ALERT

Assessment of Life-Cycle Effects of Repairs on Tankers

ALERT Project Overview

- Coordinated Action funded by European Commission
- A two year project
- Started 1st. November 2006
- This is an interim report on progress to date
- Programme evolved from the recommendations in the report on the loss of the Prestige
- It will examine the cumulative effect of repairing a tanker throughout its life, looking for present best industry practice and ways in which that practice can be improved

ALERT Partners

IMO Secretariat - observer

Funding provided by the European Commission 6th Framework Programme

ALERT Project Overview

Overview

WP1

WP2

WP3

WP4

WP5

Conclusions

- What is the effect of joining new steel to old steel?
- What additional stresses are put into a ship's structure during a repair?
- How is fatigue in a structure affected when part of the structure is replaced?
- How do the effects of repairs change during a ship's life?
- Could detection of defects be improved?
- How can any possible adverse effects of repairs be detected and minimised?
- How effective are current best practices?

ALERT Project Overview

- Overview
- WP1
- WP2
- WP3
- WP4
- WP5
- Conclusions

- This Project is a preliminary exercise, it will not be doing fundamental research.
- The intention is to identify:
  - Current best practice and
  - Areas in which in-depth work is required.

ALERT Project Overview

Overview

WP1

WP2

WP3

WP4

WP5

Conclusions

5 Work Packages:

1. Ship repair practices
2. Condition monitoring of ships
3. Structural assessment methods
4. Through life management
5. Integration, dissemination and exploitation

WP1: Ship Repair Practices

Work package 1 overview

Overview

WP1

WP2

WP3

WP4

WP5

Conclusions

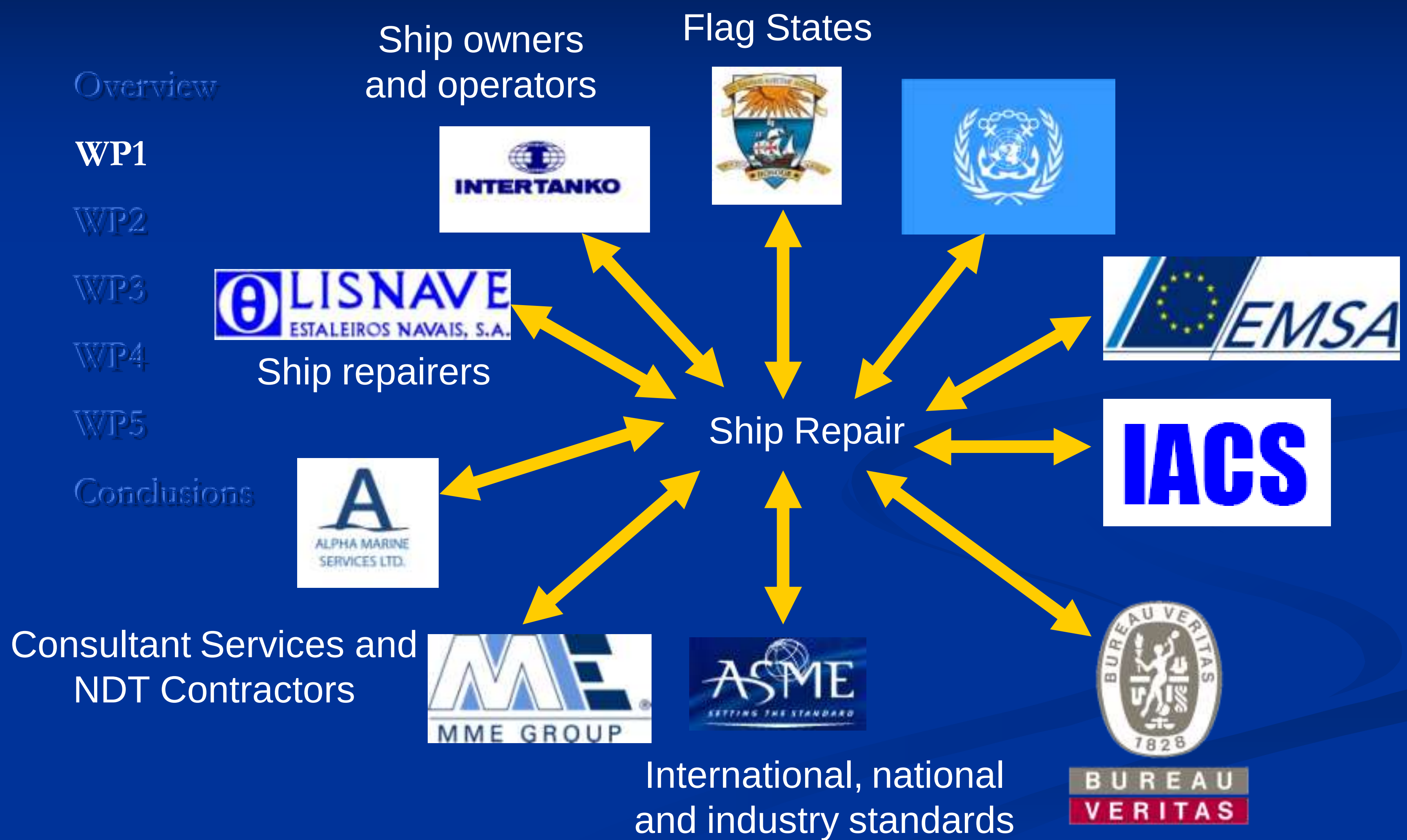
- Objective of this work package is to critically review the current knowledge and understanding, and identify future research and development needs in the following areas:
  - **Standard practices and class society requirements for the repair of ships**
  - **Alternative repair practices**
  - **Consequences on structural reliability of new to old steel replacement, and**
  - **Development and implications of common repair, inspection and maintenance procedures, requirements and acceptance by the classification societies.**

