Master Thesis

Automated Modelling of Ship Structures in Early Ship Design Phase

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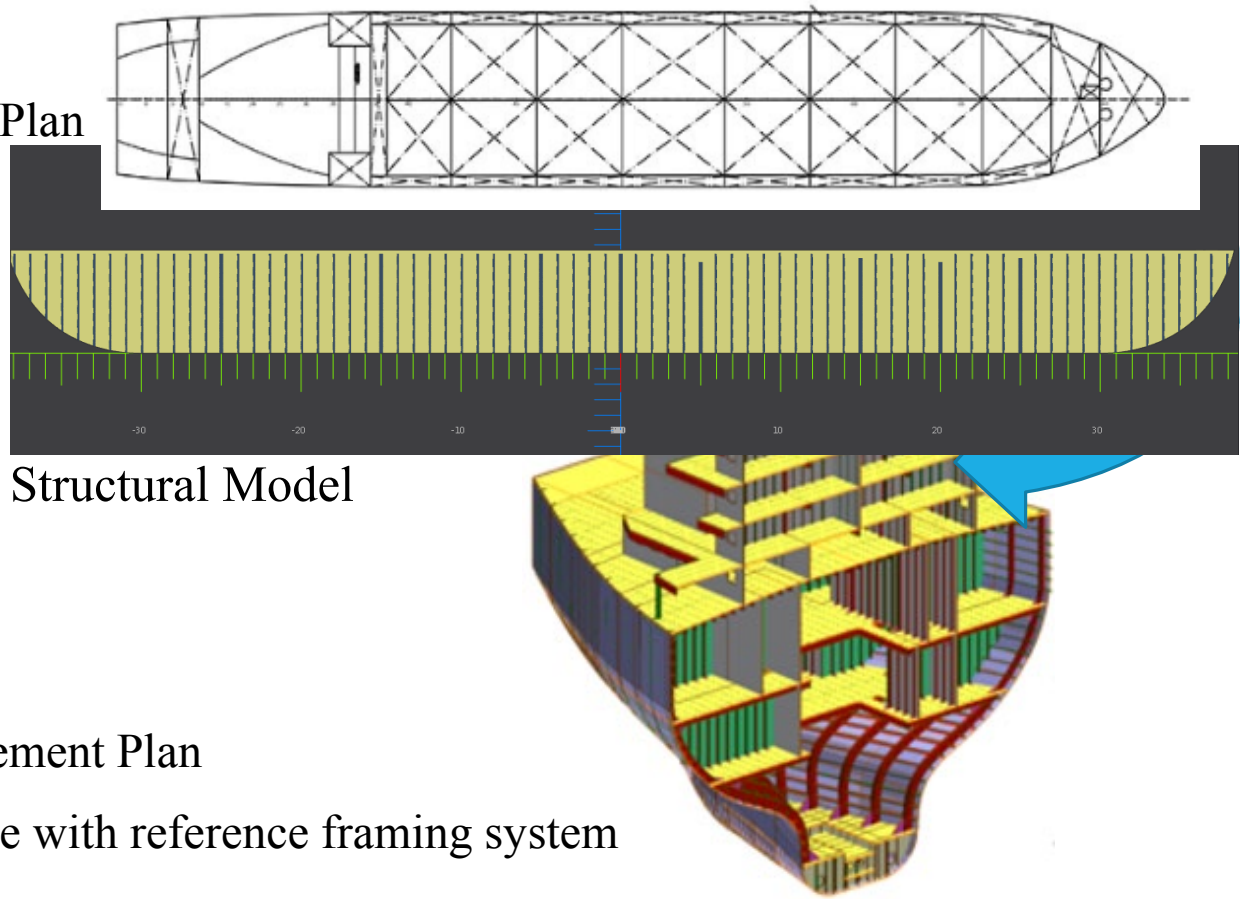
MOTIVATION

- Automate 3D modelling
- Structural Model in early design stage
- 3D structure model – Export for FEA
- Preliminary global strength check at early design phase
- Approx. margin in longitudinal strength – Flexibility for designer
- Minimize human effort
  - No drawing preparation
  - Save time – Miscellaneous calculations – BOM, weld length, paint area, weight estimation etc.

