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Challenges and Myths of Offsite Fabrication for Mega Projects

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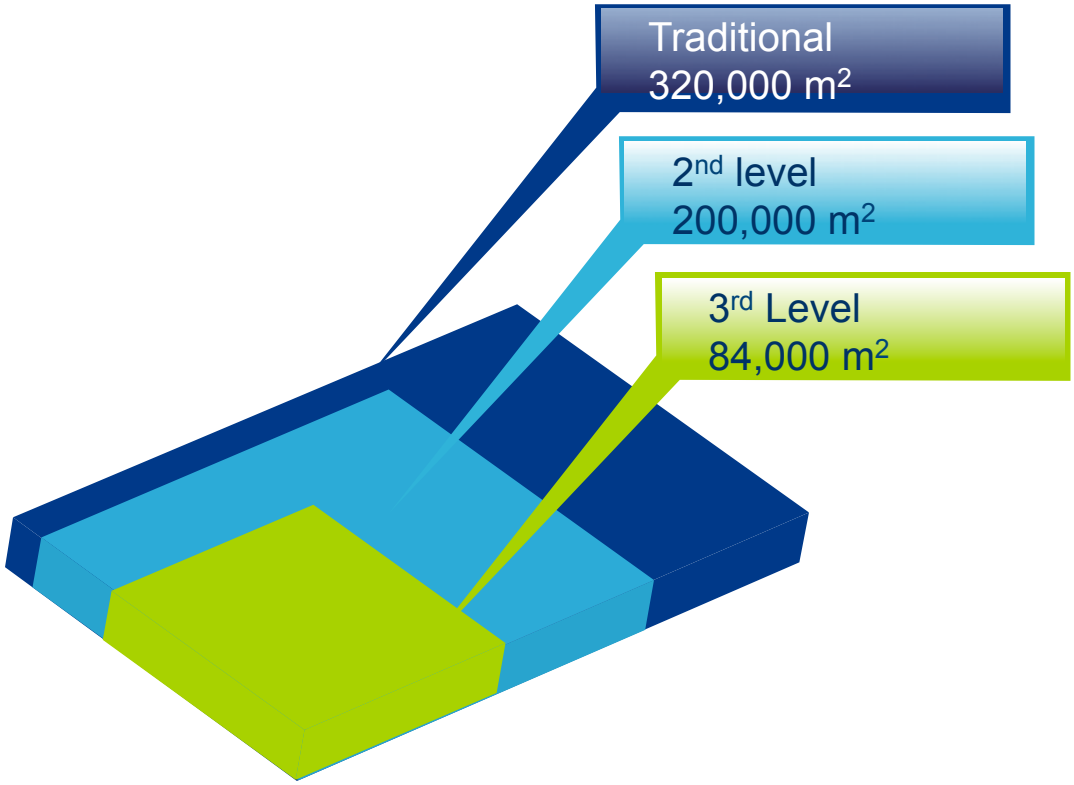
How did we get here and why is there a need for change in project delivery?

- Increasing non-standard projects with challenges
  - Technology (deep water, pre-salt, Arctic)
  - Organization (multiple owners)
  - Geopolitical (location, non-commercial interests)
- Performance is declining despite:
  - Best in class process (FEL and Stage Gate)
  - Best in class systems (sophisticated & proprietary)
  - Best personnel
- Risk is being declined by the EPC contractors
  - Performance incentives have minimal effect
  - Risk increasingly carried by owners
- Pressure to improve ROC or Capital Efficiency

