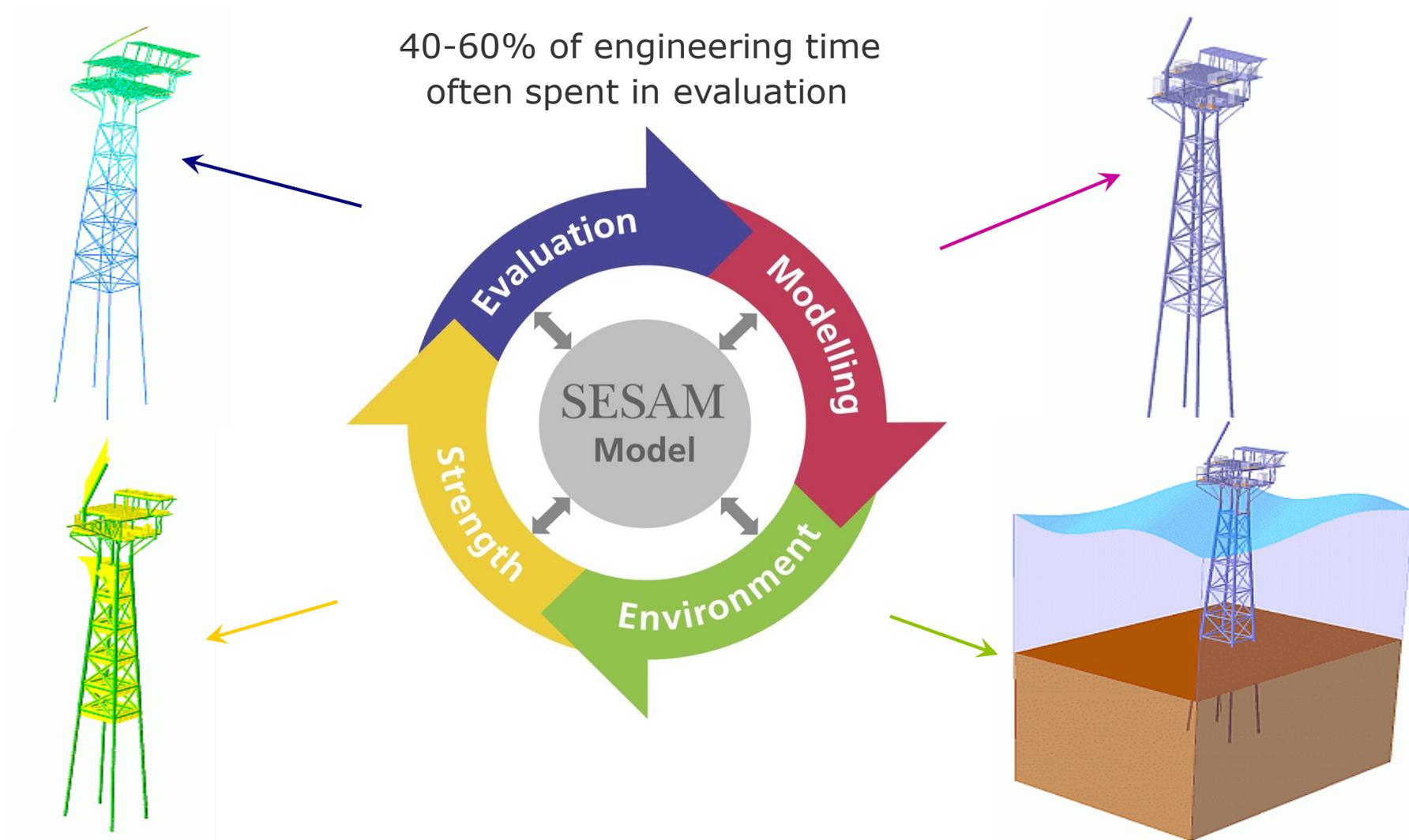
- Our tool for more complex workflows includes pre-defined workflows that will ensure dataflow
 - Spectral fatigue
 - Hydrodyn. analysis



- Make you own workflow based on your best practice and share in your organization
 - Procedure & workflow
 - Include non Sesam programs like e.g. Excel
 - Pre & Post scripts
 - Include attachments, e.g. drawings, check list



The importance of the Sesam design loop



Poll 2

When doing re-design/design iterations, do you:

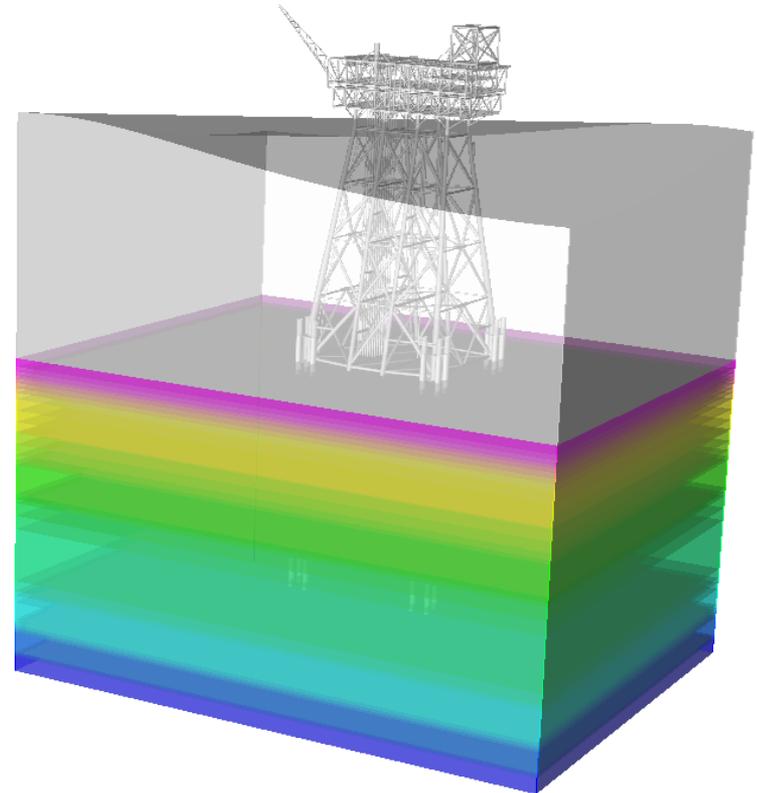
- 1) Use one integrated tool (no manual data transfer and rerun)?
- 2) Manually update input files and rerun all analysis?
- 3) Not applicable

Modelling and analysis:

Sesam makes you faster. How?

Easy and intuitive modelling is core

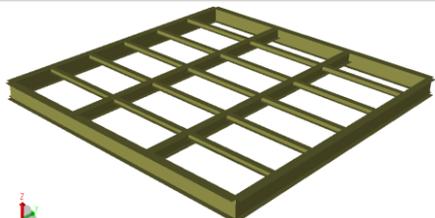
- One concept model for all
 - Fixed structures and floating structures
- Repetitive modelling
 - Insert beam, divide beam, properties
- Complex modelling
 - Curved surfaces, divide hull by adding transverse bulkhead, leg/inner piles
- Load definitions
 - Independent of structure
 - Equipment modelling
- Define environment
 - Wave, current, wind, soil
- Define code check parameters
 - Members, tubular joints, plates



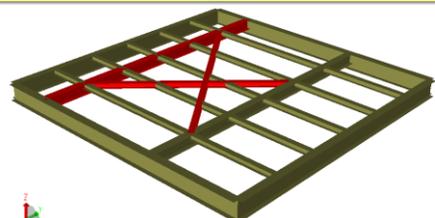
Efficiency because of concept model and one data model

■ Concept modelling

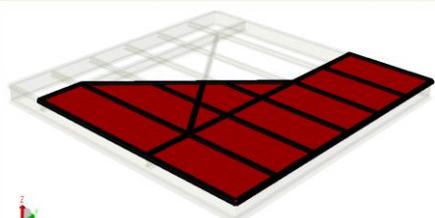
Beam connections automatically made when making a model



Automatic update of connectivity when delete, insert or move

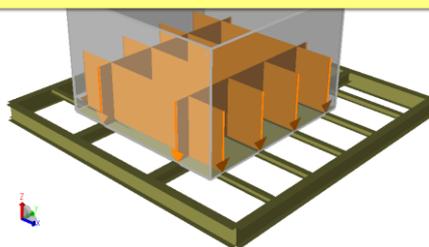


Always connection between beams and plates

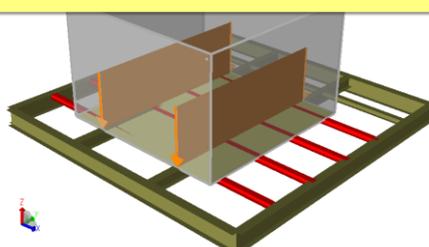


■ Equipment loading

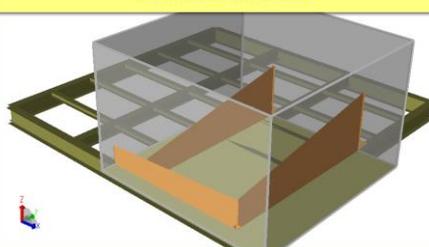
Line loads automatically applied to beams when intersected with footprints



Load generation controlled by load interfaces

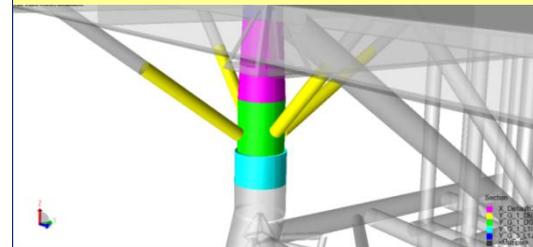


Loads always updated when moving equipments or deleting/inserting beams



■ Detailed model(s)

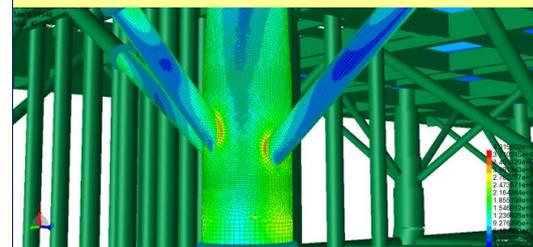
Automatic convert from beam to shell
Auto connect beams to shell