SCOPE OF WORK

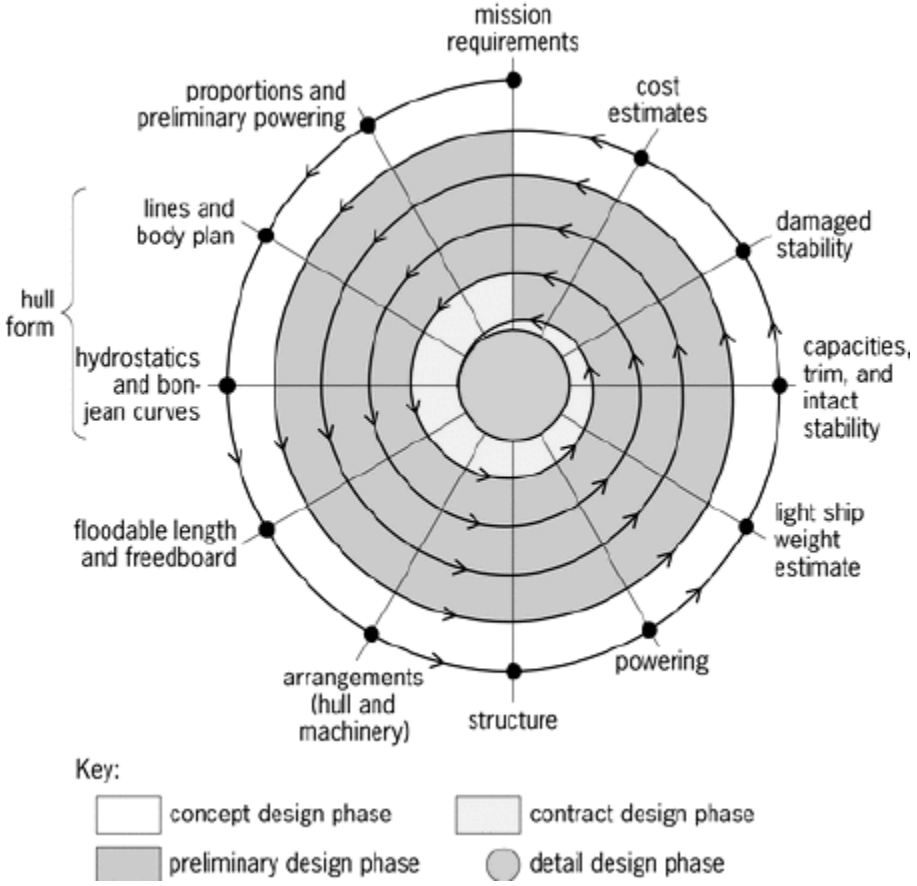
- INPUT
  - Structural arrangement/General Arrangement Plan
  - Scantling data
  - 3D hull form
- Spreadsheet Template – Structural details
- Bridge Script – Convert Spreadsheet data to 3D Structural Model
- OUTPUT
  - 3D structural Model
  - Plate arrangement same as in General Arrangement Plan
  - Structural Members (Stiffeners/Girders) in line with reference framing system



