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## **FLAGSHIP**

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# **D-A2.1 Functional Requirements TCI Demonstrator**

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## Executive summary

This document defines requirements to the demonstrator development in sub project A2 in Flagship based on the project partners' discussions and proposals. Descriptions of system boundaries, relations between Flagship sub projects and the approach to develop, implement and test the content of the demonstrator are covered. The TCI, Technical Condition Index, described herein is the basic indexing principle used by the demonstrator.

The main “objects” included in the demonstrator are the TCIs that are closely related to the Key Performance Indicators, KPIs. The KPIs are used to determine the performance in a wider sense than the TCI with respect to Environment, Safety and Energy Efficiency. When a KPI is below a defined level and an investigation/ improvement is recommended the TCI results can be used to check the operational performance and degradation with basis in the technical measurements onboard the ships. Examples are given on how to obtain TCI results.

Sub project A2 with focus on the TCI has interfaces to:

- Sub Project A1 with focus on environment
- Sub Project B1 with focus on Energy Efficiency
- Sub Project C1.5 with focus on Safety

The requirements for the demonstrator comprise three documents:

- D-A2.1 Functional Requirements TCI Demonstrator
- D-A2.2 Software Requirements
- D-A2.3 ICT infrastructure Requirements

First part of each document (chapter 1-3) places the demonstrator in a context explaining the TCI principles, the Demonstrator and organisational prerequisites needed to enable a successful demonstration. The second part, chapter 4, is specific for each document and specifies the individual requirements. This document concerns the **D-A2.1 Functional Requirements TCI Demonstrator**.

## Abbreviations

Abbreviation	Explanation
ERP	Enterprise Resource Planning
ICT	Information and Communication Technology
MMS	Maintenance Management System
PDM	Product Data Management
SP	Sub Project
TCI	Technical Condition Index
TeCoMan	Technical Condition Manager
TeCoView	Technical Condition Viewer
TOCC	Technical Operation Competence Centre
XML	Extended Mark-up Language

## References

- [1] – Flagship, Annex I “Description of work”, dated 2008-01-19
- [2] – Flagship, D-H1.1a Project Manual, dated 2008-04-11
- [3] – Flagship, D-A1.1
- [4] – Flagship meeting in Hamburg 2007-12-04
- [5] – Flagship meeting in London 2008-03-04
- [6] – [www.wikipedia.org](http://www.wikipedia.org)
- [7] – Shipping KPI project - [http://www.sintef.no/content/page13\\_12287.aspx](http://www.sintef.no/content/page13_12287.aspx)

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## 1. Introduction

### 1.1 Scope

This document defines the requirements to the demonstrator development in SP A2 based on the project partners' discussions and proposals. Descriptions of system boundaries, relations with other Flagship sub projects and the approach to develop, implement and test the content of the demonstrator are covered. The TCI as the basic indexing principle used by the demonstrator is described.

Enabling the demonstrator is also the objective for the requirements to software and ICT infrastructure and hence chapter 1-3 is common for all deliverables D-A2.1, D-A2.2 and D-A2.3, and the unique requirements are described in chapter 4.

The main objective of SP A2 is to demonstrate how the TCIs generated by the TeCoMan system can be utilised in work processes to create a better shipping business.

This main objective consists of the following sub objectives:

1. Selecting technical systems for TCI modelling
2. Selecting input data (measurements)
3. Developing TCI models
4. Implementing TCI models and data collection
5. Demonstrating TCI presentations/reports and measurement registrations
6. Demonstrating TCI use in the work processes

### 1.2 TCI Definition

The TCI, the Technical Condition Index, is defined as follows:

*The Technical Condition Index, denoted TCI, is defined as the degree of degradation relative to the design condition.*

*The TCI can apply to equipment, a system, a whole ship or a fleet of ships. It may take values between a minimum and a maximum value, where the maximum value describes the design condition,  $TCI=100$ , and the minimum value describes the state of total degradation,  $TCI=0$ .*

*The state of total degradation is the condition so unsatisfactory that the equipment, system or ship is prevented from carrying out its primary function.*

It is not always easy to distinguish the TCI from the KPI. The KPIs are financial and non-financial metrics used to help an organization define and measure progress toward organizational goals [6]. The TCI has its basis in technical measurements from design/ constructions in dynamic or static state. In some instances the KPI and TCI can be the same, i.e. if one uses fuel consumption as a KPI, this will be the same as the TCI fuel consumption.

### 1.3 Project layout

This sub project is closely related to sub projects A1, B1 and C1.5 as illustrated in Figure 1. A challenge might arise if SP A1, B1 and C1 demand innovative TCIs after SP A2 has finalised the TCI modelling, this is illustrated by the red arrow. The demonstrator will exemplify usefulness of the TCI models prepared and how they will meet the Flagship objectives.