WP1 Task overview

- Task 1-1 Standard practices, Class Society requirements for the repair of ships and alternative repair practices
- Task 1-2 Consequences on structural reliability of new to old steel replacement
- Task 1-3 Development of common repair, inspection and maintenance

Relationships in ship repair

- Overview
- **WP1**
- WP2
- WP3
- WP4
- WP5
- Conclusions



Recent developments

Overview

WP1

WP2

WP3

WP4

WP5

Conclusions

- IACS progress
  - Recommendation 96 (April 2007)
- Experience feedback
  - With modern computing it is possible to collect more and more data.
    - Databases have been developed in classification but will take some years to mature
  - Condition assessment and monitoring development
    - Class societies are working to develop better and faster ways to quickly analyse a ships condition so it will be possible to make a more informed decision on the appropriateness of a repair.

Analysing the reliability of repairs

- Correlation between survey and incident data could be improved
- Anecdotal evidence confirms that repairs do fail – but it is not known at what frequency

Conclusions

- There are developments in ship repair knowledge and guidelines, for example IACS recommendation 96, new data collection programs
- It is important to establish reliable data collection systems
- The ship repair industry is a multi-stakeholder affair
  - It is important that we continue to develop best practice guidelines and regulations through cooperation

WP2: Condition Monitoring of Ships

Task 2.1 Non-Destructive testing of welds

Task 2.2 Detection and recording of fatigue cracks

Task 2.3 Corrosion detection and protection

Non – Destructive Testing of welds

- **Detectability of welding defects depends on:**
  -Methods applied
  -Capability of the NDT-operator
  -Extent of examination.
- Requirement for non destructive testing of Repairs are determined on a case by case basis.
- Not all specified techniques have adequate POD (Probability of Detection) characteristics

Non-Destructive Testing of welds

Overview
WP1
WP2
WP3
WP4
WP5
Conclusions

- The capability of the NDT-operator could be improved by adding specific knowledge of ships structures.
- The extent of examination and selection of area's is verified by the Class surveyor on the basis of the NDT program submitted by the ship repairs yard
- The intensity of testing and locations tested influences the number of defect detected.