Picture from: Home - Napa, 2018, www.napa.fi

CHALLENGES FOR 3D STRUCTURE MODELLING IN EARLY DESIGN STAGE

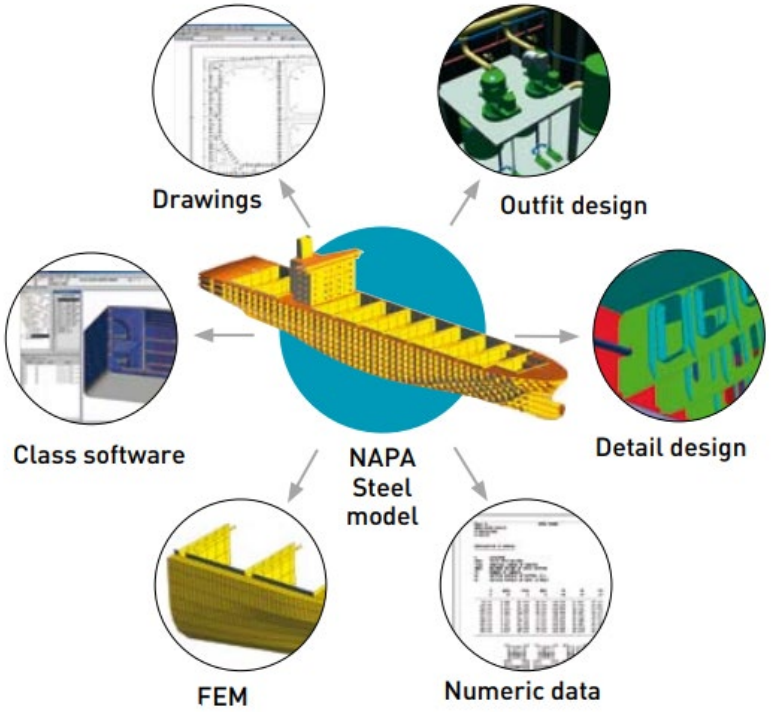
- Early Design - Concept and preliminary stages
- Short time period – Few weeks
- 3D Model - Generated in detailed design
- Data available, but ... need plenty of human hours
- Difficult to incorporate design revisions
- Lot of time - structural details (bracket, manholes)



Picture from : Vossen, Christina & Kleppe, Robert & Randi Hjørungnes, Siv. Ship Design and System Integration, 2013

AUTOMATION - NAPA & FEATURES

- Automation – 3D structure modelling faster
- Implemented using NAPA C# scripting platform
- Steel model – Early design stage
- Same model – Different functions
  - Numeric data – COG, BOM, weight, weld length etc
  - Idealized meshed model for FEA
  - 2D structure and plan drawings
- NAPA interface complies major class rules