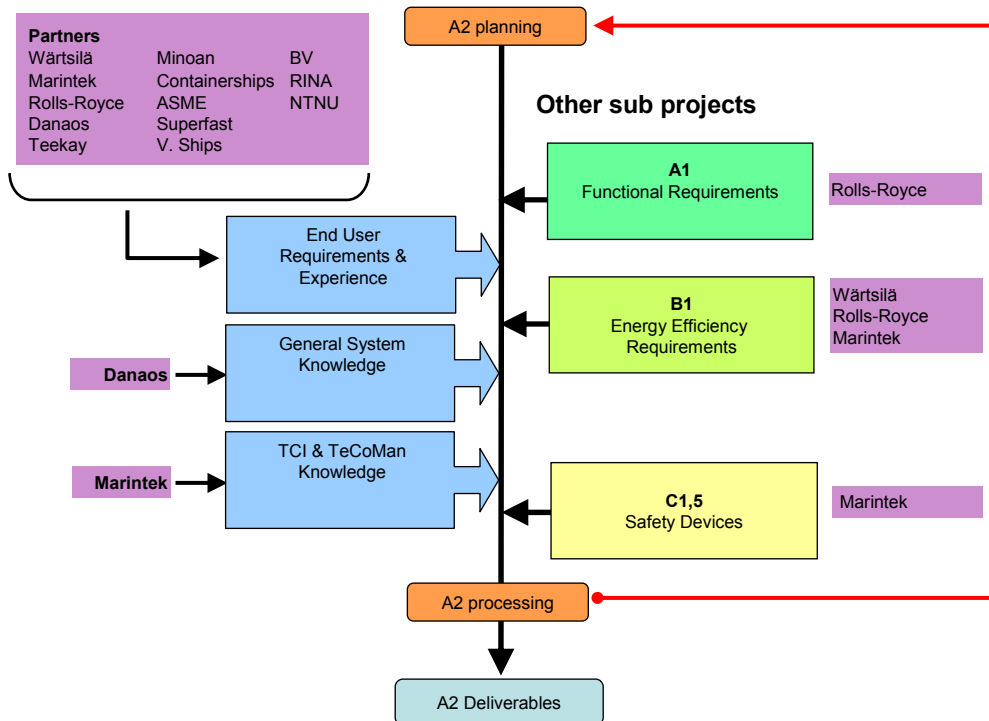


Figure 1 - Setup of Sub Project A2

On the left in Figure 1 is listed the know-how in Sub Project A2. On the right are the results of other Sub Projects that probably are utilised in SP A2. The timeline, the vertical black line in Figure 1, illustrates the “problem” that only SP A1 is completed before “End User Requirements & Experience” of SP A2 are settled, while SP B1 and SP C1.5 are completed later. This means that mainly the results from A1 can be utilised. For B1 and C1.5 as much as possible of the outcome of these sub projects will be utilised. This means basically the following matrix:

- How will A1 – environment – relate to A2 – TCI
- How will B1 – energy efficiency – relate to A2 – TCI
- How will C1.5 – safety – relate to A2 - TCI

Below this is outlined for each of the KPIs related to SP A1, B1 and C1.5.

#### 1.3.1 Relation A1 – environment – A2 – TCI

Figure 2 below shows that the A1 Environment KPI is measured in the environment – not on board the ship. In the example the environmental KPI is too low (“not acceptable”) and the environmental damage in question is soot that possibly can come from shore production facilities or ships. If use of a methodology from A1 comes to the conclusion that the pollution is too high and correspondingly the environmental index is too low a request for TCI results from possible

polluters is a possible scenario. Based on the results the polluters that most likely caused the pollution are asked to investigate/ improve.

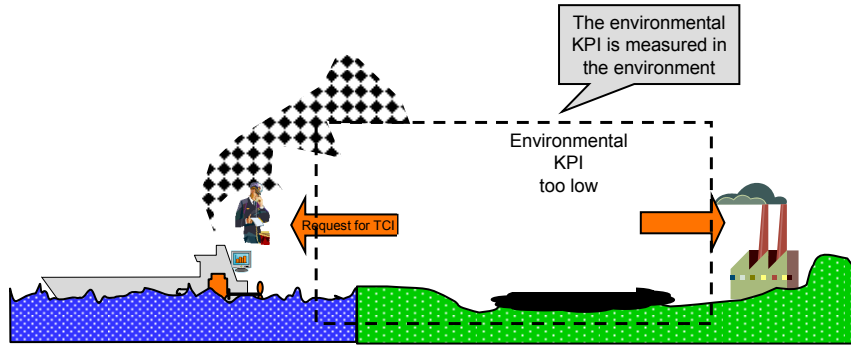


Figure 2 - Relations between environmental KPI and TCI

It should be observed that due to the danger of pollution there will most probably be a time frame within which the ship has to provide their TCI.