Full control of mesh quality
Automatic meshing and editing

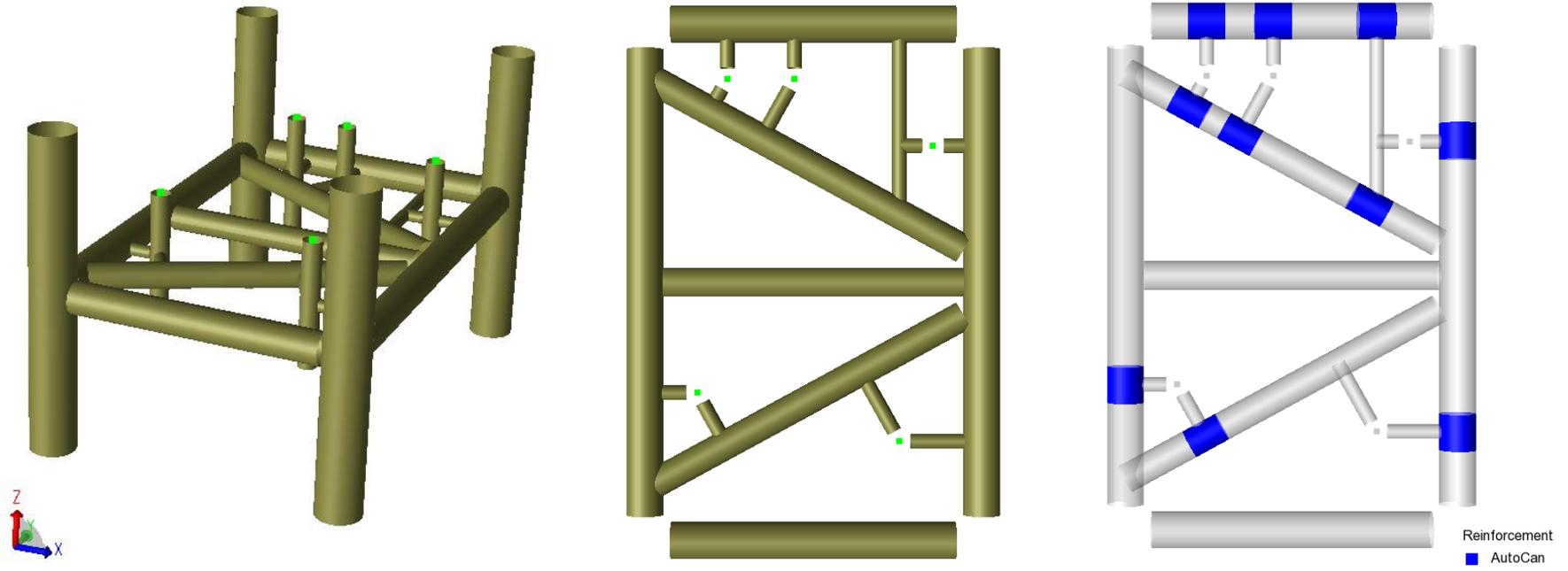


Integrated analysis
Seamless transfer of loads from rest of structure



Speed up modelling – Example 1

- Interactive modelling by snapping onto eccentric models and auto update model when eccentricities change
 - Divide eccentric members
 - Add new members to eccentric members



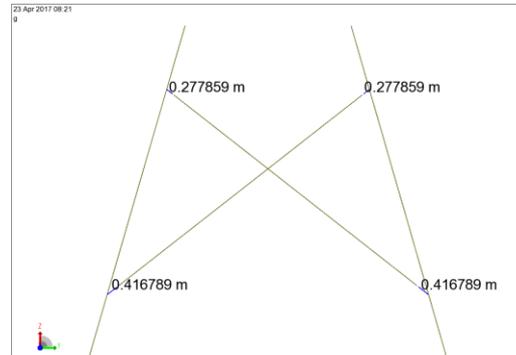
Divide or add new members to eccentric members was a tedious process – this is now very easy to do

Speed up modelling – Example 2

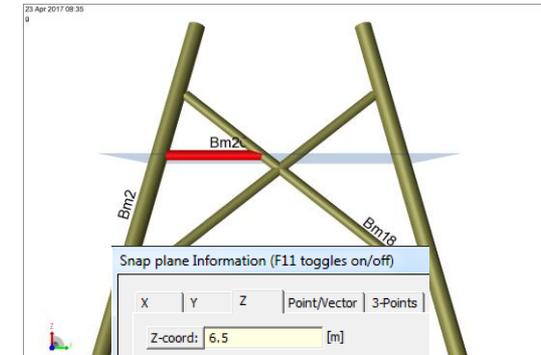
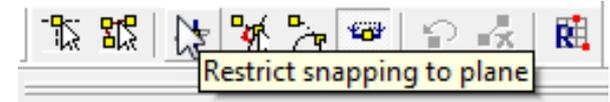
- X-joint modelling and adding horizontal braces



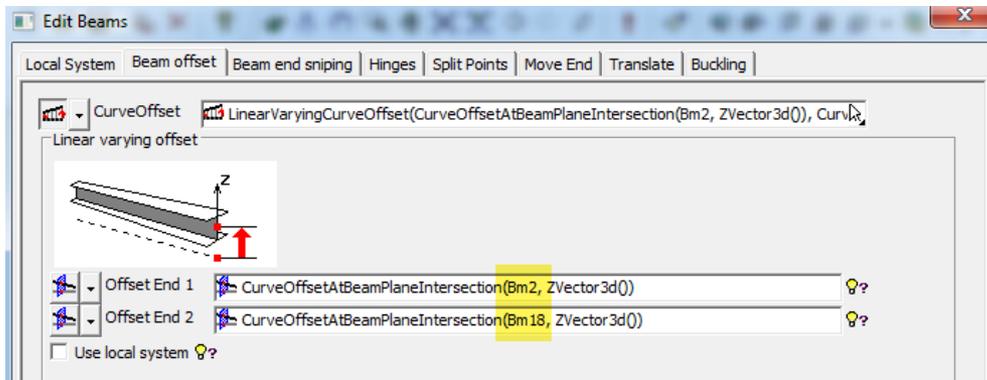
Two legs, two braces, four tubular joints



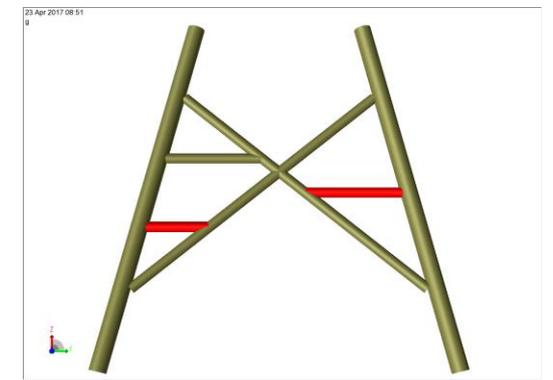
Braces have been flushed to outer chord



Bm20 is inserted by use of "Restrict snapping to plane"



Bm20 automatically inherits relevant eccentricity details from Bm2 & Bm18



More beams inserted by use of "Restrict snapping to plane"

Speed up modelling – Example 3

- Converting soil data from a soil data report

Pile Diameter = 2438 mm

Depth [m]	T-Z DATA														
	T(1)	Z(1)	T(2)	Z(2)	T(3)	Z(3)	T(4)	Z(4)	T(5)	Z(5)	T(6)	Z(6)			
0.0	0.0	0.0	2.5	0.0	3438.0										
1.4	0.0	1.5	3.0	2.5	7.6	3.8	13.9	4.5	10.5	6.0	24.4	4.0	48.8	4.0	228.6
3.3	0.0	4.2	3.0	7.0	7.6	10.5	13.9	12.0	18.0	14.0	24.4	11.2	48.8	11.2	228.6
3.3	0.0	4.2	3.0	7.0	7.6	10.5	13.9	12.0	18.0	14.0	24.4	11.2	48.8	11.2	228.6
6.6	0.0	8.1	3.0	13.5	7.6	20.3	13.9	24.3	19.5	27.0	24.4	21.6	48.8	21.6	228.6
9.8	0.0	8.6	3.0	11.0	7.6	18.5	13.9	19.8	19.5	22.0	24.4	17.8	48.8	17.8	228.6
14.9	0.0	8.1	3.0	13.5	7.6	20.3	13.9	24.3	19.5	27.0	24.4	21.6	48.8	21.6	228.6
14.9	0.0	8.0	3.0	10.0	7.6	15.0	13.9	18.0	19.5	20.0	24.4	16.0	48.8	16.0	228.6
27.9	0.0	13.5	3.0	22.5	7.6	33.8	13.9	40.5	19.5	40.0	24.4	36.0	48.8	36.0	228.6
27.9	0.0	80.0	2.5	80.0	3438.0										
30.4	0.0	87.0	2.5	87.0	3438.0										
31.1	0.0	87.0	2.5	87.0	3438.0										
31.1	0.0	10.0	3.0	17.5	7.6	20.3	13.9	31.5	19.5	35.0	24.4	28.0	48.8	28.0	228.6
37.9	0.0	13.5	3.0	22.5	7.6	33.8	13.9	40.5	19.5	40.0	24.4	36.0	48.8	36.0	228.6
37.9	0.0	80.0	2.5	80.0	3438.0										
43.8	0.0	80.0	2.5	80.0	3438.0										
43.8	0.0	18.0	3.0	27.5	7.6	41.3	13.9	48.5	18.0	55.0	24.4	44.0	48.8	44.0	228.6
65.0	0.0	24.0	3.0	40.0	7.6	60.0	13.9	72.0	19.5	80.0	24.4	64.0	48.8	64.0	228.6
65.0	0.0	80.0	2.5	80.0	3438.0										
72.0	0.0	80.0	2.5	80.0	3438.0										
72.0	0.0	30.0	3.0	50.0	7.6	75.0	13.9	90.0	19.5	100.0	24.4	80.0	48.8	80.0	228.6
74.0	0.0	30.0	3.0	50.0	7.6	75.0	13.9	90.0	19.5	100.0	24.4	80.0	48.8	80.0	228.6
74.0	0.0	80.0	2.5	80.0	3438.0										
83.7	0.0	80.0	2.5	80.0	3438.0										
83.7	0.0	80.0	2.5	80.0	3438.0										
91.8	0.0	80.0	2.5	80.0	3438.0										
91.8	0.0	45.0	3.0	75.0	7.6	112.5	13.9	135.0	19.5	150.0	24.4	120.0	48.8	120.0	228.6
104.9	0.0	45.0	3.0	75.0	7.6	112.5	13.9	135.0	19.5	150.0	24.4	120.0	48.8	120.0	228.6
104.9	0.0	52.5	3.0	87.5	7.6	131.3	13.9	167.5	19.5	180.0	24.4	140.0	48.8	140.0	228.6
124.0	0.0	87.0	2.5	87.0	3438.0										
124.0	0.0	87.0	2.5	87.0	3438.0										
126.0	0.0	87.0	2.5	87.0	3438.0										
126.0	0.0	87.0	2.5	87.0	3438.0										
140.9	0.0	72.0	3.0	120.0	7.6	188.8	13.9	222.5	19.5	240.0	24.4	192.0	48.8	192.0	228.6

Notes:
 1. "T" is load in kilopascals, [kPa]
 2. "Z" is displacement in millimeters, [mm]
 3. Data for tension and compression coincide.