Picture from: Home - Napa, 2018, www.napa.fi

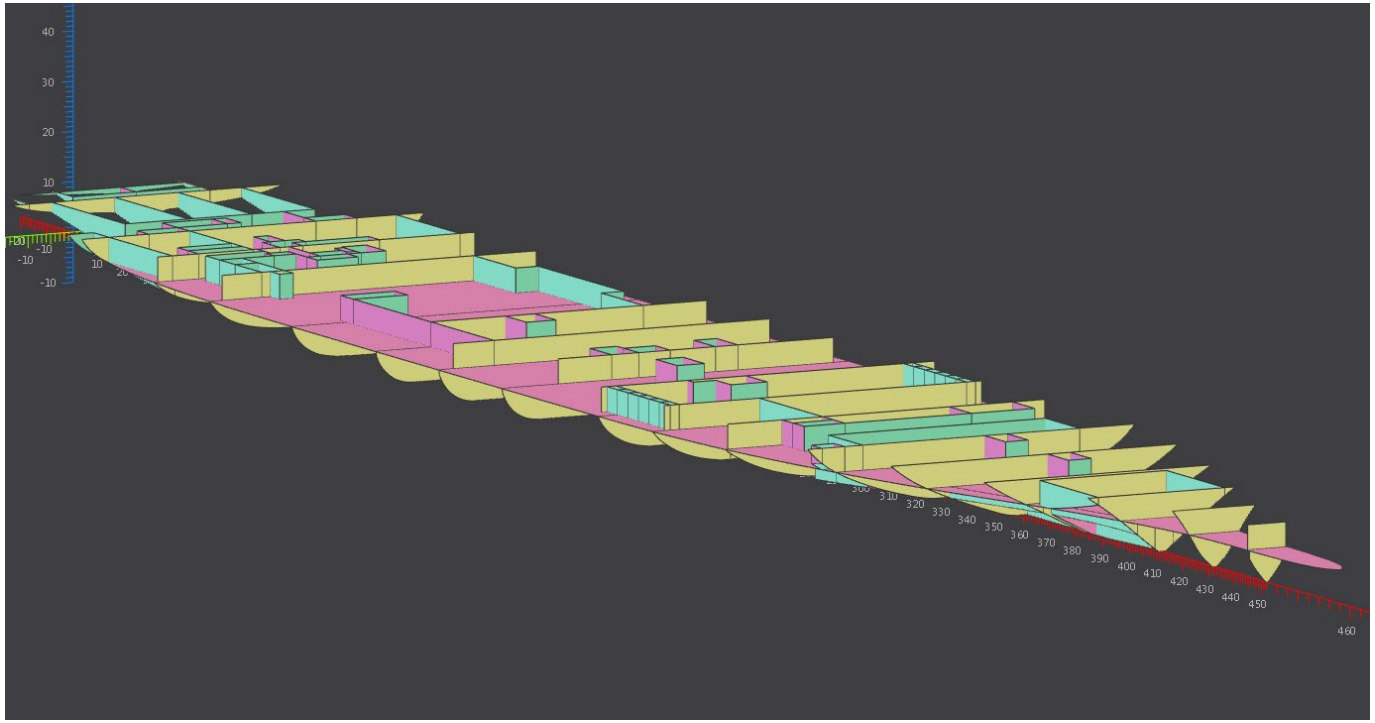
WORK FLOW

- Input Data
  - 3D Hull Shape – Hull form software
  - General arrangement plan – .dxf format
  - Spreadsheet with structural details – scantling calculation
- 3D structure model generation
  A. Generate horizontal decks
  B. Create vertical walls – Extrusion Tool
  C. Automatic generation of structural members based on spreadsheet input
  D. Modification of structure model – Drawing revisions

A B C D

GENERATE HORIZONTAL DECKS

- Horizontal decks generated – Required heights (eg: z = 5.0, 8.0)
- Decks trimmed – Ship 3D hull form
- Assign structure type – “DECK”
- Whole deck – Single piece



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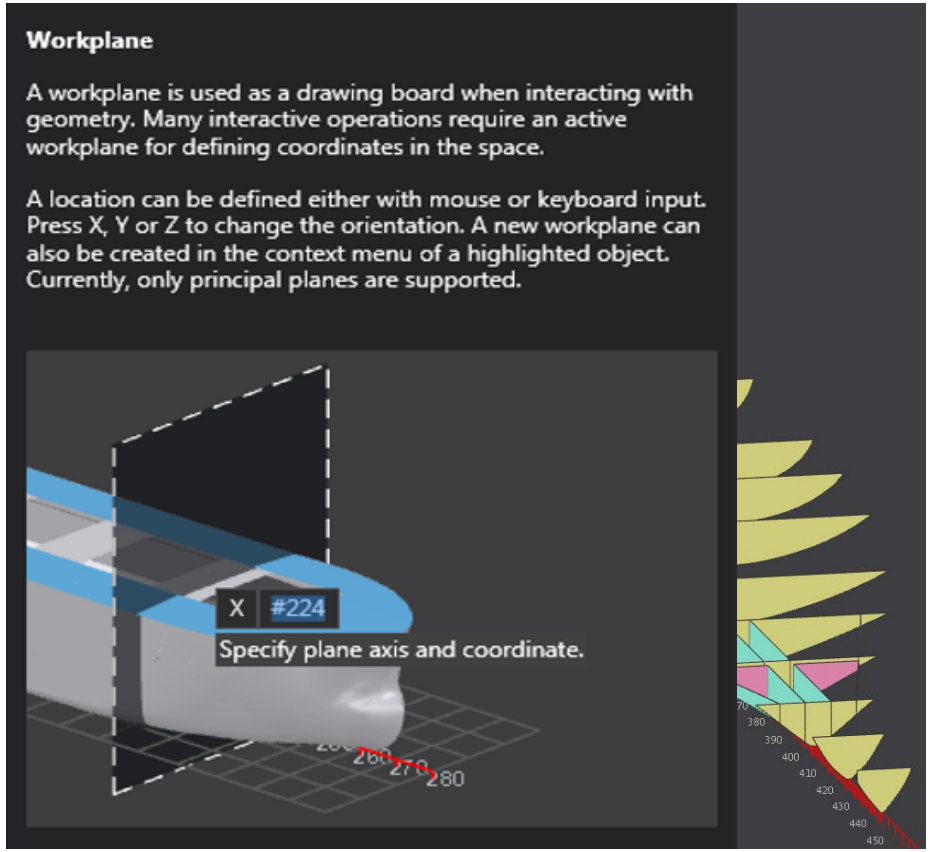
EXTRUSION TOOL – VERTICAL WALLS