1.3.2 Relation B1 – energy efficiency – A2 – TCI

In Figure 3 below the more complex relations between energy efficiency and the TCI are shown. First of all the efficiency can be a measure for a ship alone or for a fleet of ships. The efficiency could also mean a measure for a transportation chain or a total production line including as shown below a factory making the products and the ship transporting the products to the customer.

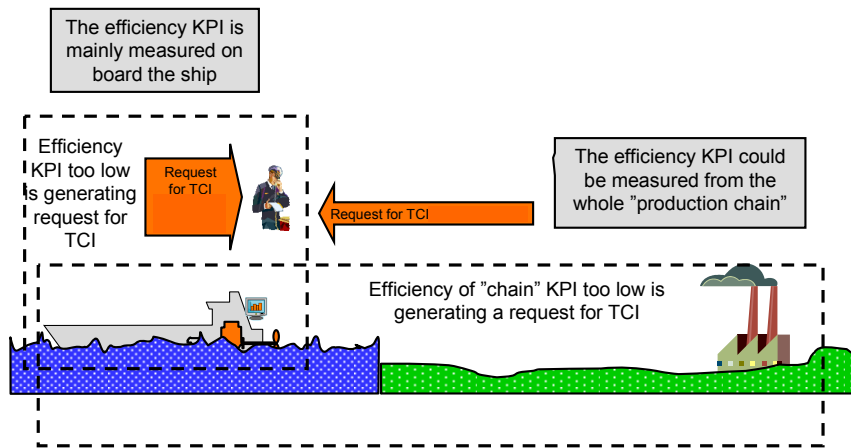
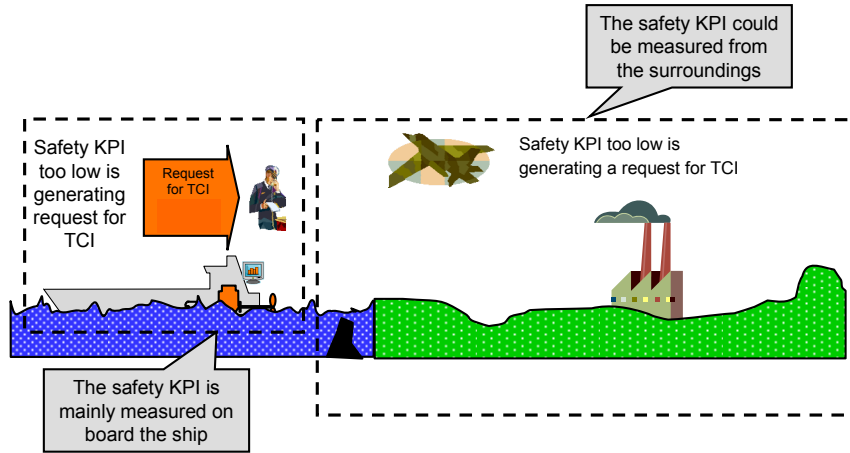


Figure 3 - Relations between B1 energy efficiency, KPI and TCI

The energy efficiency KPI for the ship will mainly be investigated and defined in sub project B1. When the KPI does not meet the required level the ship may receive a request for a TCI.

1.3.3 Relation C1.5 – safety – A2 – TCI

The safety KPI is handled by sub project C1.5. This is a rather complex KPI as shown in Figure 4 below. In this case the KPI could be obtained for the ship itself or for the surroundings. The way of obtaining the safety KPI for the surroundings is very complex but possible to define usable.



**Figure 4 - Relations between safety KPI and TCI**

**1.4 Change Drivers**

The “Change Drivers” for Shipping Business described in SP A1 are related to responsible roles and to innovative solutions for among others practical application of TCI. The Change Drivers are indicated by green and yellow arrows as illustrated below.



**Figure 5 - Examples of change drivers**

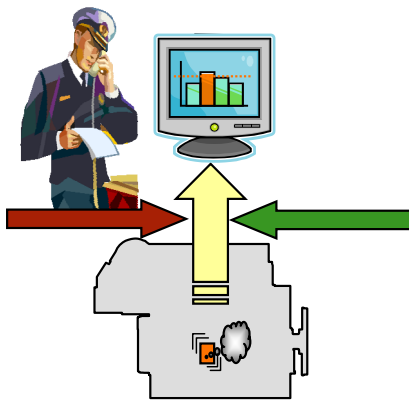
A “new” change driver was developed after the initial ones in SP A1 – the “Environmental perception/performance” as shown by the yellow arrow in Figure 5. The Change Drivers are used in illustrations and text when appropriate, as an example of use of the driver “Environmental perception/performance”, refer to Figure 12.