A typical soil data report

Enter Soil Curve Data

Metric: [Dropdown] Unit Selector: Type 1 Minimum layer thickness: 0.1 m

Pile Diameter: 243.8 cm

Add Sol Curve
 Sol Curve Type: T-Z

Depth Below Mudline: 14.90 m TFactor: .0001 ZFactor: .499

Use Constant Values [Checked] Symmetric Data [Checked]

#	Depth	Curve Type
1	0.01	T-Z
2	1.55	T-Z
3	3.30	T-Z
4	3.45	T-Z
5	9.80	T-Z
6	9.95	T-Z
7	14.90	T-Z
8	15.05	T-Z
9	27.90	T-Z

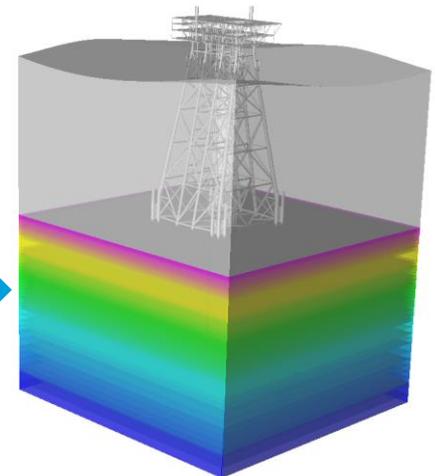
T [kN/cm²] Z [cm]

Date: 13 Oct 2015 17:00:32

T-Z Curve

Save Data to file [Button] Generate JS File [Button] Close [Button]

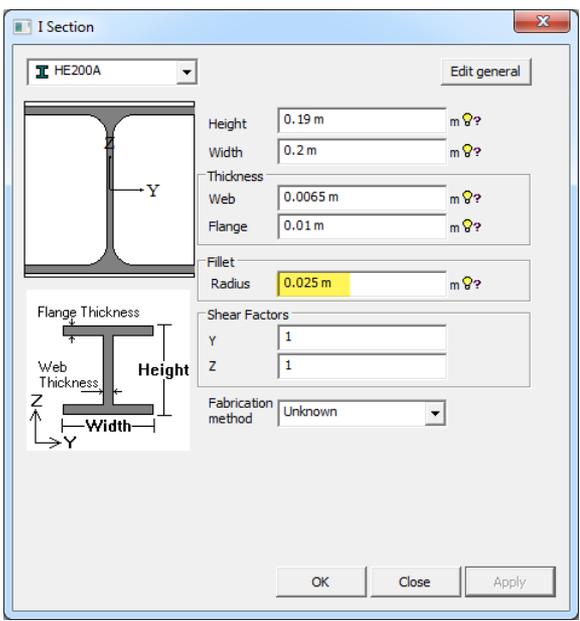
Import the data report and automatic conversion to analysis format. Flexibility to check and change if needed



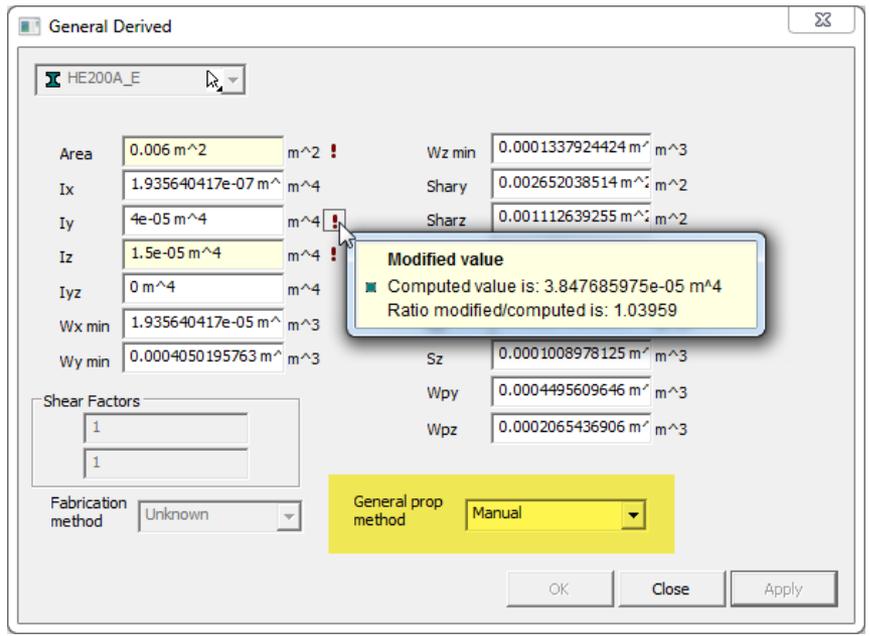
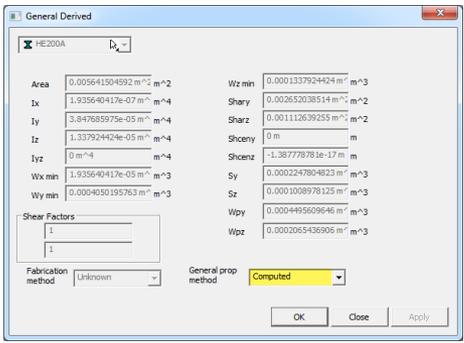
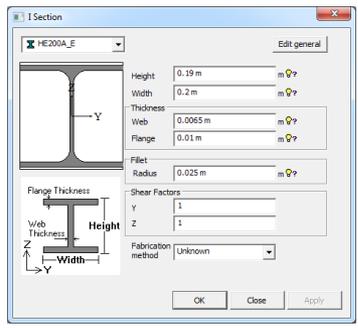
The soil data imported and ready for analysis

Speed up modelling – Example 4

- Include fillets in I and L profiles

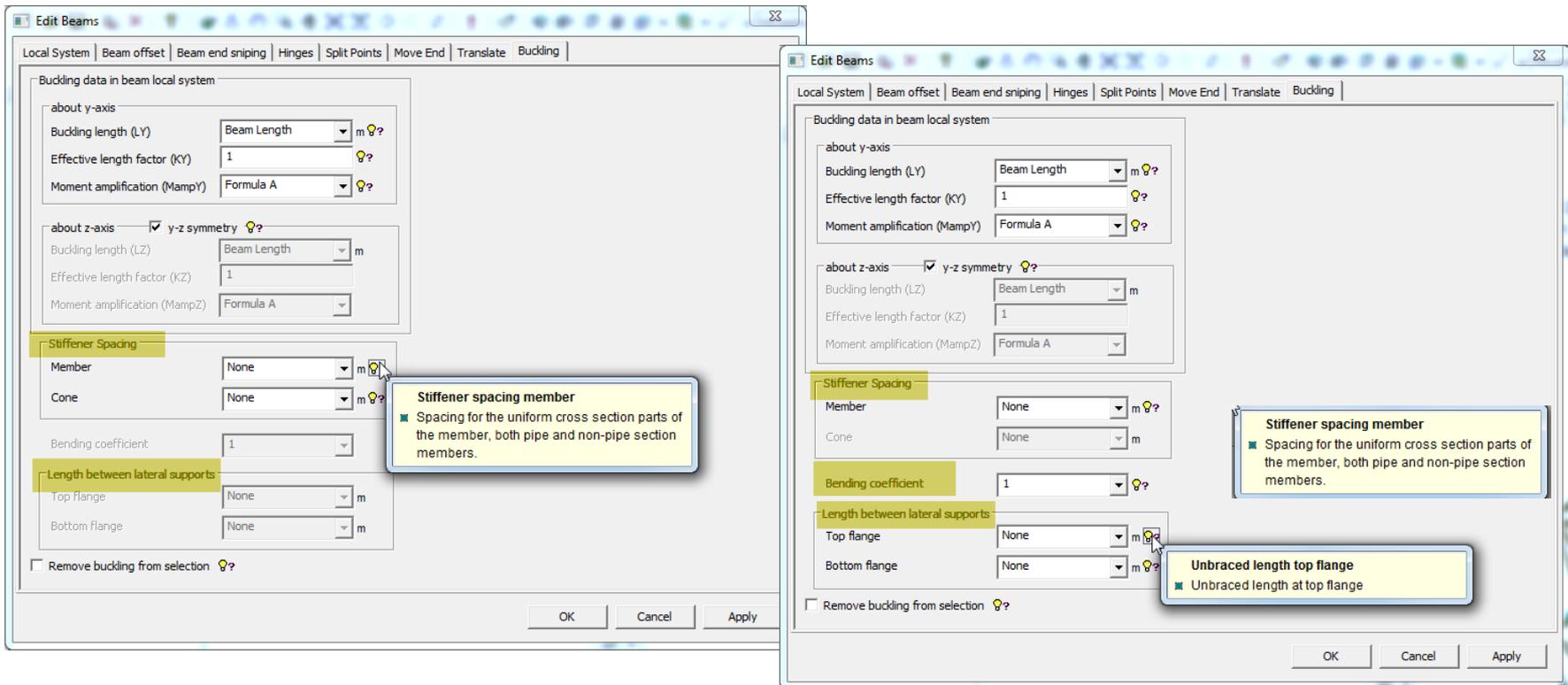


- Edit all section properties



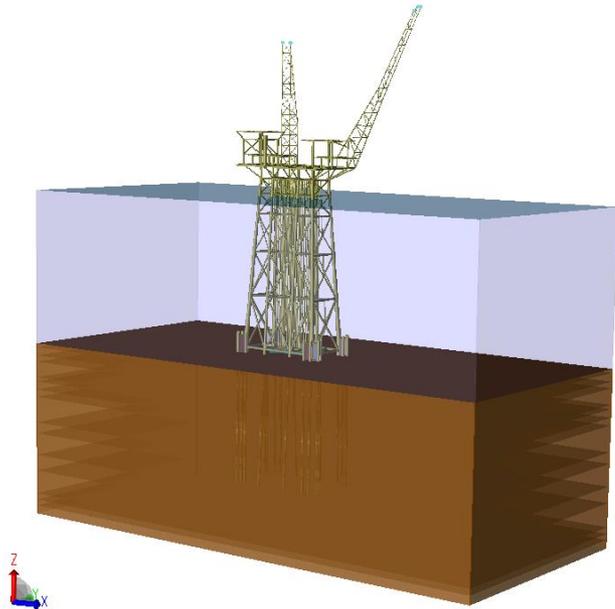
Speed up modelling – Example 5

- Complete code check definition on structure concept model
 - Now easier since all can be defined on structure concept model – the new definitions to structure concept model are highlighted below



Speed up modelling – Example 6

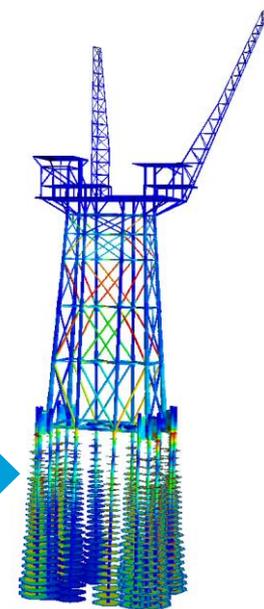
- Previously it was needed to run a utility tool to convert the pile and soil data used in a linear structural analysis including a non-linear pile-soil analysis (i.e. by use of Splice)
- This is no longer needed as a Splice analysis always will create the pile and soil data for use in Usfos