Detection and recording of fatigue cracks

- Visual inspections is the most economical method for the inspection of large tanker structures.
- More advanced testing methods have better POD characteristics.
- The development of better POD curves requires more extensive test data than is available at present.

Detection and recording of fatigue cracks

- The detection of cracks by visual means will be improved by:

  -Prior knowledge of area's with stress concentrations

  -Historical information of fracture damages in similar structures.

  - Adequate lighting conditions with clean and safe access

Corrosion detection, protection…

- Tanker corrosion is not new
- Tested & tried coating systems are available
- Industry guidelines are available
- Sufficient in-service inspection requirements inplace
- Steel replacement <u>quality standard</u> – not compulsory
- Market forces – OCIMF members

Corrosion detection, protection…

- Steel replacement guidelines, coating of replaced steel & repair guarantee
- CTF – tank coating maintenance file & access platforms - CSR
- How to reduce need for steel replacement:
  - Specification & coating newbuild stage
  - Supervision during construction
  - Shipbuilder's guarantee for structure and coating – one (1) year

Corrosion detection, protection…

- How to reduce……… (cont.):
  - Shipbuilder's guarantee for structure and coating – one (1) year
  - Feedback to shipbuilder – one (1) year
  - Extend ship builders hull structure and coating guarantee to first renewal survey – 5th year anniversary
  - Information / experience sharing
  - Environmental impact of steel replacement

Corrosion detection, protection...

- Overview
- WP1
- **WP2**
- WP3
- WP4
- WP5
- Conclusions

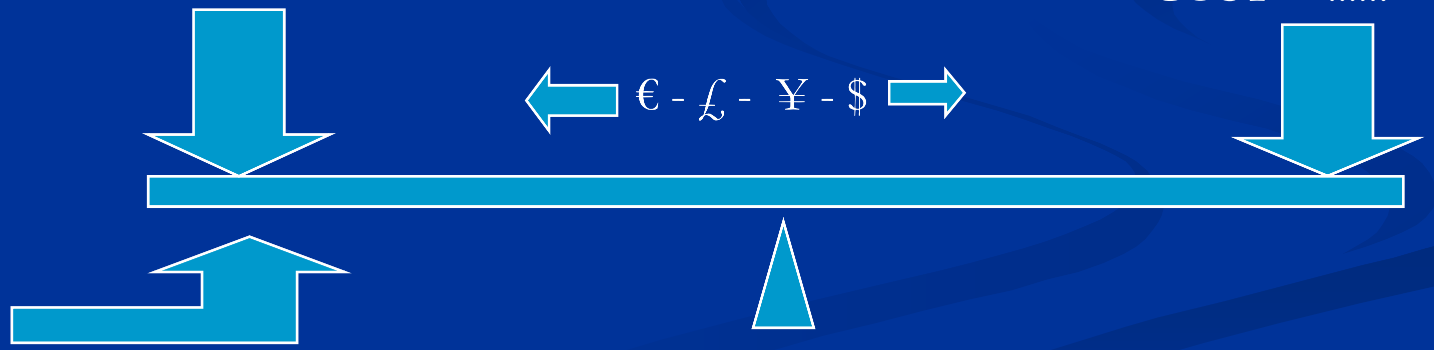
- Quality seesaw – ”it is the economy stupid!” (Bill Clinton)

Hull structure
Tank coating
Workmanship
(1) One year guarantee

Regulation
Specification
Knowledge
Research

Experience
Performane
Quality systems

LIFE CYCLE COST + ...?



Five(5) year builders guarantee

Market, OCIMF – SIRE etc

WP3: Structural Assessment Methods

Global Strength Assessment Methods

Overview
WP1
WP2
WP3
WP4
WP5
Conclusions

- Methods used for assessment of new-build ships include:
  - Empirical and Analytical Methods
    - Section Modulus based approaches
    - 2-D Progressive Collapse methods
  - Numerical Analysis methods
    - Finite Element Analysis
    - Idealised Structural Unit Method (ISUM)
- Can these methods consider effects of repair?