## 2. TCI calculations

### 2.1 Basics

Obtaining the TCI basically means to transform technical measurements to technical indices. When measurements are converted to indices they can be aggregated by different summation methodologies to indices on higher levels in a TCI hierarchy. The TCI hierarchy can present different views of a system, e.g. environment, energy efficiency and safety, i.e. views important for Flagship. The TCIs are presented in tables or as graphs showing the trend/ history of the results.

All condition degradation generates signals, odours, etc. of some kind. This is imminent and always there. The task is thus to transform these degradation signals into “user obtainable” signals that can be easily observed and furthermore easily and precisely given values that are compared to a stipulated alarm limit as illustrated in Figure 6. A main bearing in bad, inferior, condition generates condition signals in form of e.g. smoke and vibrations. These “odours” shall be transformed into figures that are compared towards an alarm limit and shown on e.g. a monitor. This process, illustrated by the yellow arrow, shall ideally not need any human intervention/help, but it is important to have in mind that the transaction of information to shore organisation might not be feasible without manual registration of sensor data. In the ideal case the generation of the TCI will be neutral from the operator’s point of view and the only human intervention comes when the TCI is out of scope and decisions need to be made.



**Figure 6 - The TCI basic setup**

The burgundy arrow in Figure 6 represents the important input, the configuration of the TCI system. When a main bearing shell is changed from a lead based bearing to a bronze based bearing the TCI configuration is changed. The reason is obvious since the lead based bearing is more dangerous to the environment than the bronze base bearing when extensive wear occurs. The operators are not allowed to change the configuration directly since shore organisation must be aware of and take responsibility for significant changes in the product structure, i.e. the ship. The operators maintain optimal performance of the ships as built or revised and implemented in the TCI system provided.

The green arrow in Figure 6 represents the geographical position of the ship observing the fact that the TCI related to environment is also dependant to geographic areas. Arctic areas are especially sensitive to certain kinds of pollutions (e.g. black smoke or soot) and thus the index of a worn fuel nozzle is stricter in the arctic region.

## 2.2 Monitoring

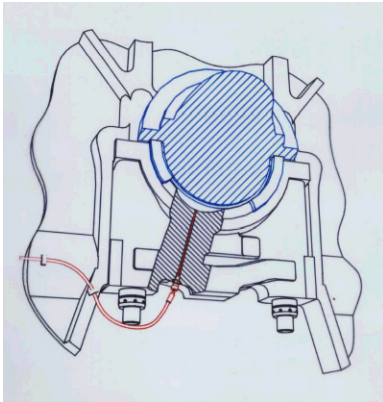
The “goal” of the monitoring is to catch the signals or properties generated by the equipment as a result of operation or deterioration. This means that besides components such as bearing shells also fluids such as lube oil can be monitored.

### 2.2.1 How to monitor?

The signals for system operational performance or system degradation should be distinguished as the monitoring methodology is different. For example:

- Due to operational performance **Heat** is typically generated in the bearing shell
- Due to degradation **Smoke** is typically generated in the bearing shell (or crankcase)

Transducers or sensors installed on the bearing shell monitor the shell temperature as illustrated in Figure 7. Typically, the shell temperature is one measurement that gives information about the operational performance of the bearing. The temperature signal is always there also when the condition is OK and thus a longer pre-warning period prior to risky situations occur is obtained.



**Figure 7 - Monitoring the temperature of the main bearing shell**

Degradation gives signals that should normally not occur like smoke or large amounts of lead in the lube oil. Drawbacks monitoring these signals are late sensing of fatal developments and difficulties in sensing e.g. the colour of exhaust gases. Degradation signals are therefore used for alarms when operational performance signals are not available or uncertain.

Monitoring could be either continuous or intermittent. Typically temperature measurement or monitoring is continuous. Fuel quality monitoring on the other hand is normally intermittent, i.e. is performed by taking samples for analysis. The same is true regarding measurement of ignition pressures by portable devices or measurement of vibrations by likewise portable devices.

On board implementation of the demonstration could therefore for practical reasons (ease of implementation) use manual registration if the ship-owner accepts additional workload for registrations that are not already implemented.