***Linear model (GeniE) with
pile and soil data***



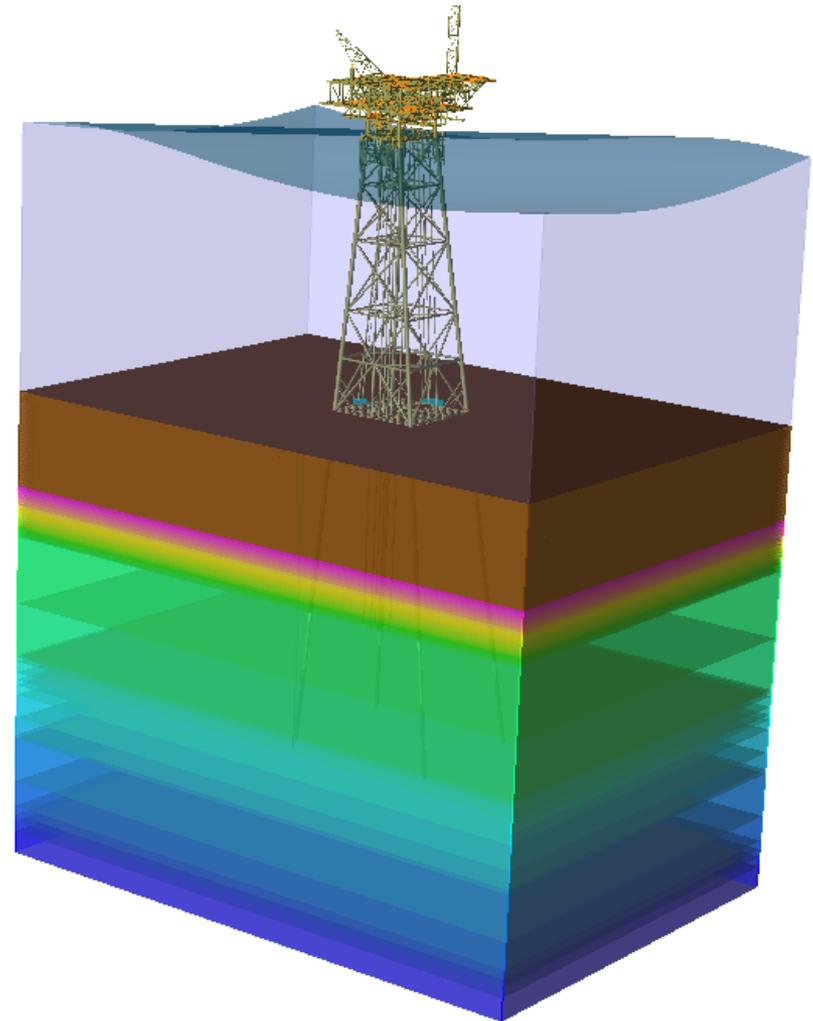
***Automatic data
conversion
of pile and soil data***



***Non-linear model (Usfos)
with pile and soil data***

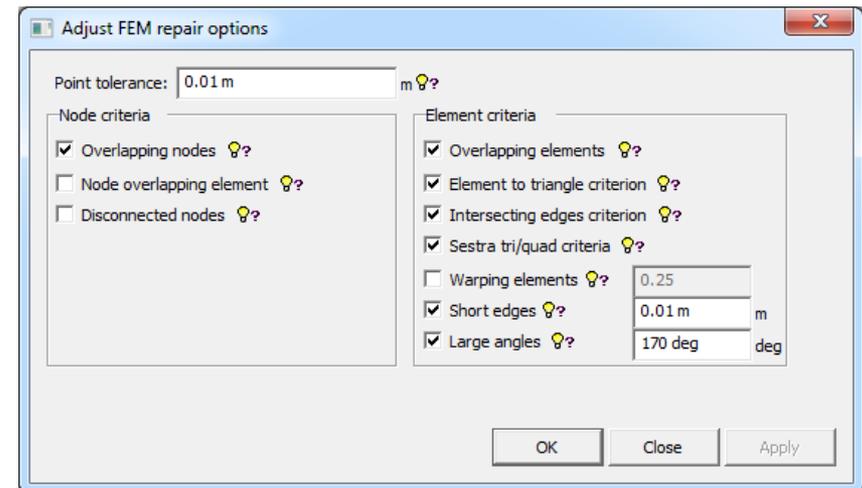
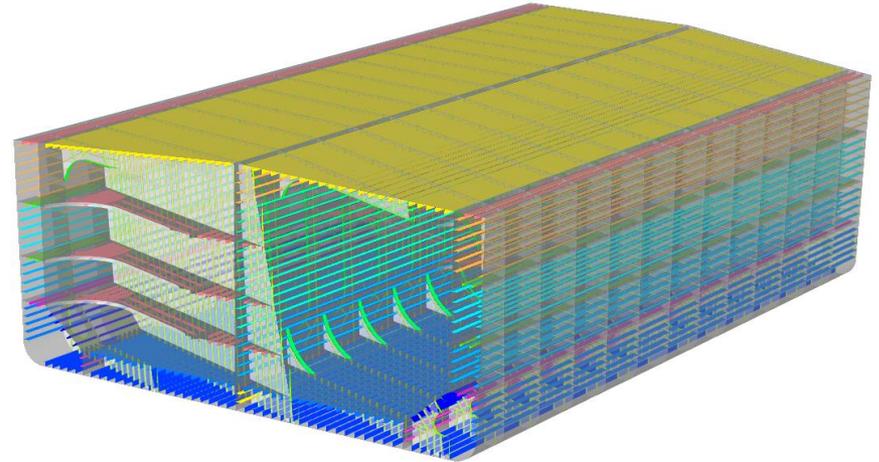
Re-use other data - 1

- For fixed structures – from Sacs
 - Import structure, segments, concentric members, sections, materials, loads, weight, load combinations, wave load data, multiple water depths, sea state dependent coefficients, marine growth data, wind velocity, wind area, pile, 'wishbones', soil, member code check data, cone and joint can reinforcement
- From StruCad3D & StaadPro
 - Structure, sections, materials, loads & load combinations



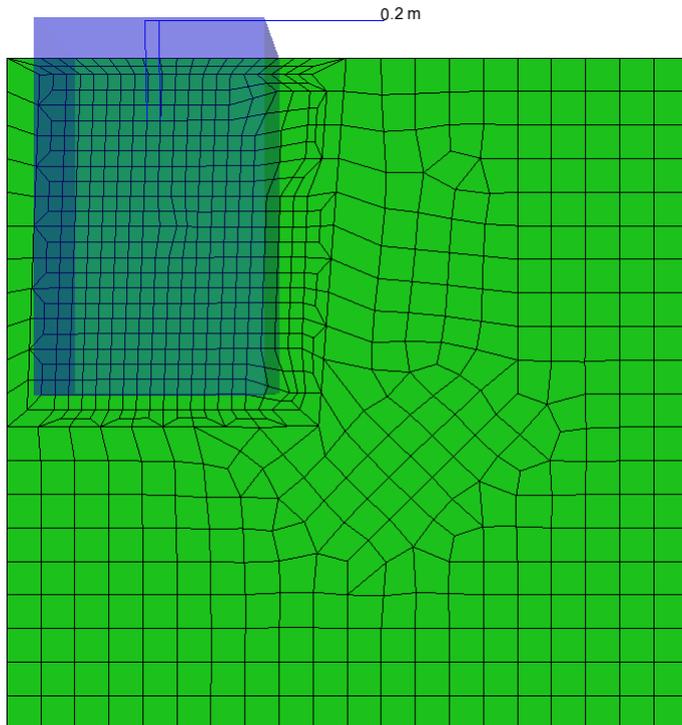
Re-use other data - 2

- Import curves and create surfaces
 - Import cross section data from Nauticus Hull
 - Import DXF curves from CAD systems
 - Import curve data from Rhino 3D
- Import surfaces
 - From NAPA via Sesam Hull Translator
 - Via the ACIS .SAT format
- Import complete models (structure & properties)
 - Via the Sesam FEM format (Nastran, Ansys, Napa Steel, Aveva)



Full control of mesh quality

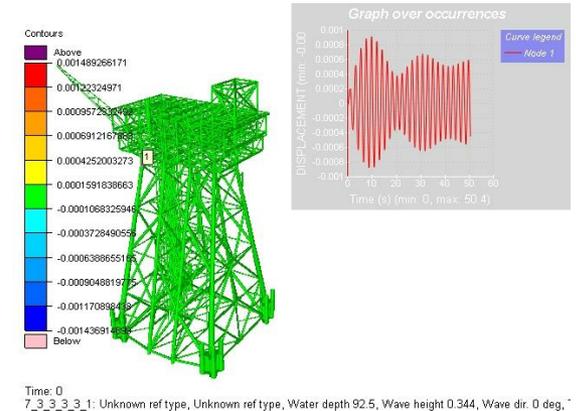
- Automatic meshing gives often a satisfactory mesh layout. In some cases it is necessary to edit or to refine the mesh to achieve the desired quality (details, mesh for fatigue etc.)
- Below are two examples of autogenerated refined mesh – the user does not need to make the transition between coarse and refined mesh



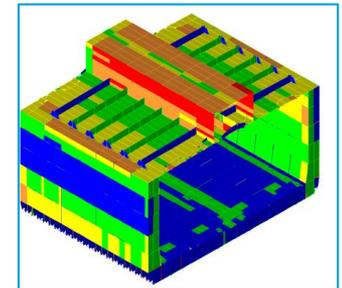
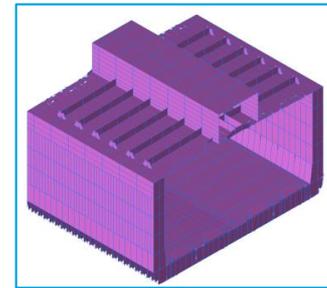
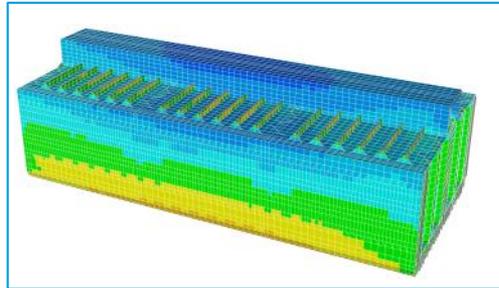
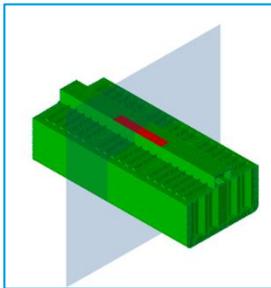
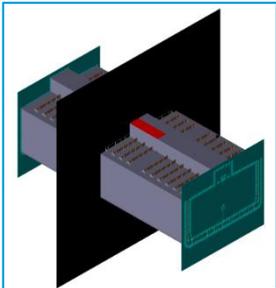
Faster analysis

- Time and frequency domain forced dynamic analyses are now **30 times faster than before**

- Faster analysis – typically 20 min vs 11 hours
- Many more wave load conditions can be included
- Run much larger analysis than before
- Automatically detect steady state for use in fatigue
- Automatically create RAO and base shear



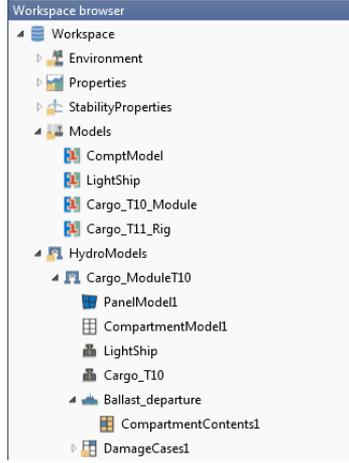
- Linear static analysis of 3 Cargo Hold Analysis and topside analysis without environmental data is **3 times faster than before**