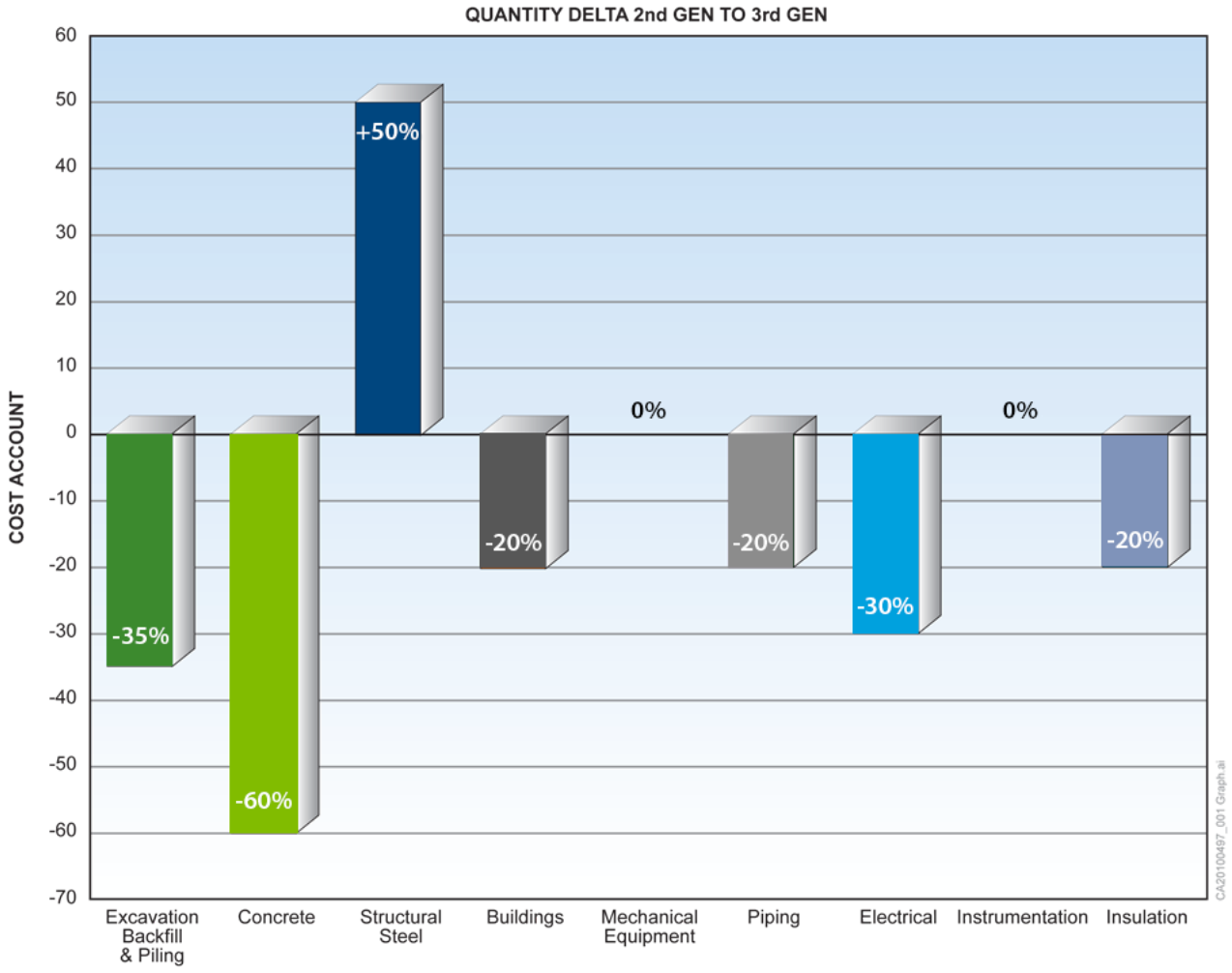
What has been the industry response to increasingly poor project performance

- Increasing owner supervisory staff numbers
- Increasing detail and assessment for front end loading
- Non-standard custom intervention on projects
- Global procurement
- Changes in methods (Modularization)