### 2.2.2 What to monitor?

In today’s ship machinery the monitoring equipment is rather extensive. The mandatory ones are the cooling water temperature and the lube oil pressure. None of these are, however, very useful from an environmental point of view. Candidates for environmental monitoring may be:

- Amount of lead in the lube oil
- Amount of NOx in the exhaust
- Degree of soot or black smoke

**2.3 Transforming readings**

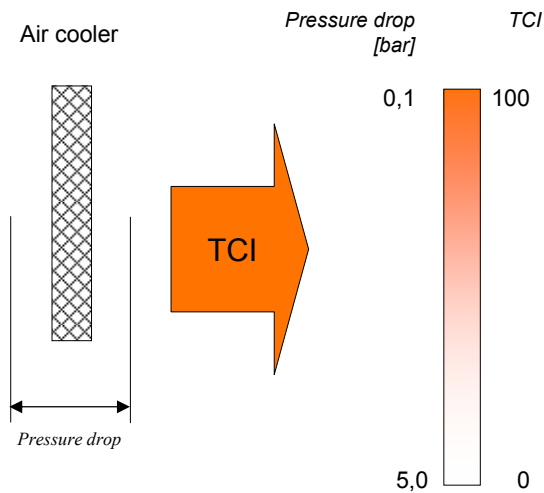
The signals from operational performance or degradation are usually transformed into voltage or current and then via an analogue to digital converter into numbers. Based on these numbers the TCI has to be calculated for the component or system considered. The TCI values between 0 and 100 are normally used to easily communicate the condition and decision making, thus minimising the time when a ship is operated under substandard conditions.

There are different scenarios for obtaining a useful TCI and some of them are described below.

**2.3.1 Scenario 1 – calculation of TCI is possible**

Exemplified by the Air cooler for an auxiliary engine:

The objective of the air cooler is to cool the charge air. A normal operational performance measure is to measure the pressure drop over the cooler. By measuring this drop a good indication of its condition is achieved. This indication can be turned into a TCI as shown in Figure 8 below.



**Figure 8 - Generating TCI by monitoring an air cooler**

**2.3.2 Scenario 2 – calculation of TCI is not feasible**

Exemplified by the Injection nozzle for auxiliary engine:

The evaluation of the injection nozzle condition is “tricky” as the nozzle itself only gives part of the answer as the efficiency of the combustion process is probably more important. Measurements like distribution of the exhaust gas temperature and the engine output indirectly answer the “condition” questions. However, transforming these measurements into a reliable TCI is maybe too complicated. As shown in Figure 9 the answer to what to measure will therefore just be a question mark.

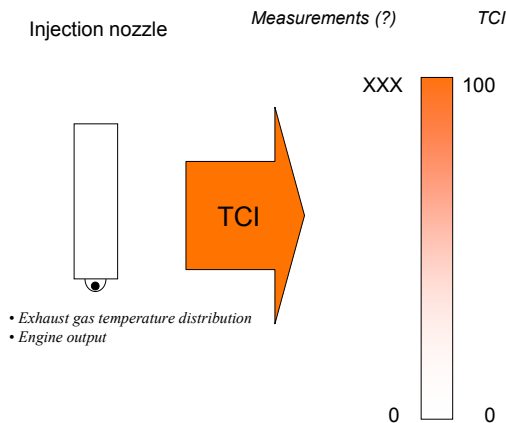


Figure 9 - Challenges in transforming measurements into a TCI

### 2.3.3 Scenario 3 – calculation of TCI at a higher system level

Exemplified by the Auxiliary engine:

When it is not feasible to measure the condition of a component as shown above, a “compromise” is to consider an aggregated unit, in this example the whole auxiliary engine. This means that the TCI of the injection nozzle is not separately evaluated at all, but is included in the TCI which is an aggregation of all the measurements for which there exists a reference in form of e.g. test run protocols as shown in Figure 10.

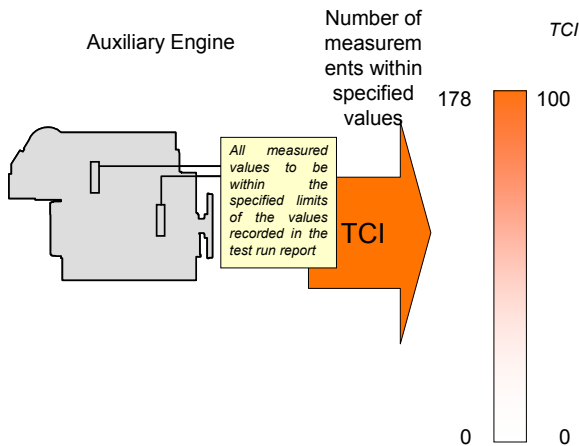


Figure 10 - “Stepping up” the size of the entity to measure

## 2.4 Aggregation

An important part of the TCI usage is the “aggregation”, i.e. evaluating the impact of a TCI in a context. Table 2 below outlines what this means by giving two examples.