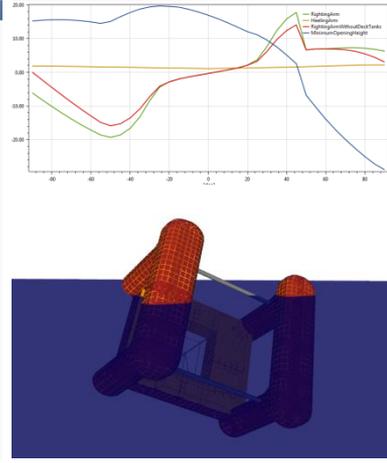
A significant improvement of stability analysis

Function

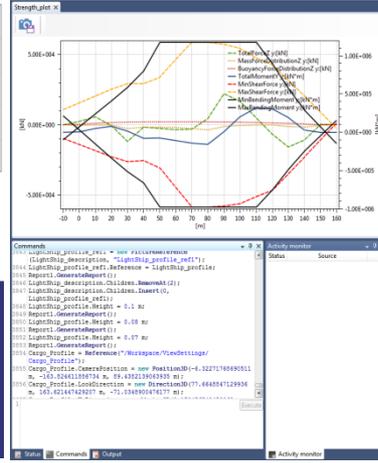
User friendly



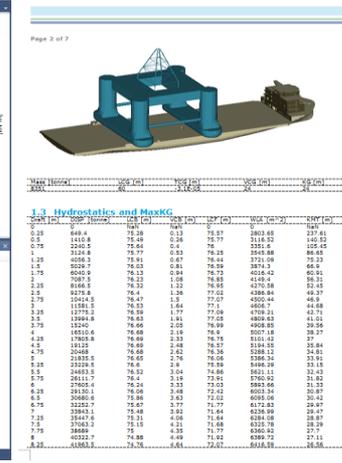
Robust



Flexible

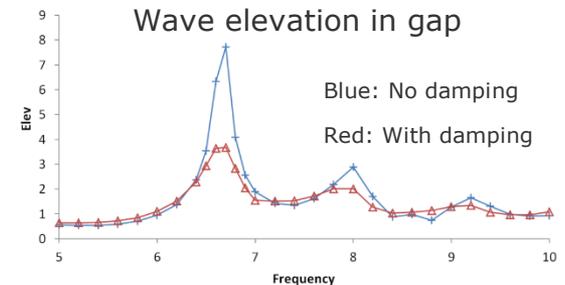
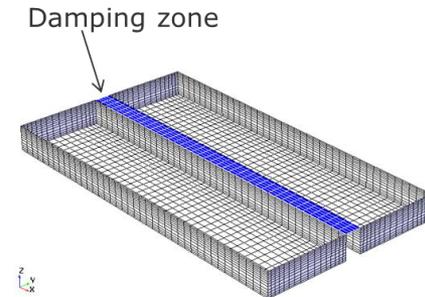
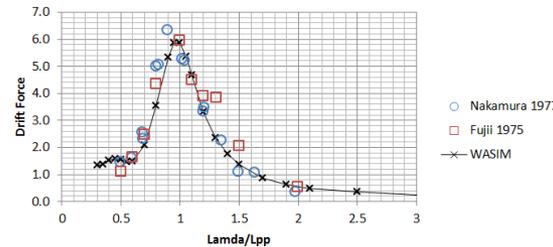
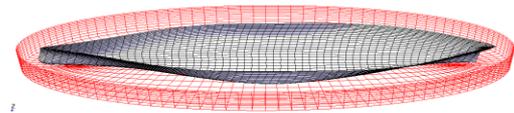
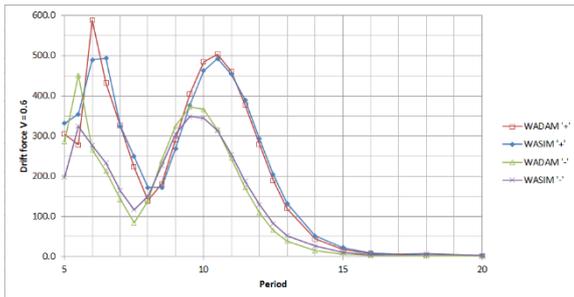


Reportable



Advances in hydrodynamic analysis

- Include low forward speed in frequency domain analysis (wave/current interaction)
- Compute added resistance for vessels with forward speed (time domain analysis)
- Free surface damping
- 64 bit software
- Larger models
- **2 times faster**



Complete functionality for structural assessment during new design, operation and life extension of fixed and floating structures

ULS, FLS, ALS

Completeness means no need for using multiple tools – fewer data transfer problems, lower license costs, lower training costs

Code checking – API, AISC, ISO, NORSOK, EUROCODE

- Member code check
 - Normally deterministic loads
- Tubular joint check
 - Normally deterministic loads
- Topside floater
 - Integrated floater analysis (frequency or deterministic loads)
 - Accelerations
 - RAO

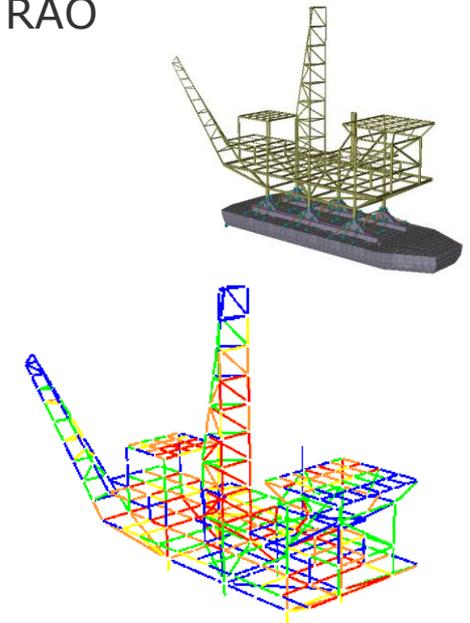
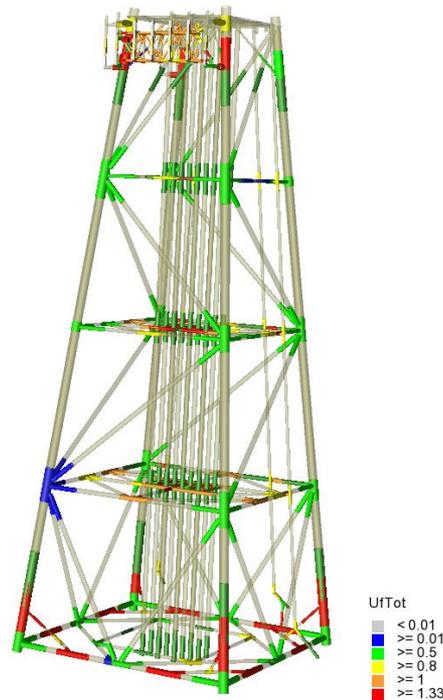
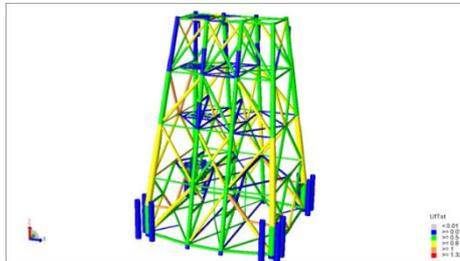
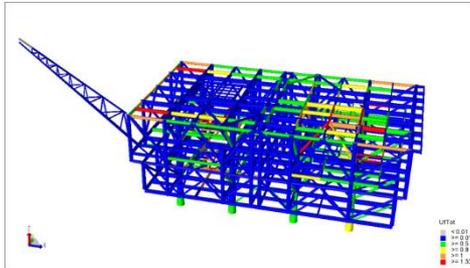
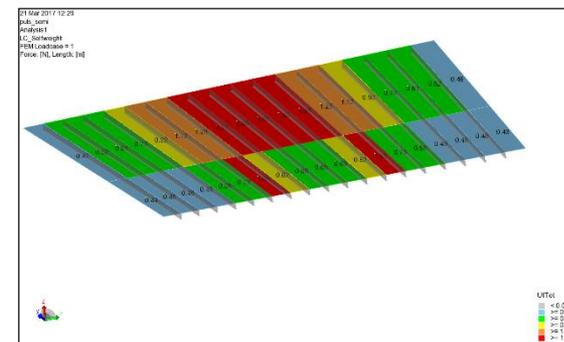
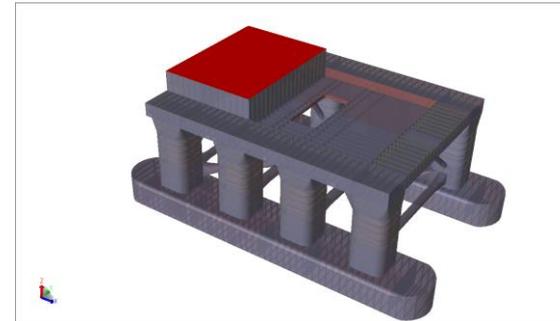
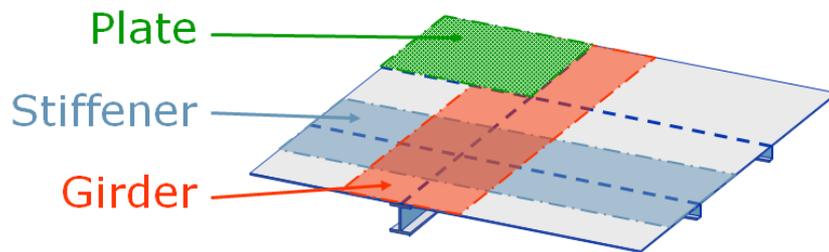
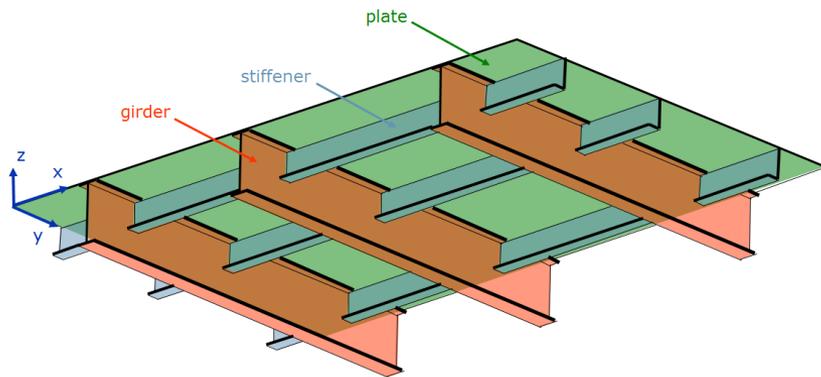


