Structural Assessment of Aged Ships

1.0 OBJECTIVE.

1.1 The objective of this project is to predict the survivability of a strength-degraded aged structure in a specific wave condition. The outcome would be a reliable assessment of that structure to withstand that loading condition thereby providing the asset-management and operational crew the best information on which to base any decision to put that structure into that scenario. This gives management the opportunity to minimize the risk to personnel and the environment.

1.2 The proposed approach will use currently emerging numerical techniques of structural degradation assessment with fluid-structure interaction to predict the response of the specific structure in the specific wave loading. The project's focus will take a generic reference ship, degrade its structural integrity by some known amount based on historical precedent and current best-practice, and then subject this degraded ship structure to a known limit-state wave condition. The analysis will place a detailed structural finite element model of the ship into a fluid environment that represents the wave conditions, and allow the ship to respond to the wave conditions, thereby producing a time-varying load stress state within the ship. The stress state will be evaluated against classification code allowable stress limits to determine if the ship would survive that wave condition.

2.0 BACKGROUND.

2.1 Current design trends in vessels and structures are for increased load carrying capability whilst striving for a minimal light-ship state. The onus for structural integrity throughout the life of the vessel or structure is placed firmly with the operational crew, through increased inspection and other practices. Thus through-life maintenance costs of a contemporary vessel are increasing, yet the operation side of the vessel is under pressure to maximize the operational availability of a vessel by reducing downtime and maintenance costs. The consequence is an increased risk of a structural failure with negative consequences for the ship owner and possibility the environment.

2.2 The justification for this project is risk management for aged-ships or off-shore structures based on actual structural integrity. The project proposes a solution that will accurately determine if a specific ship with a specific history will survive a specific wave condition. Thus a quantifiable stress-state is developed on which a sound engineering decision can be made to place the ship in that specific wave environment. This is in contrast to current practice where a probability of failure is produced. The definitive stress-state determination is likely to be a preferred outcome for decision making, rather than a probability.

2.3 The applicants have a proven track record of research and applied consultancy in the field of global motions of ships and structures in waves based on mesh-free numerical techniques. Past work examined the motion of a landing craft within a well dock of a mother ship and demonstrated the versatility of the technique. A later project examining the stress-state in the flexible back-bone of a segmented model ship as it traversed waves further developed the stress-state elements of the techniques. A further study (Reference 8.3 below) illustrated actual wave-induced stresses in a crane structure mounted on a semi-submersible platform in large swells. This proposed project is a logical extrapolation of these previous works to build a tool relevant to the maritime industry. The applicants have the ability to construct, run and interrogate such models and make an assessment of the survivability of the structure using the numerical techniques described.

3.0 REQUIREMENTS.

3.1 Scope.

1. The Contractor shall first identify a suitable ship model that useful to demonstrate the objectives of the project. Ideally this will come from an established database of public domain ship models, or be passed to the contractor on a commercial confidentiality basis for the purpose of the project.

2. The Contractor shall identify a realistic state of structural degradation relevant to the model established part 3.1.1. Ideally the state of structural degradation will be from measurements taken

on a real ship to maintain relevance and practicality to the project, and provided to the contractor for the purpose of this project.

3.2 Tasks..

1. The Contractor shall locate a structural model of a ship and incorporate the recorded structural degradation of the specific ship into the finite element model for the purposes of this project.

2. The Contractor shall use their existing intellectual property to develop a numerical simulation of the wave condition for the assessment of the ship in these sea conditions. This process shall employ mesh-free particle methods which have previously been demonstrated to be a versatile tool to model the non-linear response of ships and structures in severe waves.

3. The Contractor shall run a numerical simulation of the ship in the described wave conditions for the purpose of evaluating the actual response of the ship, specifically the stresses at critical locations with the ship structure, accounting for the degraded integrity of the ship. This is the novel and critical outcome of the project.

4. The will review the results of the numerical simulation and provide an assessment of the stresses exhibited, commenting on the severity of these stresses relative to either the allowable stresses as dictated by the relevant classification rules, or an expert structural engineer's perspective, thereby providing a definitive assessment on the ability of the structure to survive the prescribed wave condition that was modeled.

3.3 Project Timeline.

Task	Task	Q1	Q2	Q3	Q4
3.2.1	Locate, convert and debug FE ship model. Also collate degradation data and incorporate into the FE model.				
3.2.2	Define, develop and validate the wave environment modelling.				
3.2.3	Run the ship and wave-environment models and debug.				
3.2.4	Assess outcomes and write final report				

4.0 <u>GOVERNMENT FURNISHED INFORMATION</u>.

4.1 Standards for the Preparation and Publication of SSC Technical Reports.

5.0 <u>DELIVERY REQUIREMENTS</u>.

5.1 The Contractor shall provide quarterly progress reports to the Project Technical Committee, the Ship Structure Committee Executive Director, and the Contract Specialist.

5.2 The Contractor shall provide a report detailing the processes employed to address the project aims, the origin of all data used, a description of the numerical techniques employed (excluding prior intellectual property), the means used to assess the quality of the final results, and a comments on the stresses observed within the structure. General comments shall be provided on the difficulties encountered, the overall success of the project, and suggested areas that may be undertaken in the future to continue or enhance the work completed within this project.. The ultimate aim of this research is a details structural map at various instances in time, i.e. age of the ship, that provides a crew and management with insight into areas of the hull/structure that are likely to suffer the highest compromise in structural integrity. The idea behind such a tools is that it will allow the crew and management to be very vigilant with regard to inspection and monitoring of those areas so as to have an optimal repair strategy/maintenance strategy to address these. This early stage of the research will be focused on delivery the components which will be at the heart of such a tool, rather than the tool itself.

5.3 The Contractor shall provide a print ready master final report and an electronic copy, including the above deliverables, formatted as per the SSC Report Style Manual.

6.0 PERIOD OF PERFORMANCE.

6.1 Project Initiation Date: Date of Award

6.2 Project Completion Date: 12 months from the Date of Award.

7.0 GOVERNMENT ESTIMATE. These contractor direct costs are based on previous project participation expenses.

7.1 Project Duration: 12 months.

7.2 Total Estimate: $97,900.00

8.0 REFERENCES.

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8.9 Cartwright, B., Renilson, M., Macfarlane, G., McGuckin, G.,Cannon, S., "Motions of a landing craft in a flooded well dock - effect of well dock design", Proc. RINA Conf. Military Support Ships, London, 2007.

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8.11 Cartwright B, McGuckin D, Turner T, Cannon S, "The Modelling of Landing Craft Motions inside a flooded Well Dock Using Smoothed Particle Hydrodynamics", Proceedings of the Pacific International Maritime Conference, Sydney, pp 150-159, 2006.

8.12 Cartwright B, Groenenboom PHL, McGuckin D, "A Novel Approach to Predict Non-Steady Loads on Vessels in Severe Seas", In Proceedings of the 14th International Offshore and Polar Engineering Conference, Toulon, France, May 23-38 2004

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