Global Strength Assessment Methods

- Repairs can be considered by:
  - Increase in Section Modulus
  - Modification to:
    - Material thicknesses
    - Deformations – both weld induced and misalignments
    - Residual Stresses
- Some methods for assessing Global Strength are able to consider more effects than others

Local Strength Assessment Methods

- Overview
- WP1
- WP2
- **WP3**
- WP4
- WP5
- Conclusions

- Local strength of tanker structures depends highly on the buckling strength of the individual structural members
- After buckling, the structural member looses its ability to carry additional compressive loads.
- Buckling of local structural members concerns not only plate fields between stiffeners, but also free plate edges at cut-outs and flat bars as well as the flanges of girders which may be prone to tripping (torsional buckling).

Local Strength Assessment Methods

Overview
WP1
WP2
WP3
WP4
WP5
Conclusions

- The strength of a structure depends on the strength of the connections between the different components
- Fatigue cracking is an issue
- Critical points in tanker structures are mainly determined by two factors:
  - the amount of cyclic stresses including positive (tensile) mean stresses
  - the notch severity of the structural detail and weld

Local Strength Assessment Methods

- Local Strength also impacted by:
  - Corrosion
  - Local deformations
  - Fatigue cracks and weld defects
  - Residual stresses
- All need to be considered when assessing strength of repaired structure