- Import – .dxf format general arrangement plan
- Each deck plan separately – Workplane (eg: XY plane @ z=0)
- Reference point to import – Origin (0, 0, 0)
- Each line extruded within min and max limits
- Vertical walls trimmed – Ship hull form
- Important !!! Drawing quality
  - Continuous line – Not broken or split
  - Connection between lines – Proper
  - No deck boundaries



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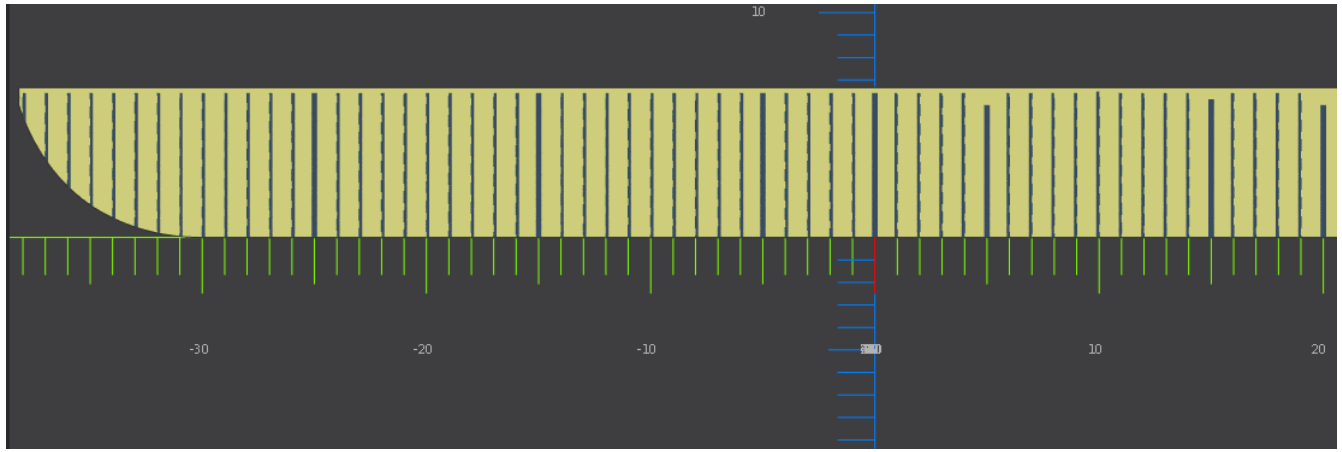
AUTOMATIC GENERATION OF STRUCTURAL MEMBERS

- Bounding box – Based on limits

Limits & Structural Type							Stiffener			
Sl.No	MVZ	Z min	Z max	Y min	Y max	Type	Stiffening	Moulded	Material	Profile Size
1	2	4.00	7.00	-25.00	25.00	LBH	VERTICAL	FRONT	AH32	FB150X10

- Selection Criteria – Based on structure type (blank means all members)
- Select objects with COG inside bounding box – Satisfying selection criteria
- Create trace lines – Stiffening type
- Trace lines – Reference framing system
- Generate stiffeners – On trace lines
- Profile size, material and direction



