1.0 **OBJECTIVE.**

1.1 To conduct comparisons between the requirements of CSR (Common Structural Rules), test data and non-linear FEA, and ISO Technical Specification 18072-2 with the aim of benchmarking the partial resistance factors in ISO TS 18072-2 so it can be used to assess the ultimate strength of ship hull girders and their components, in a manner consistent with the requirements of CSR.

2.0 **BACKGROUND.**

2.1 Ships Rules have made some significant advances recently with the development of Common Structural Rules for both tankers and bulk carriers (CSR) [8.1]. Although the CSR requirements are far more explicit than previously in relation to quantifying hull girder and component strength, they do not always provide explicit formulae for strength as distinct from providing explicit requirements for the sizing of scantlings of hull girders and their components.

2.2 The international standard ISO 18072-1 [8.2] dealing with the general requirements for limit state assessment of ship structures became in effect in November 2007. Since then, a draft ISO standard 18072-2 [8.3] has been developed in attempt to fill this gap. However, because of concerns over the appropriateness and accuracy of the strength equations proposed therein, the developers of 18072-2 were encouraged to issue the draft as a Technical Specification (TS 18072-2) so as to provide the opportunity to review the requirements in detail and, further, to undertake a benchmarking exercise against existing test data and suitable non-linear finite element analyses (FEA), and relevant CSR requirements to:

- demonstrate the accuracy of the proposed equations;
- determine partial resistance factors for ultimate strength assessment.

This proposal seeks funding to execute this benchmarking.

2.3 The ultimate strength assessment of ship hull girders and their components is challenging. This arises because of the implicitly complex behavior of even simple plate panels and stiffened plates particularly in the presence of inevitable initial fabrication distortions and residual stresses when subject to combinations of in-plane biaxial direct, bending and shear stresses and lateral pressure. This is further complicated by interaction with longitudinal and transverse stiffening elements that themselves also suffer complex local and overall buckling behavior. Quantifying the ultimate strength of the hull girder adds further dimensions of complexity because fabrication effects can cause the girder behavior to be non-linear even at low levels of loading.

2.4 Because of this complex behavior of hull girders and their components, inevitably the equations available for their strength assessment are many and varied. These range from relatively simple analytical solutions to detailed FEA. However, from the perspective of accurate and user-friendly strength formulations, analytical solutions are to be preferred and this is the approach adopted in TS 18072-2.

2.5 To ensure that the selected solutions satisfy the basic requirements, considerable numbers of comparisons are necessary. Some benchmarking exercises have already been undertaken by, for example, ISSC (International Ship and Offshore Structures Congress). However, the objective of these has not necessarily been to select equations for wide application such as required by TS 18072-2, or to determine corresponding partial resistance factors to ensure consistency with existing Rules. The need to determine partial resistance factors increases the amount of effort
considerably compared with just comparing the predictions of strength formulations and thus needs funding in order to achieve this extra goal.

3.0 REQUIREMENTS.

3.1 Scope.

- Whilst the Contractor already has substantial databases of plate panel, stiffened plate and hull girder test and non-linear FEA results, the first task will be to ensure these are complete through appropriate literature searches and personal contacts.
- The Contractor shall identify candidate strength formulations for plate panels, stiffened plates and hull girders to be used in the benchmarking. This selection shall be performed in conjunction with the contributors to the development of TS 18072-2 and members of the PTC (Project Technical Committee).
- One of the challenges in dealing with Rules is to identify the loading, especially pressure, that is applicable when arriving at a scantling requirement. This aspect will be evaluated carefully, checking with relevant certifying authorities as necessary.
- The Contractor shall use the selected TS 18072-2 strength formulations to effect comparisons with the test and FEA databases to statistically quantify their modeling accuracy, i.e. the ratio of test value to predicted value will be determined in terms of mean and COV (coefficient of variation). The Contractor requires this information for use in the derivation of the partial resistance factors.
- The Contractor shall estimate the statistical modeling parameters for the loading. The loading consists primarily of wave-induced and still water stresses as well as pressure loading for many girder components. The estimates of the statistical parameters will be based on information in the public domain. The Contractor requires this information for use in the derivation of the partial resistance factors.
- The Contractor shall derive the partial resistance factors for application of TS 18072-2 to the ultimate strength assessment of ship hull girders and their components, using the partial load/action factors specified in the CSR together with a spread of partial load/action factors either side of the CSR factors.
- The Contractor shall effect comparisons between the partial resistance factors derived for the candidate strength formulations with those specified in CSR. Similarities and differences will be discussed in detail.
- The Contractor shall prepare a detailed report of all the work undertaken.

3.2 Tasks.

- Task 1 - the Contractor shall undertake literature surveys of and update/create databases as necessary:
  - ultimate strengths of plate panels, of stiffened plates and of hull girders subject to complex loading, concentrating on experimental and non-linear FEA results;
  - statistical parameters of loading on ship hull girders and their components.
- Task 2 – the Contractor shall identify candidate strength formulations for plate panels, stiffened plates and hull girders for use in TS 18072-2: to be performed in conjunction with the developers of TS 18072-2 and the PTC.
• Task 3 - the Contractor shall determine the loading patterns on hull girders and their components used in the scantling specifications in the CSR, with the assistance of relevant certifying authorities.
• Task 4 - the Contractor shall quantify the statistical parameters for the modeling uncertainties parameters for the candidate strength formulations.
• Task 5 - the Contractor shall derive partial resistance factors for the candidate strength formulations covering the partial load/action factors specified in the CSR plus a spread of partial load/action factors around the CSR factors.
• Task 6 - the Contractor shall compare the derived partial load/action factors and those specified in CSR and seek detailed explanations for the similarities and the differences.
• Task 7 - the Contractor shall prepare a detailed report of the work.

3.3 Project Timeline. See Enclosure 1.

4.0 GOVERNMENT FURNISHED INFORMATION.

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

5.0 DELIVERY REQUIREMENTS. (Identify the deliverables of the project).

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

5.2 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: $100,000.

7.3 The Independent Government Cost Estimate is attached as enclosure (x).

8.0 REFERENCES.

8.1 IACS, Common Structural Rules for Double Hull Oil Tankers, January 2006.

8.2 ISO 18072-1 Ships and marine technology — Ship structures — Part 1: General requirements for their limit state assessment.


9.0 SUGGESTED CONTRACTING STRATEGY.
9.1 Contracting strategy.

NOTE:
- Please do not submit any proprietary information in this outline. This will be posted on the SSC Website regardless if the project is selected to be funded.
- All projects will be competed via Government Services Administration (GSA) or Commerce Business Daily (announced)

Enclosure 1

Project Timeline

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<thead>
<tr>
<th>Task No.</th>
<th>Task Title</th>
<th>Months</th>
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<tbody>
<tr>
<td>1</td>
<td>Literature surveys - update/create databases</td>
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<td>2</td>
<td>Candidate strength formulations</td>
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<tr>
<td>3</td>
<td>CSR loading patterns on hull girders &amp; components</td>
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<td>4</td>
<td>Modeling uncertainties parameters for candidate strength formulations</td>
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<td>5</td>
<td>Derive partial resistance factors</td>
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<td>6</td>
<td>Compare derived partial load/action factors and CSR factors &amp; explain similarities and differences</td>
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<tr>
<td>7</td>
<td>Project Report</td>
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