T3-3: Influence of Residual Stress

Overview

WP1

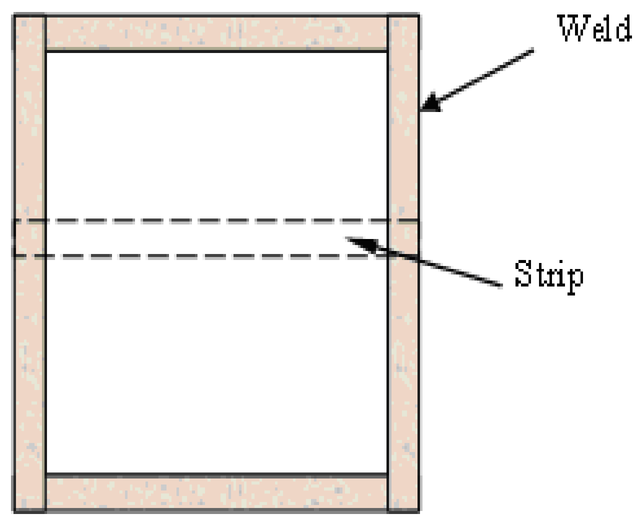
WP2

WP3

WP4

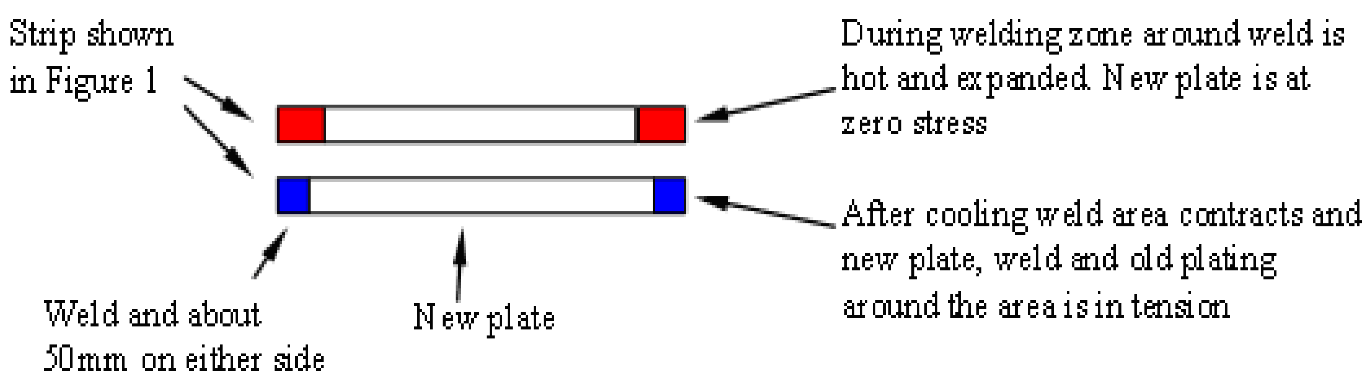
WP5

Conclusions

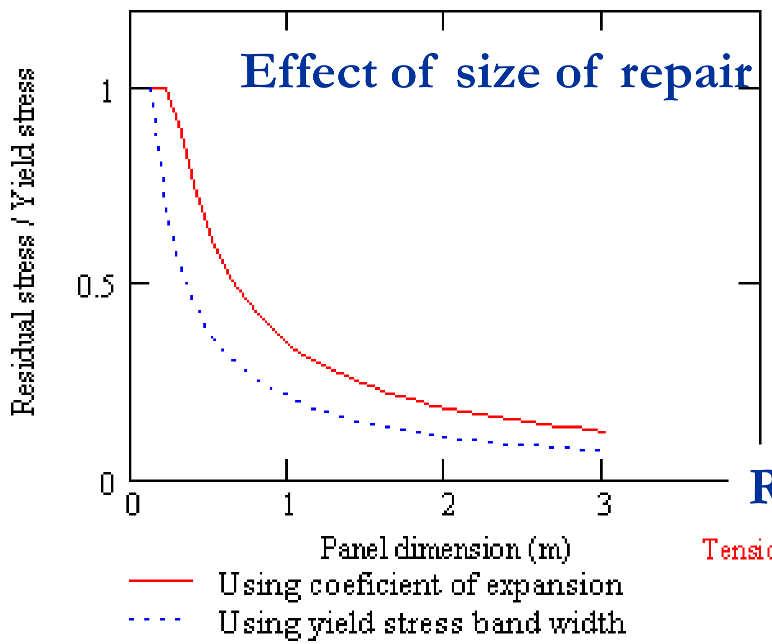


Welding introduces residual stresses.

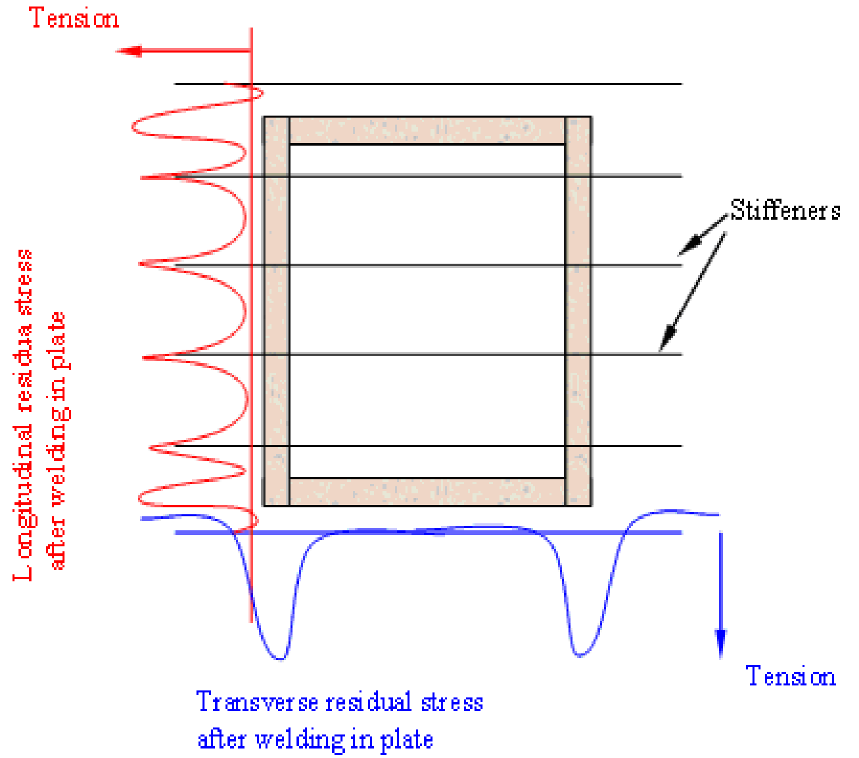
Effects of repairs introducing different residual stress patterns and reintroducing residual stresses are considered.