**Table 1 - “Aggregation”**

Entity	Example 1	Example 2
Enterprise	Shipping Partner	Shipping Partner
Fleet	Fleet 3	Fleet 3
Ship	Ship 3	Ship 3
Department	Propulsion	Propulsion
Equipment	Main Engine	Main Engine
System	Crankshaft	Lube Oil system
Component	Main bearing	Lube Oil Filter cartridge ●

**Example 1**

In this example Ship 3 has a damaged Main Bearing in its Main Engine, and as a consequence the engine cannot rotate and the ship is without propulsion and out of business. But, as the ships are separate business entities, the fleet is still in business. However, if the consequence of the failing ship is violation of a contract signed for a fleet of ships the whole enterprise could be in severe trouble.

**Example 2**

In this example we have a typical setup for four-stroke engines where the main lube oil filter is of duplex type with two separate compartments that each can take the whole oil flow. This means that when the cartridge in one compartment is being clogged the filter unit can be switched over to the other compartment whilst the first one is fixed. This means that a bad TCI for lube oil filter pressure drop in the best case only will affect the measured/ evaluated component in question, i.e. the lube oil filter cartridge. Redundancy that this example focuses on at component level is applicable on higher levels in a hierarchy – even on “Department” level.

### 3. Demonstrator

The relations between the sub tasks are colour coded in the Demonstrator as shown in Figure 11 and Figure 12. The coding and subsequent task contents are as follows:

#### 3.1.1 D-A2.1

..... The blue dashed lines are the system boundary of the demonstrator. Deliverable D-A2.1 defines functional requirements to elements inside the boundary.

■ The orange background illustrates demonstrator parts that are located onboard the ship, refer Figure 12, the connection to work processes are essential for successful implementation.

#### 3.1.2 D-A2.2

■ The grey background illustrates the software that calculates and presents the TCIs. Deliverable D-A2.2 defines the software requirements for provision of TCIs to restore to allowed operation conditions, refer Figure 11 and Figure 12. The software is based on the existing TeCoMan application.

#### 3.1.3 D-A2.3

■ The pink background illustrates the infrastructure that integrates the software calculating TCIs with the necessary readings and work processes. Deliverable D-A2.3 defines the requirements to the ICT infrastructure to include manual readings and if feasible possibly automatic acquisition of data can be performed.

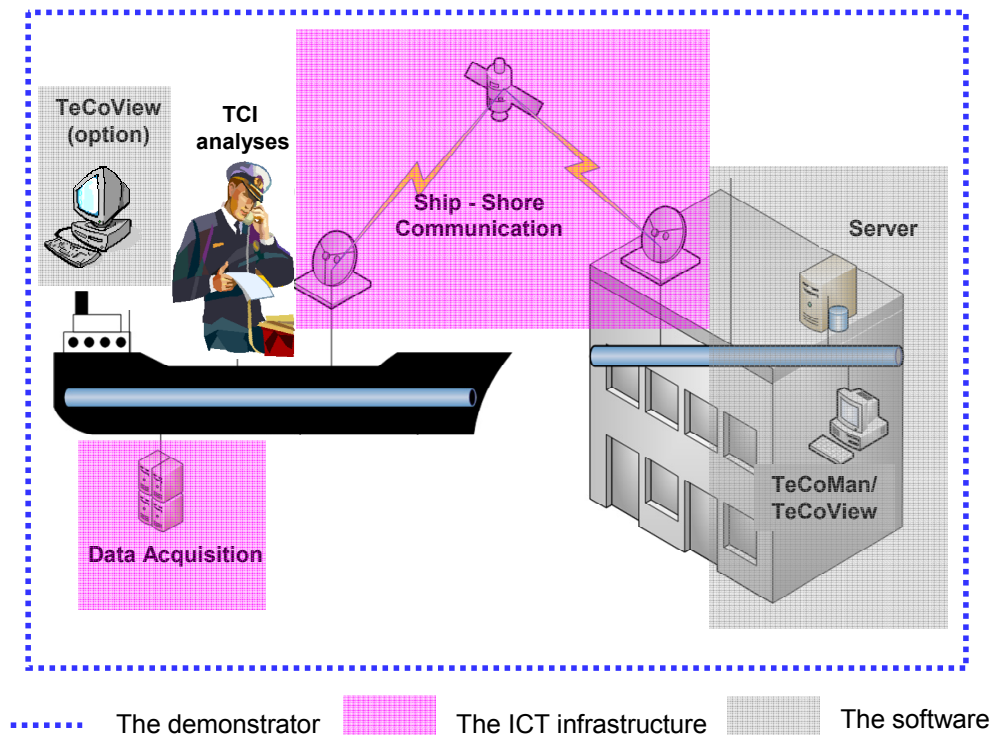
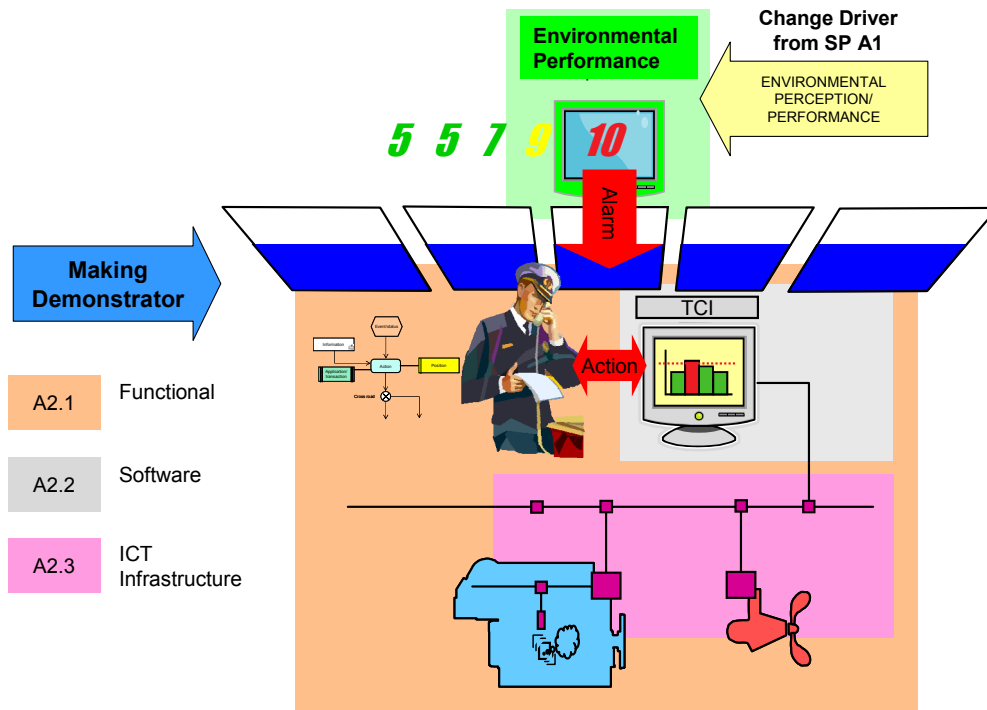