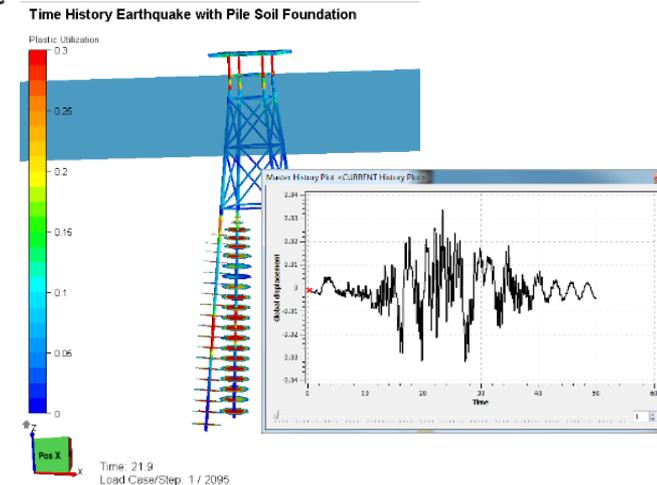
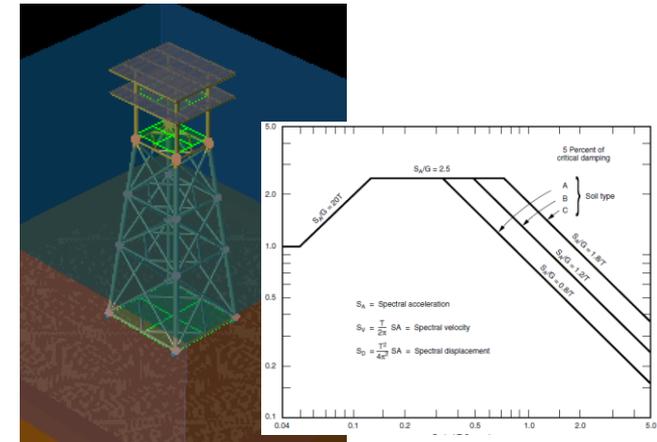
Plate code checking

- When topside/deck is an integrated plate construction instead of typical I/Box/L profiles
- Plate code check according to NPD, DNV RP-C201.1, DNV RP-C201.2 (Puls), API



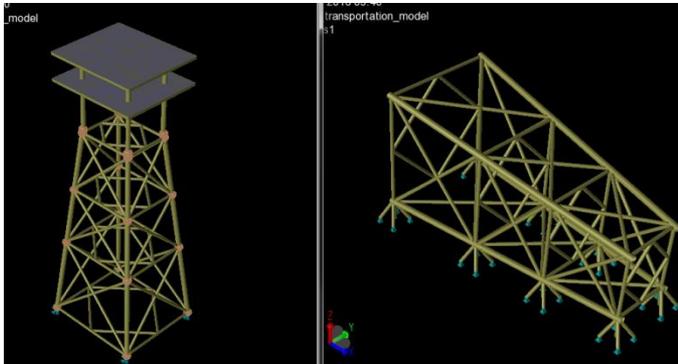
Earthquake analysis and code checking

- Response spectrum approach strength level earthquake analysis and the code checks based on API RP 2A 21st/22nd, ISO and Norsok
 - User defined ground response spectrums gives flexibility
 - Multiple modal combination methods provided by the program
 - Comprehensive static and seismic load combinations to ensure the safety of each member and connection
 - Fully supporting the member and tubular connection code checks according to the latest API RA 2A edition
- Ductility level earthquake design analysis
 - Support non-linear time history response analysis from the ground acceleration time history
 - Include both the plasticity of the structure and the non-linear soil
 - Use the linear model as basis to increase the efficiency



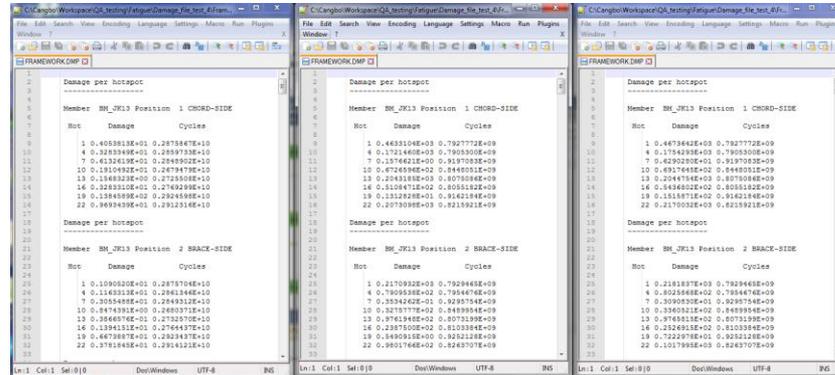
Member fatigue

- Deterministic, stochastic, spectral, time domain fatigue and simplified deterministic
- Static or dynamic structural analysis
- Periodic or non-linear time domain wave loads
- Fatigue accumulation
 - The damage of **each** hotspot can be accumulated automatically, **Sesam is alone to do this**
 - The analysis models are different in the various fatigue analyses. Previously time consuming hand calculations at key locations had to be used to accumulate the fatigue