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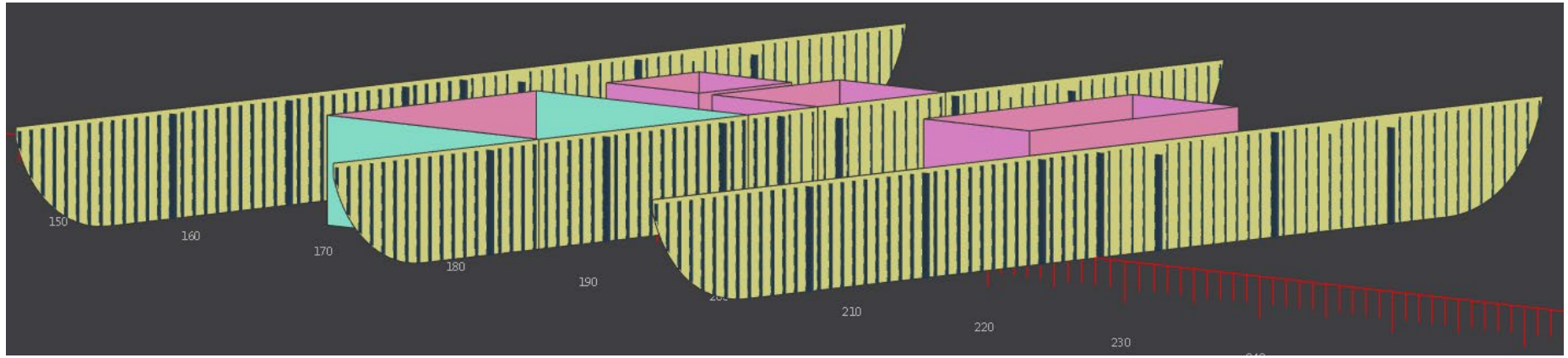
AUTOMATIC GENERATION OF STRUCTURAL MEMBERS

- Same procedure for girders

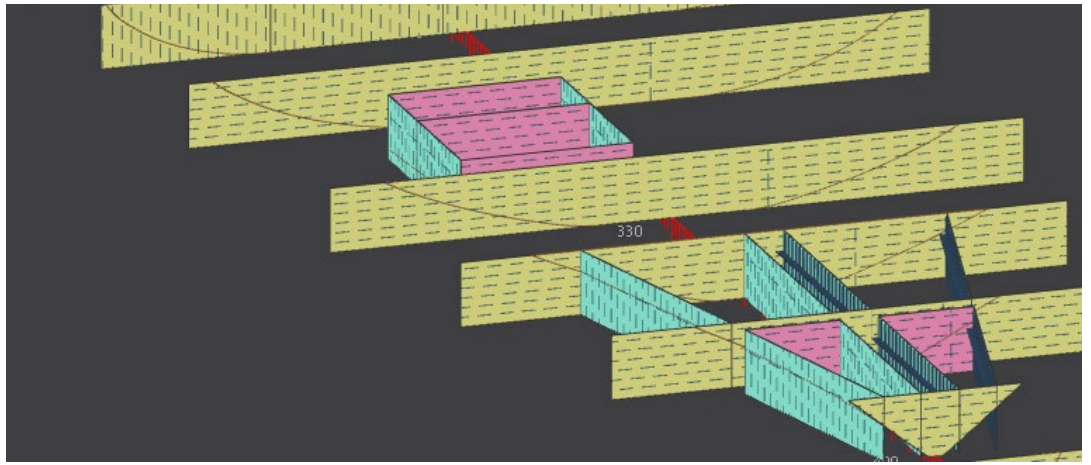
Limits & Structural Type							Girder				
Sl.No	MVZ	Z min	Z max	Y min	Y max	Type	Stiffening	Moulded	Material	Girder Size	Girder Locations
3	1	0.00	4.00	-25.00	25.00	TRANSBHD	VERTICAL	FRONT	A	400X10/150X15	6.0,-3.0

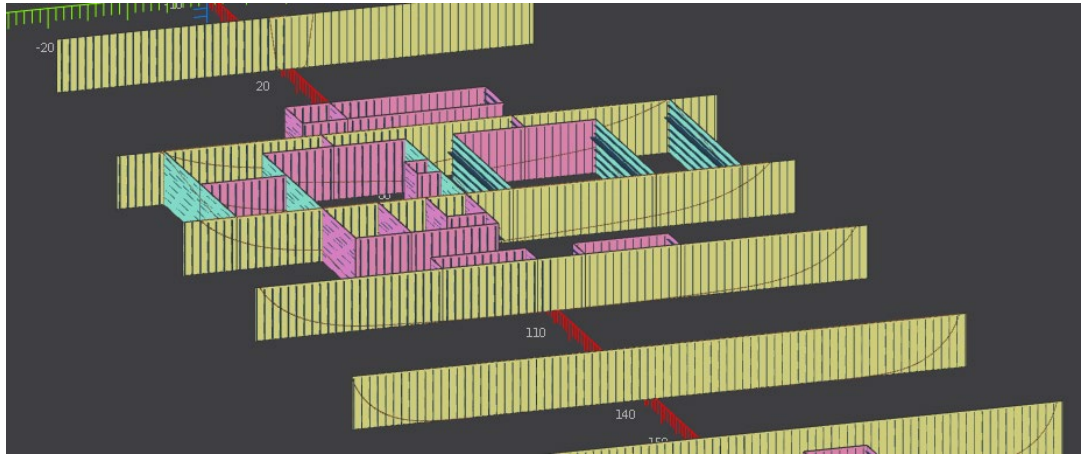
- Longitudinal bulkhead – Girders in web frames
- Transverse bulkhead – Girder may not be symmetric – Location manually entered