T3-3: Residual Stress



Residual Stress Pattern after Repair



Larger panels result in lower radial tensile stresses

Effect of stresses parallel to welds more important than those normal to welds except for very small inserts

Strength Assessment of Repairs

- Overview
- WP1
- WP2
- **WP3**
- WP4
- WP5
- Conclusions

- Ideally structural assessment methods need to be able to consider the effects of:
  - Structural miss-alignment of repairs on strength;
  - Extent of repaired area;
  - Effects of stiffness miss-matches between repaired (restored area) and degraded material adjacent to repair.
  - Residual stresses need further investigation

WP4: Through Life Management

Task 1 Review of existing rules and guidance on repair scheduling and methodology

Task 2 Reliability calculations used to assess significance of good and poor repairs

T1: Existing Rules

Overview
WP1
WP2
WP3
WP4
WP5
Conclusions

- **IACS *Z10.4*** *Hull surveys of Double Hull Oil Tankers*
- **IACS *Z 13*** *Voyage Repairs and Maintenance*
- **IMO *MSC/Circ.1070*** *Ship Design, Construction, Repair and Maintenance*
- **IMO *MSC/Circ. 1055*** *Guidelines on the Sampling Method of Thickness Measurements*
- **Classification Societies Rules**

T1: Guidance

Overview
WP1
WP2
WP3
WP4
WP5
Conclusions

IACS

Classification Societies

Tanker Structure Co-operative Forum

Oil Companies International Marine Forum

IMO *MSC/Circ.1070* *Ship Design, Construction, Repair and Maintenance*

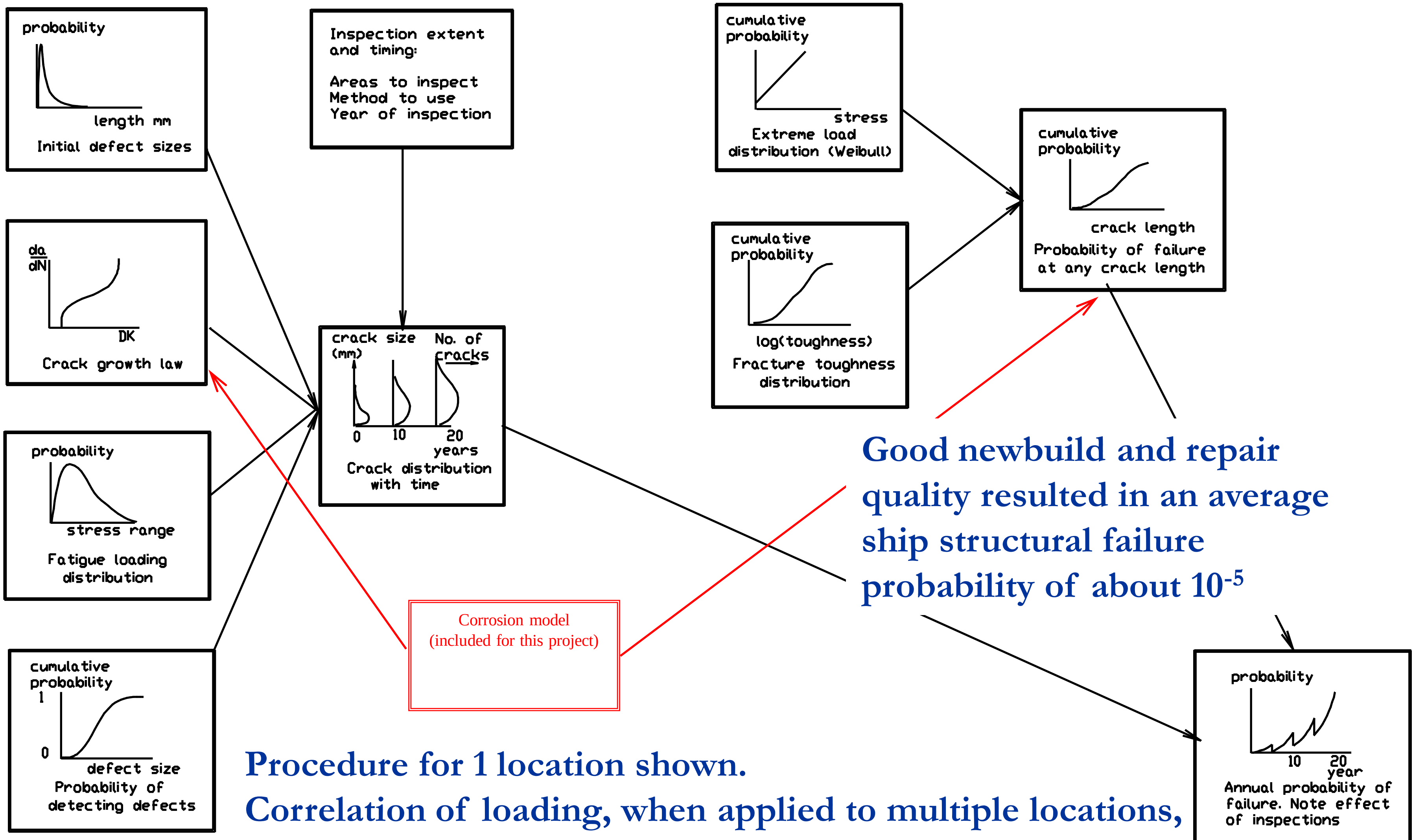
IMO *MSC/Circ. 1055* *Guidelines on the Sampling Method of Thickness Measurements*