**In-place
analysis model**

**Transportation
analysis model**

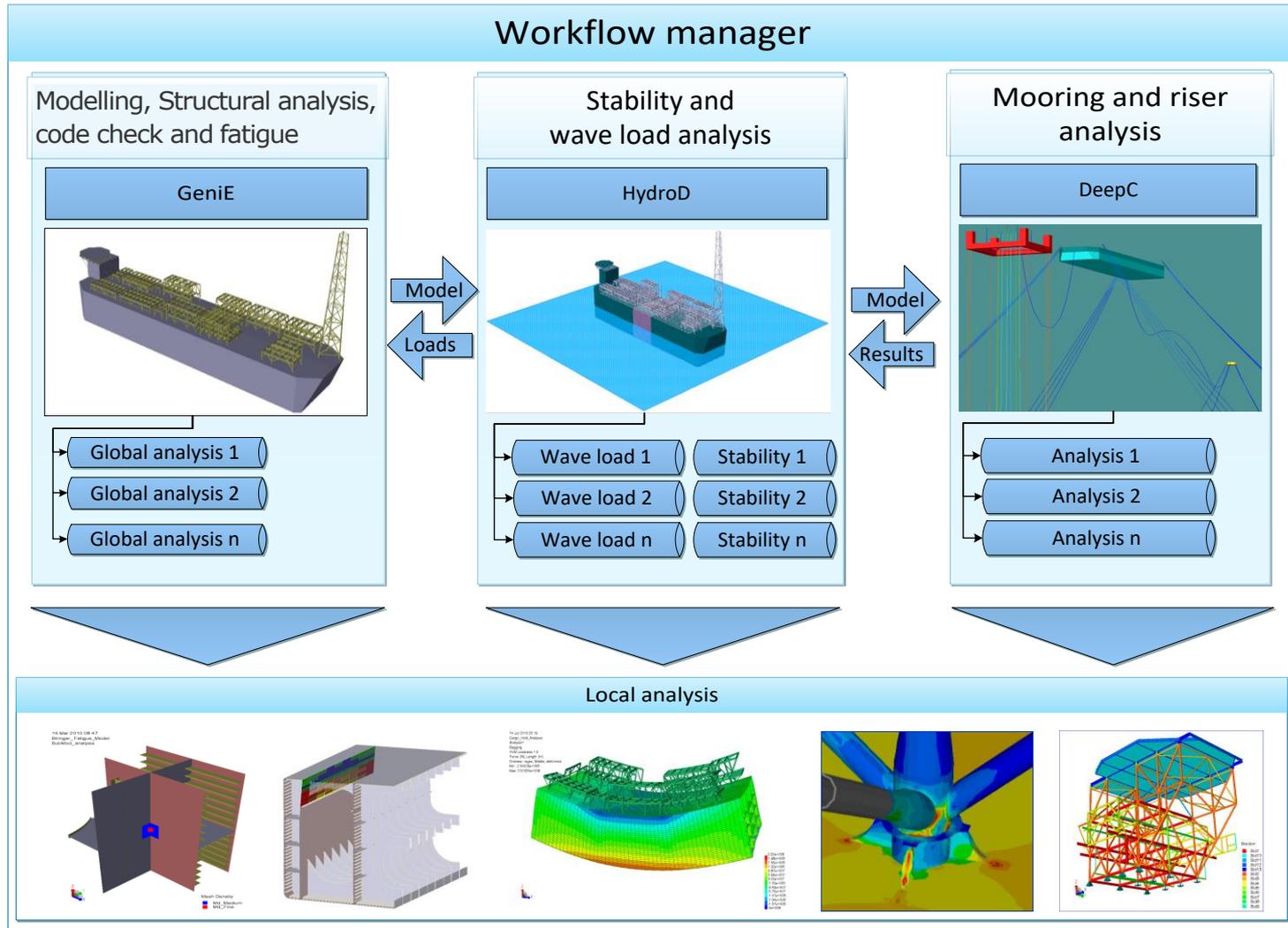


**In-place
fatigue results**

**Transportation
fatigue results**

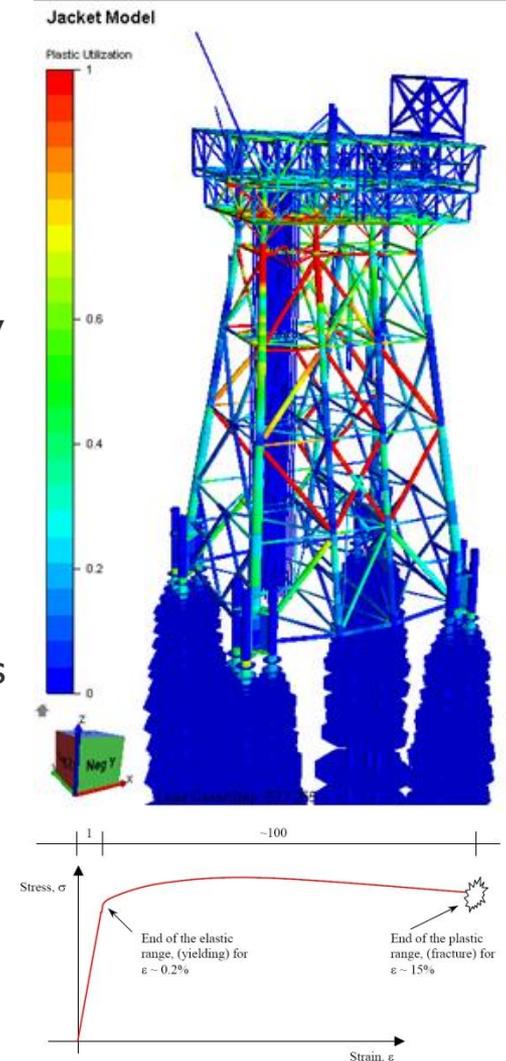
**Accumulated
fatigue results**

Fatigue of plated structures

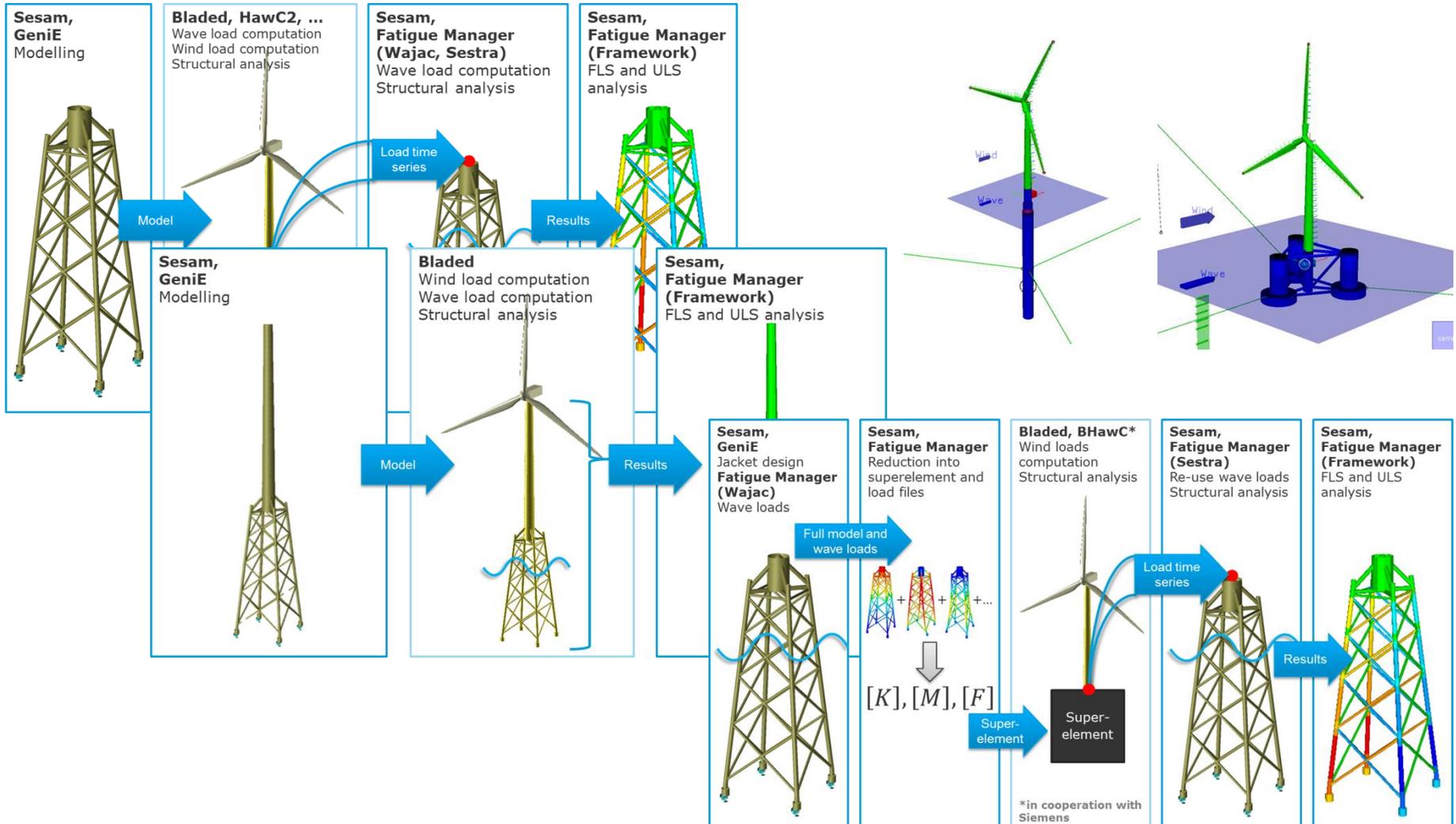


Non-linear analysis – “push-over”, accidents etc.

- Used in new design, operation and life extension
 - Static and dynamic non-linear pushover analysis due to design wave condition (e.g. to find Reserve Strength Ratio RSR)
 - Static and dynamic non-linear analysis due to large deformations and accidental loads (dropped object, ship impact, blast & fire)
- Gaining performance and quality
 - Non-linear dynamic response analysis based on true non-linear theory and not only a dynamic response based on linear assumption
 - Unloading is key in non-linear analysis; the unloading process is handled accurately
 - Automatic detect steady state and very fast analysis; purpose built solver
 - Use the linear model as basis to increase the efficiency



OWT foundation analysis



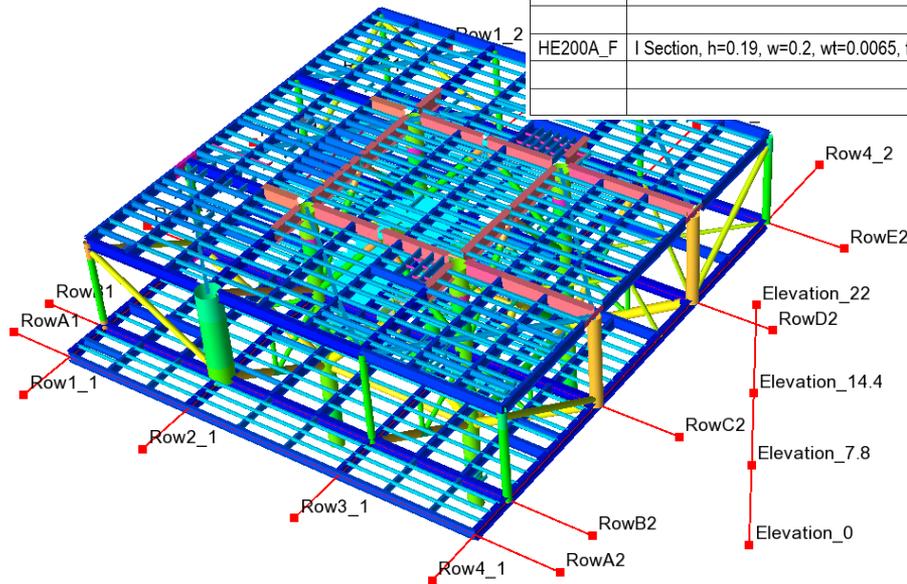
Verify and document:

Less work for you. Less work for those reviewing your work.

We focus both tabular reports and graphics

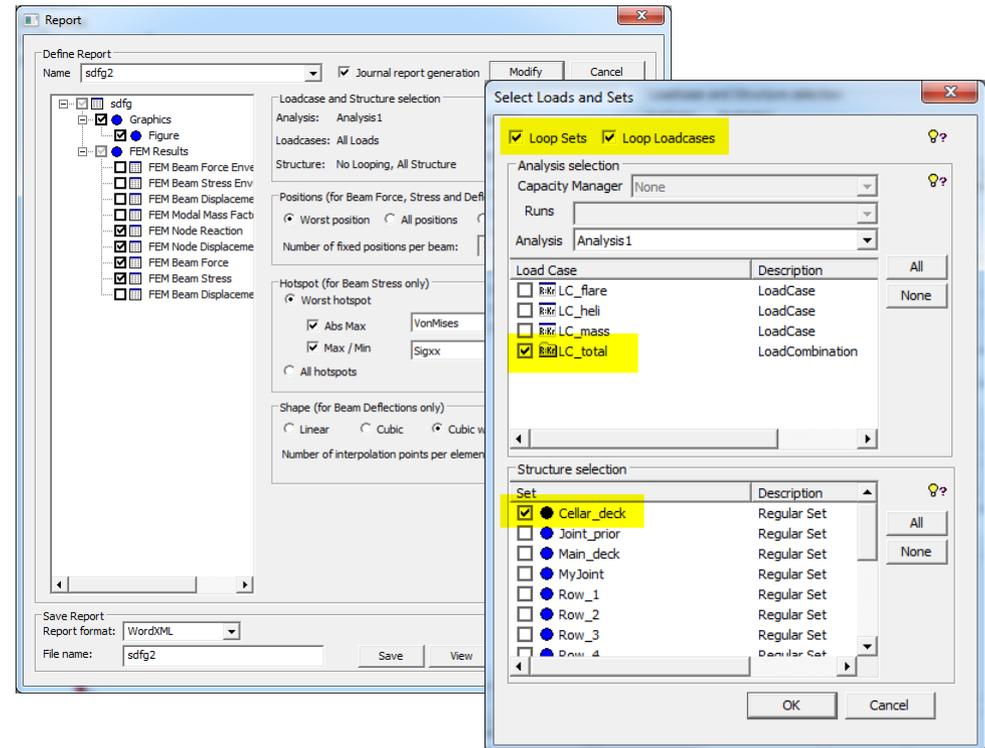
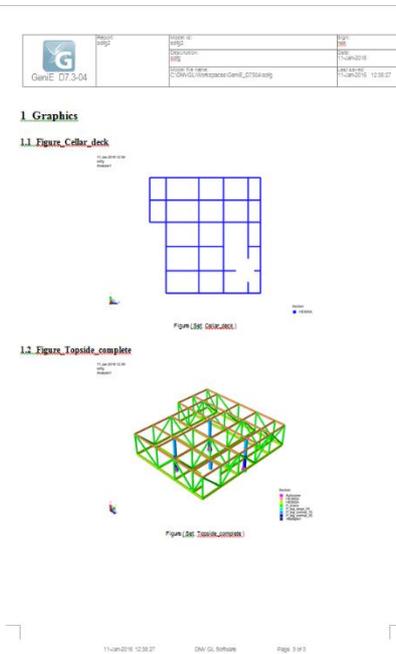
- Tabular reports are necessary because of precision
- Graphics (pictures) speed up the understanding of a model

Name	Description	Area [m ²]	Ix [m ⁴]	Iy [m ⁴]	Iz [m ⁴]	Iyz [m ⁴]	Wxmin [m ³]	Wymin [m ³]
		Wzmin [m ³]	Shary [m ²]	Sharz [m ²]	Shceny [m]	Shcenz [m]	Sy [m ³]	Sz [m ³]
		Wpy [m ³]	Wpz [m ³]	Method				
HE200A	NVS lib : HE 200 A NS-EN 10034	0.005105	1.93564e-07	3.50945e-05	1.33372e-05	0	1.93564e-05	0.000369416
		0.000133372	0.00264371	0.00112106	0	0	0.000203481	0.000100898
		0.000406963	0.000201796	Computed				
HE200A_E	I Section, h=0.19, w=0.2, wt=0.0065, ft=0.01, fr=0.025	0.006	1.93564e-07	4e-05	1.5e-05	0	1.93564e-05	0.00040502
		0.000133792	0.00265204	0.00111264	0	-1.38778e-17	0.00022478	0.000100898
		0.000449561	0.000206544	Manual				
HE200A_F	I Section, h=0.19, w=0.2, wt=0.0065, ft=0.01, fr=0.025	0.0056415	1.93564e-07	3.84769e-05	1.33792e-05	0	1.93564e-05	0.00040502
		0.000133792	0.00265204	0.00111264	0	-1.38778e-17	0.00022478	0.000100898
		0.000449561	0.000206544	Computed				



Reports can be made to your preference

- Word, Excel, text, web based
- Tabular and graphics
- Picture generation can be automated
- Standard report templates can be made and shared