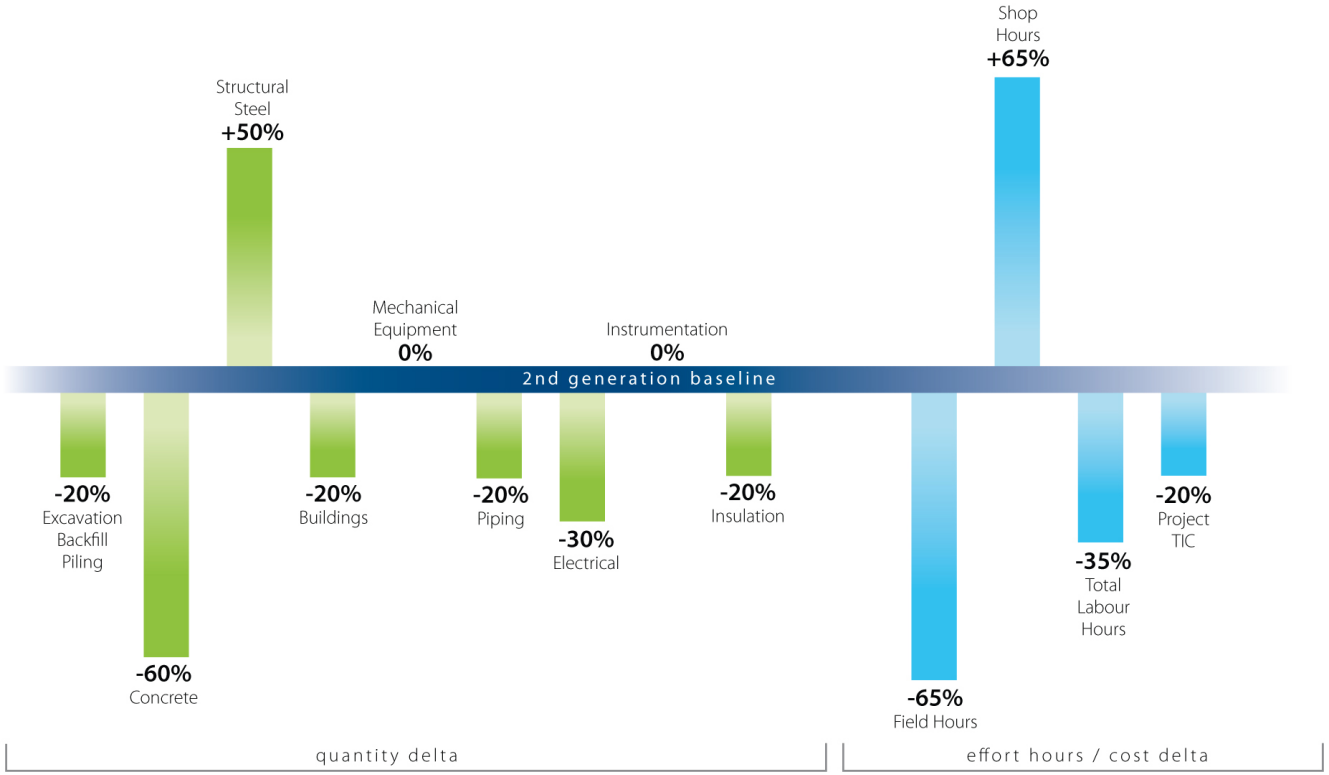
3rd level Modular
Site Envelope Statistics



3rd Level Modularization Quantities Impact



3rd level Modularization
Quantities, Effort Hours and Cost Impact



3rd Level Modularization Execution/Engineering Differences

- “Modularization drives layout”, not the layout driving modularization
- Integration required across the entire supply chain
- Vendor data is critical to support the design
- Engineering must work as a totally integrated team
- Interconnecting pipe racks not used
- Offshore design practices utilized where practical
- Weight and dimension management critical to success

Case Study
3rd Level Modularization Cost Impact

- When Modularization applied to 75% of the total project:

- Cost savings resulting from:
  - Reduced quantities due to smaller footprint
  - Productivity gain for work shifted to shop
    - Average 40% decrease in hours for module assembly vs. equivalent scope in the field
  - Reduced indirect costs with less field hours

Modularization Integrated Planning, Supply Chain Management and Project Execution

Modular engineering has additional constraints
- Module boundary defines available volume
- Effective layout dependent on component dimensions

Engineering work packages are more detailed
- Certified vendor data required earlier
- Parallel multi-discipline collaboration
- Vertical distributed execution with New Delhi

Fabrication work packages are highly structured
- Modeling more detailed
- Compilation of documents required earlier
- Fabrication shop input during design
- Material delivers critical

Work face planning
- Dependent on receipt of information and materials

Case Study
Modularization Execution Differences

Design and Module Assembly

- Module fabricators participated in constructability reviews
- Complete E&I installation pre-module shipment
- Module shop completions and pre-commissioning activities
  - Hydro-testing and flushing
  - Insulation
  - Vessel inspection and final closure
  - Cold alignment
  - Continuity testing and motor run-ins
  - Instrument calibration
- Complete turnover packages at module shop

Case Study
Modularization Execution Differences

Material Management

- Early focus on all POs for vendor data
  - Engineering only release of initial POs
  - Commercial protection (cancellation, pricing and escalation)
- Supply agreements
  - Equipment (client preferred vendors) incl. electrical
  - Structural steel
  - Piping bulks
  - Electrical cables
  - Controls Systems
  - Main automation contractor
- Material planning and control
  - Same process as steel and piping for 2nd Generation
  - Extend to E&I
  - Use of material management system
  - Expediting for specific module needs
- Solid Logistics and Weight Management Plan

Case Study
Modularization Execution Differences

Site Construction

- Construction sequence firmly established in FEED
- Modularization schedule based on construction sequence
- Engineering deliverables based on modularization schedule
- Shifted the work to the module yard
- Significantly smaller CM team
- E&I shop work dramatically reduces back-end completion scope and complexity
- Reduced risk
  - Enhanced safety (Key selection criteria on module bidders)
  - Improved operations and maintenance
  - Less winter schedule issues
  - More work in controlled environment
  - Reduced schedule once modules in place
  - Cost and schedule certainty with reduced E&I field scope