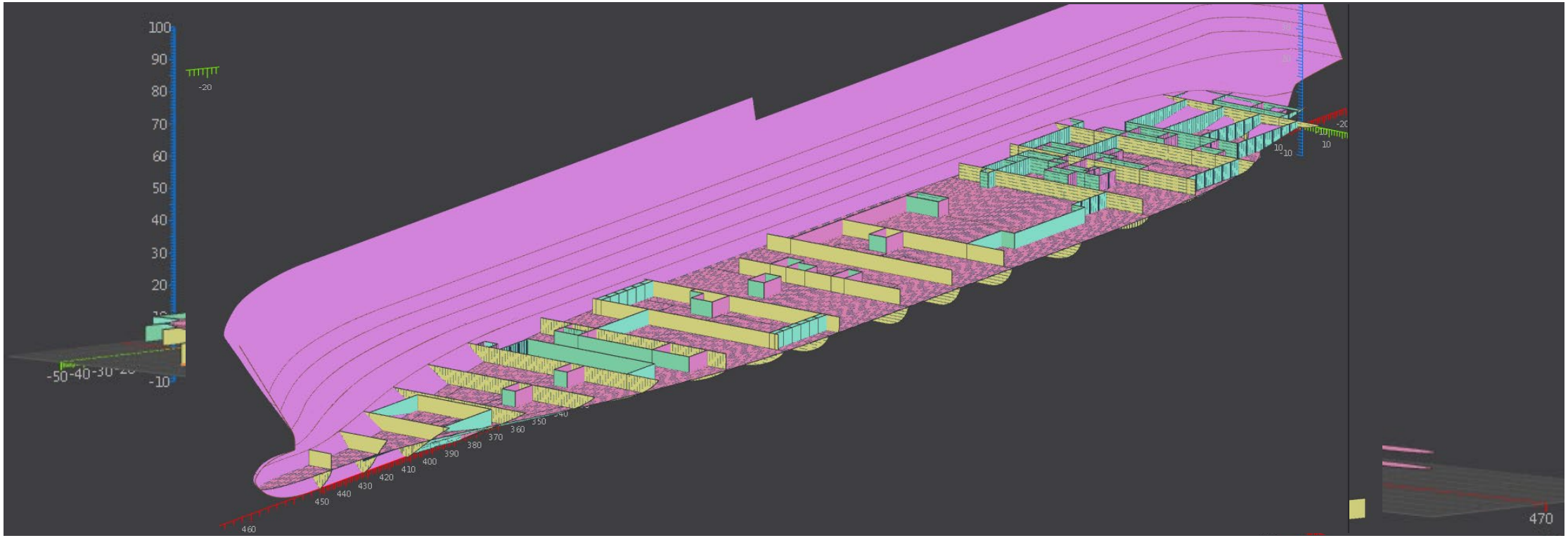
MODIFICATION OF STRUCTURE MODEL - DRAWING REVISIONS

- Early design – Lot of structural modifications
- Incorporate modifications – Updated 3D model
- Modifying individual stiffeners – Difficult
- Select plates – Same stiffener size in revision
- Existing stiffeners and trace lines – Deleted
- Based on input data – New trace lines created
- New stiffener/girder created on trace lines
- Structural model rapidly updated