Company procedures also reviewed (work in progress)

T1: Conclusions

- Good guidance from IMO, IACS and Class
  - Class involvement also based on sound judgement of Surveyors
- TSCF guideline particularly good
  - needs updating to include experience from double hull tankers
- Company procedures focus:
  - more on machinery than hull structure and
  - more on personnel safety than technical issues
    - Technical training for office and shipboard personnel recommended
- Repair yard procedures difficult to monitor when there is a long chain of subcontractors

T2: Calculation methodology



Good newbuild and repair quality resulted in an average ship structural failure probability of about 10^{-5}

Procedure for 1 location shown.
Correlation of loading, when applied to multiple locations, is taken into account

T2: Calculation Conclusions -1

Overview
WP1
WP2
WP3
WP4
WP5
Conclusions

- The poor quality repairs (large defect or a large stress concentration in a normally highly stressed area) increased the failure probability by about 50 times, effect was largest later in the life of the ship.
- A localized area of low fracture toughness increased the failure probability by 10 times, effect was largest soon after the repair.

T2: Calculation Conclusions -2

Overview
WP1
WP2
WP3
WP4
WP5
Conclusions

- Poor repair inserting low fracture toughness and defects at the same position made failure probability increase about 10^4 times and so become very likely.
- Reintroduction of shaken down residual stresses increased failure probability by about 10 times.

WP5: Integration, Dissemination, and Exploitation

Integration, Dissemination, and Exploitation

Overview

WP1

WP2

WP3

WP4

WP5

Conclusions

- Aims to integrate the Project's results together
- Dissemination of the Project's results to the wider industry
- Exploit the Project's results i.e. future research projects, etc

Conclusions

Conclusions

- Only an interim report, more work has to be done
- Gaps have been identified:
  - Data and statistics
  - Research on the effects of repairing old steel with new including:
    - Differences of strength, flexibility and fatigue between old and new structures.
  - How the effect of repairs changes during a ship's life

Conclusions

Overview

WP1

WP2

WP3

WP4

WP5

Conclusions

- When any fresh research is complete then its effects not only on repair practices but on new designs will have to be considered.

ALERT Partners

IMO Secretariat - observer

Funding provided by the European Commission 6th Framework Programme

ALERT Project Website

http://alert.ncl.ac.uk

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