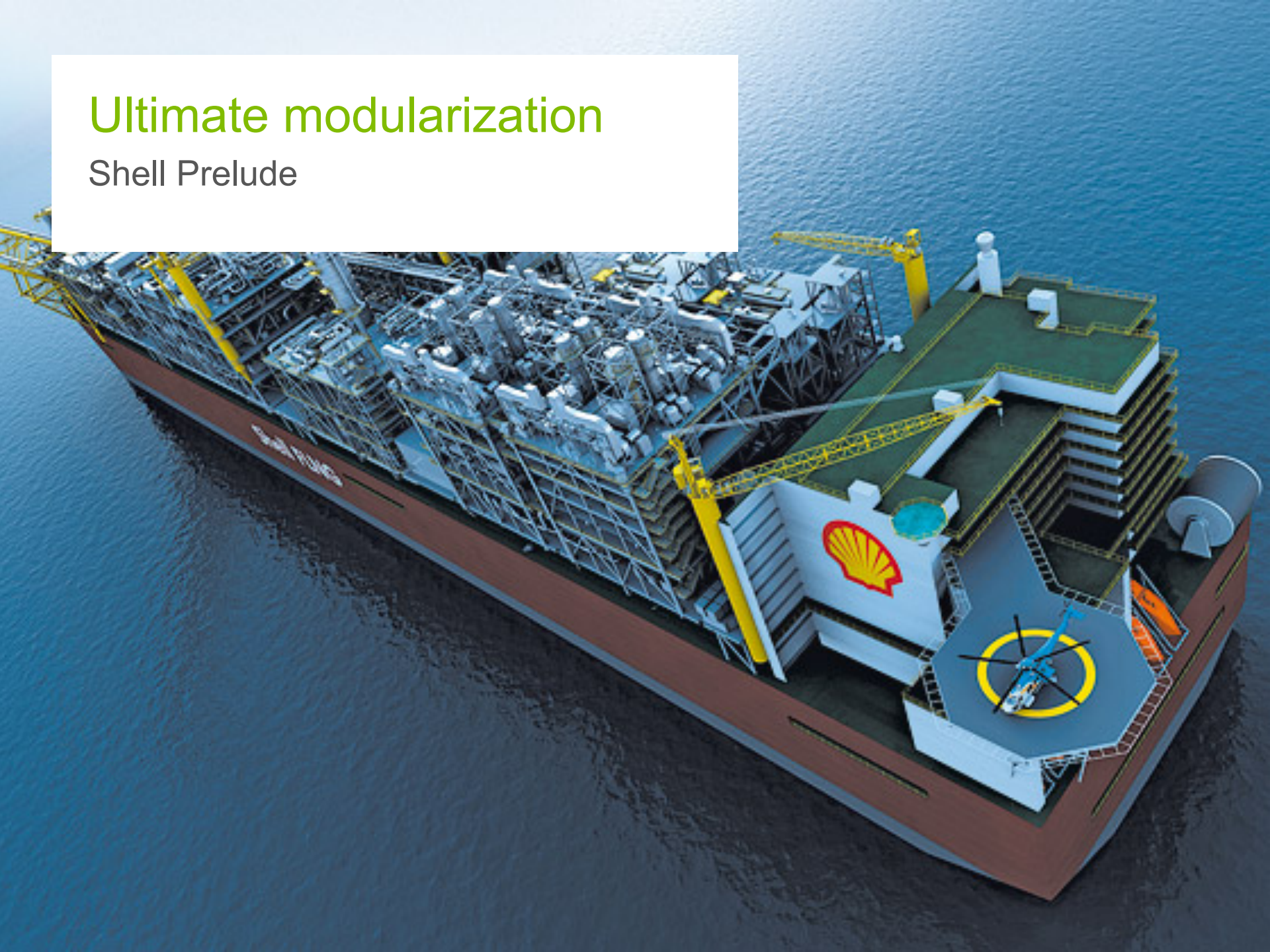
Modular Construction
Conclusion

Challenges
- Engineering design is more complex
- Competent modular design skills in short supply (offshore skill)
- Full Integration of team is vital
- Design information is required in different and more complete form
- Global supply chain exponentially increases difficulty
- Integrated vendors are beginning to have competitive advantage
- Requirement for manufacturing production skills
- Logistic evaluation a key deliverable

Myths
- Saves money – total lifecycle cost is higher as focus is shifted
- Can be managed by construction staff and labor
- Less problems during execution
- Changes can be incorporated

Ultimate modularization

Shell Prelude



Questions?