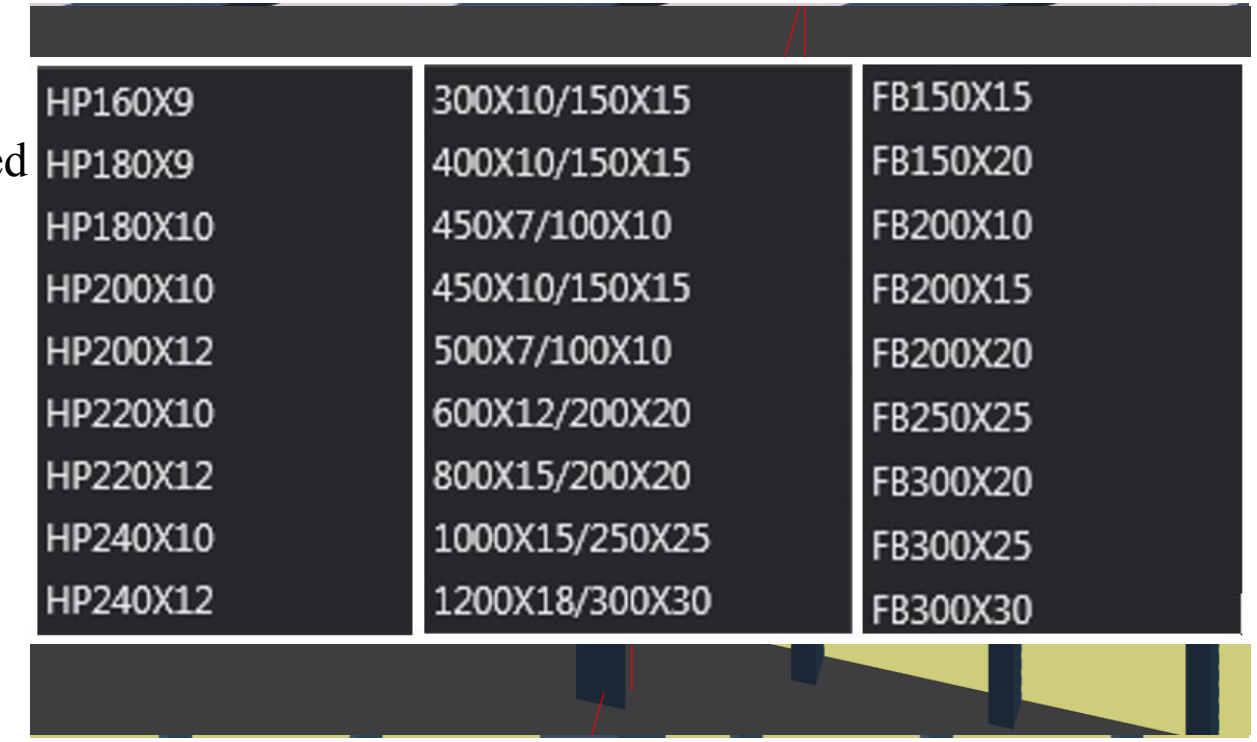
VISUAL REPRESENTATION – WORK FLOW



Sample Selection of the whole ship

CONSIDERATIONS TAKEN CARE OF

- Stiffener overlapping at girder – Eliminated
- Stiffener overlapping with bulkheads – Eliminated
- Intersecting stiffeners sniped – Continuity
- Stiffener orientation – reference axis line
- Steel structure library members only
- Quality of GA plan – Less manual effort



SUMMARY

- Rapid 3D structure model – GA plan, hull form and scantling data
- Global strength members – Plating, primary and secondary members
- Global strength check possible – Early design stage
- Automated modelling using scripting platform
- Easy to modify model – Client/class comments
- Perceptible time saving – 2 months to < a week
- Good early overview – Less rework – Shorter design spiral

FUTURE POSSIBILITIES

- Automatically assign structure type – Vertical Walls
- Automatically assign brackets – Connection type
- Generate Scallops automatically
- Include customized structural members
- Modify existing stiffener in bulkhead – Multiple new stiffener types

TO SUM UP

- **Rapid 3D structure model generation in early design stage**
  - Automated modeling to reduce time period from 2 months to < a week
- **Global strength influence considered → less structural rework**
- **Easy to maintain updated 3D structural model with design development**