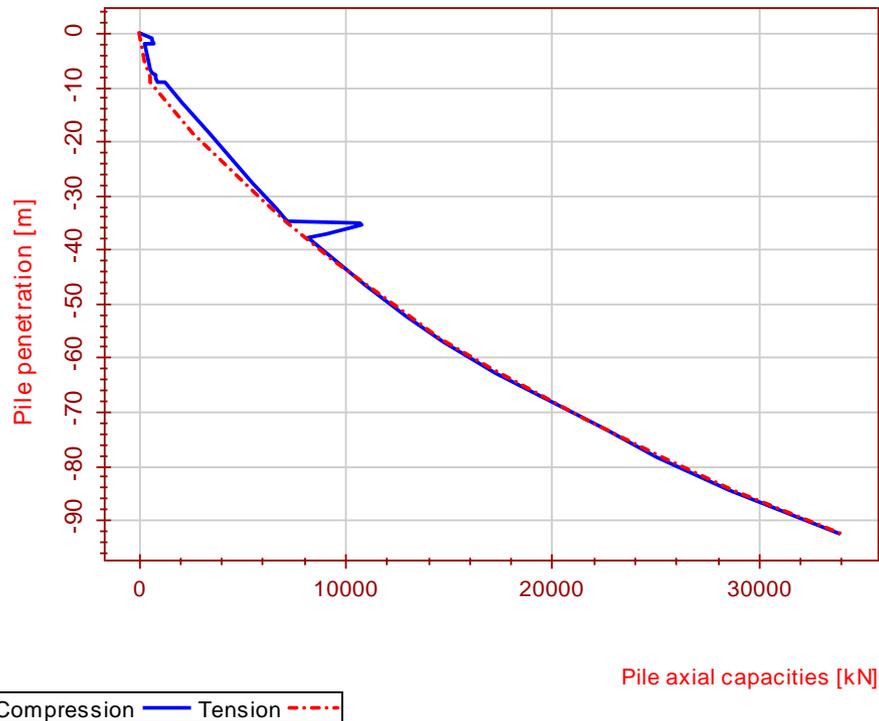


Instead of reading an output file and extract data to Excel – now it is a single click to make the 2D graphs

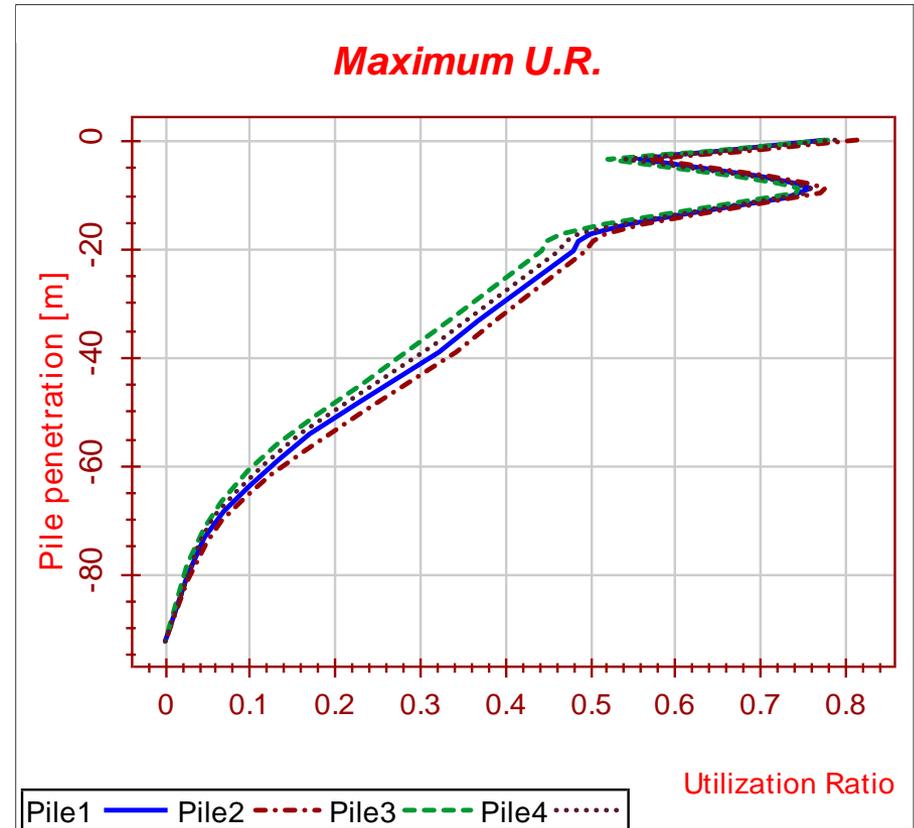
We are on the move to simplify results viewing

- Example showing pile capacity and pile code check results – “show me results”

Pile1: Pile capacity versus length (Pile weight included)



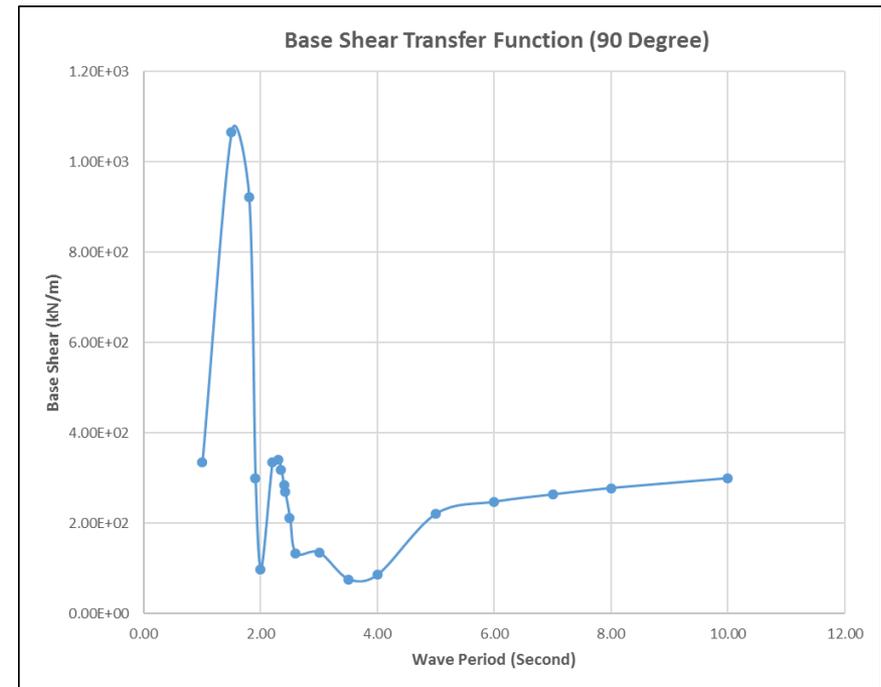
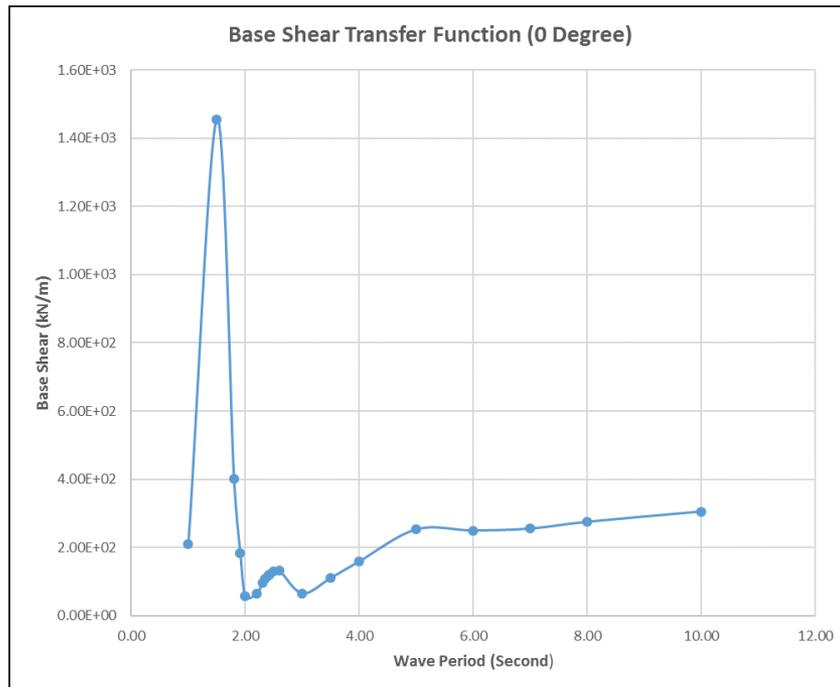
Maximum U.R.



*Instead of using two extra
Sesam programs – now it is
a single import to Excel to
make the 2D graphs*

We are on the move to simplify results viewing

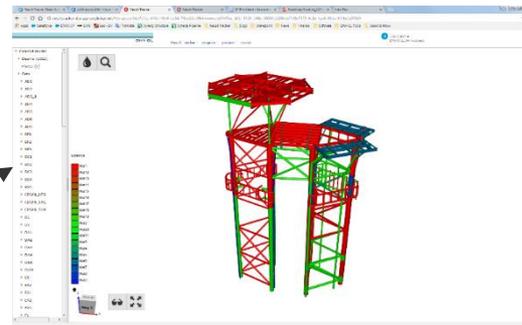
- Base shear from dynamic analysis



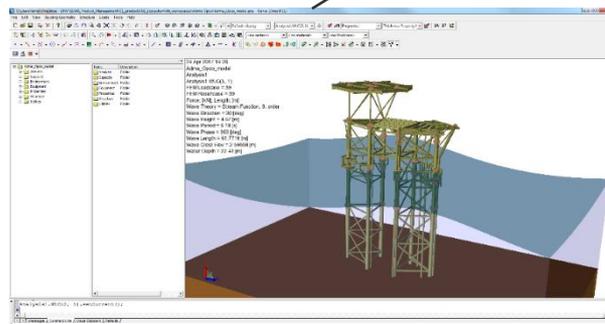
No need to be a software tool expert to view and understand a model and it's results

The main benefits of our Structure EcoSystem

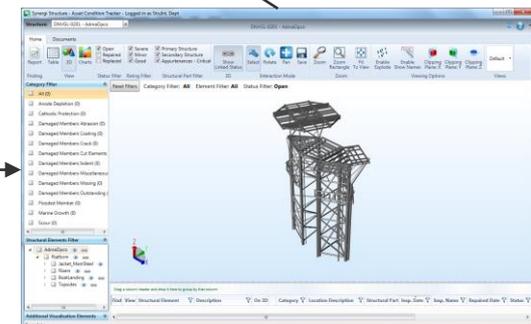
- Asset owners (or others) can review model, code check/fatigue results and inspection findings on same model
- Various sub-contractors can do strength assessment and inspection management on same asset(s)



**Structure EcoSystem
The Digital Twin Viewer**



Sesam for Strength Assessment



**Synergi Structure for Asset
Integrity Management**

To summarize

Sesam for design and strength assessment of Fixed Structures

- Engineering efficiency through
 - Concept modelling
 - Code checking & re-design and design iterations
 - Very fast fatigue analysis
 - Accurate non-linear analysis
 - Data model supporting new build, operation and life extension
 - Re-use other legacy data
- Supported by
 - Competent technical support with design experience
 - Transparent licensing model
- Interaction with our solution for asset integrity management



Customer driven development

- "Trust & influence; we need someone to talk to"
- We release regularly with new functionality to help engineers increase efficiency

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Poll 3

Are there any specific topics within design and operations you would like to explore further:

- 1) Fixed structures
- 2) Floating structures
- 3) Offshore Wind Turbine (OWT) foundation structures
- 4) Marine structures (risers, moorings, sub-sea templates)
- 5) Other

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