Figure 11 - The A2 Demonstrator set up

Figure 12 illustrates the environment in which the system is supposed to operate onboard, this includes the physical locations and to a limited extent the infrastructure requirements while operating. As can be seen in the figure the TCI results are displayed to an officer with the main system in the control room.

Observe that the specifications below are for the Demonstrator aiming at being able to demonstrate the Main and Sub objectives of the project. The demonstrator and consequently the requirements put on it is in other words not to be viewed as a fully industrial system.



**Figure 12 – Demonstrator setup supporting “Environmental Performance”**

When an important performance indicator monitored passes TCI warning limit and approaches the red TCI alarm limit the responsible officer will find the means and methods to improve operating condition. Since the TCIs are for performance monitoring and not for safety the officer in charge will decide/ plan when corrective actions should occur. To accomplish this relevant TCI results identifies the components and measurements causing the alarm.

To prove this statement the use of a “not acceptable” mode of the Demonstrator as shown in Figure 13 may be necessary.

As can be seen there are three (3) main items removed from Figure 12 that result in the “not acceptable” mode in Figure 13:

- The predefined process chart
- The TCI monitor
- Part of the ICT infrastructure

The demonstration should indicate clearly that by switching to “prime” mode and taking necessary actions return to sustained performance is obtained.

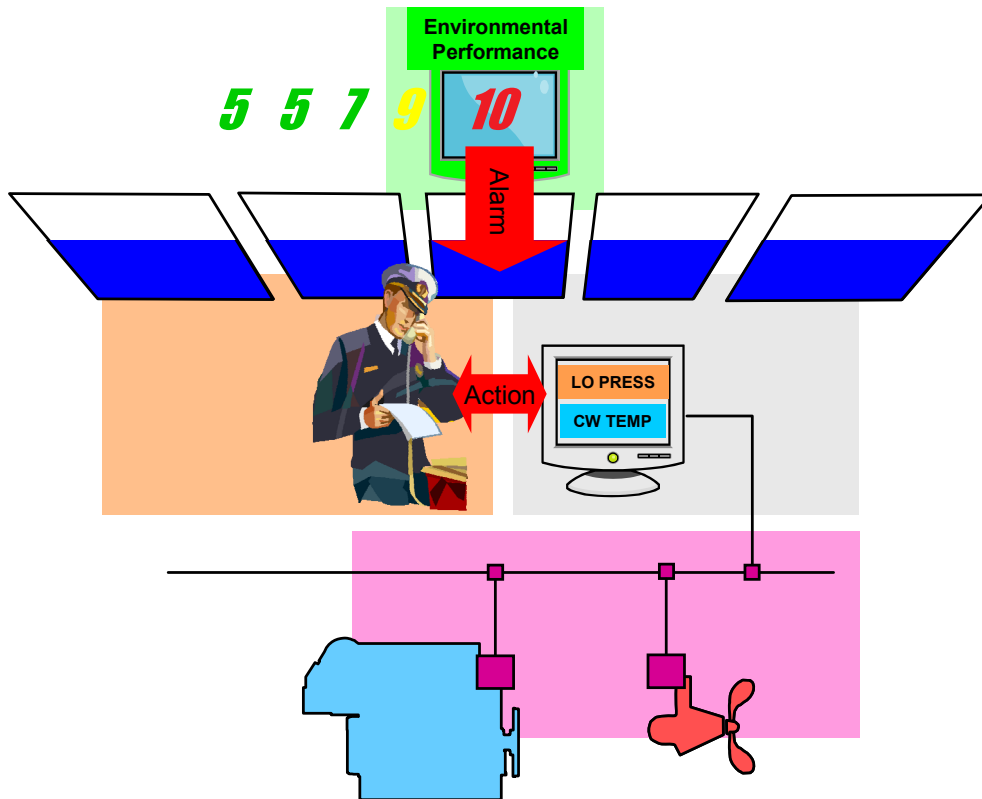


Figure 13 - Demonstrator in “not acceptable” mode (without TCI)

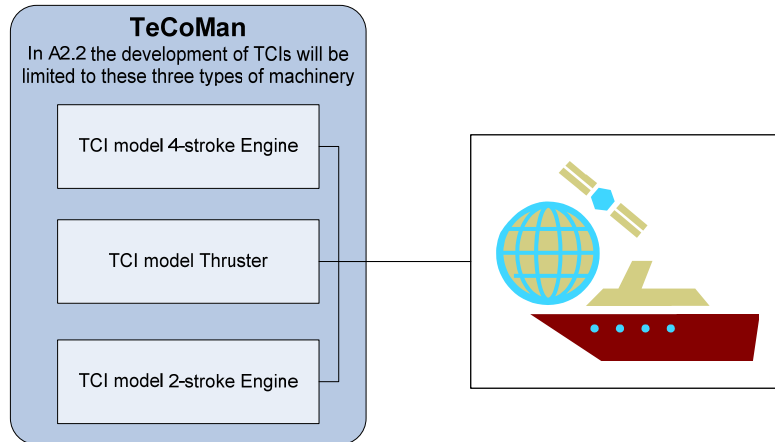
### 3.2 Systems selected

During the development of sub project A2 the project has selected which equipment it will demonstrate TCIs for. The selection is done with basis in lists of critical equipment onboard the ships, criticality analysis made for equipment and which type of equipment the manufacturers involved in the sub project has detailed knowledge about. The partners will facilitate selecting ships with specific equipment relevant for the demonstration cases, and the results will be applicable to most shipping enterprises.

The following equipment has been selected for demonstration of TCIs:

- TCIs for 2-stroke main engines. These TCIs are based on earlier development done in the project TOCC that has been partly financed by the Research Council of Norway.
- TCIs for 4-stroke generator engines
- TCIs for tunnel thrusters

The TCI cases will be demonstrated by using one or more demonstration vessels to pick up and send measurement data to the TCI models on shore where the onshore organisation provides analyses and support, refer Figure 14.



**Figure 14 – Demonstration cases**

The following partners will be the important contributors in the formulation and generation of TCI calculations for the TCI models developed:

- Wärtsilä for 4-stroke auxiliary engine
- Rolls-Royce for thrusters
- Wärtsilä and NTNU for 2-stroke main engine with background info from TOCC

Acceptable operational conditions for measurement collection, what to measure, range for measurements and how frequent to measure will be elaborated during task A2.2, but at the moment the feasible approach is to use manual readings taken at rational intervals of crew, likely options are every 14 days, month or on demand. The crews' use of TCIs for better decisions and better vessel performance is very important for their motivation. The response time from measurements are received onshore to performance analysis is performed and sent onboard will be only some minutes. If automatic acquisition of data is feasible the work load of crew will be reduced.

Ship managers will make test records and sea trials for equipment available and implement into their work processes registration and sending of measurement data for performance analysis.

Marintek will implement the TCI models into the software application TeCoMan onshore.

Site for demonstrating usage of TCIs is flexible and a ship owner's office or a research and development facility with access to models, results and communication with vessels are suited to demonstrate the TCIs and the ship-shore communication.

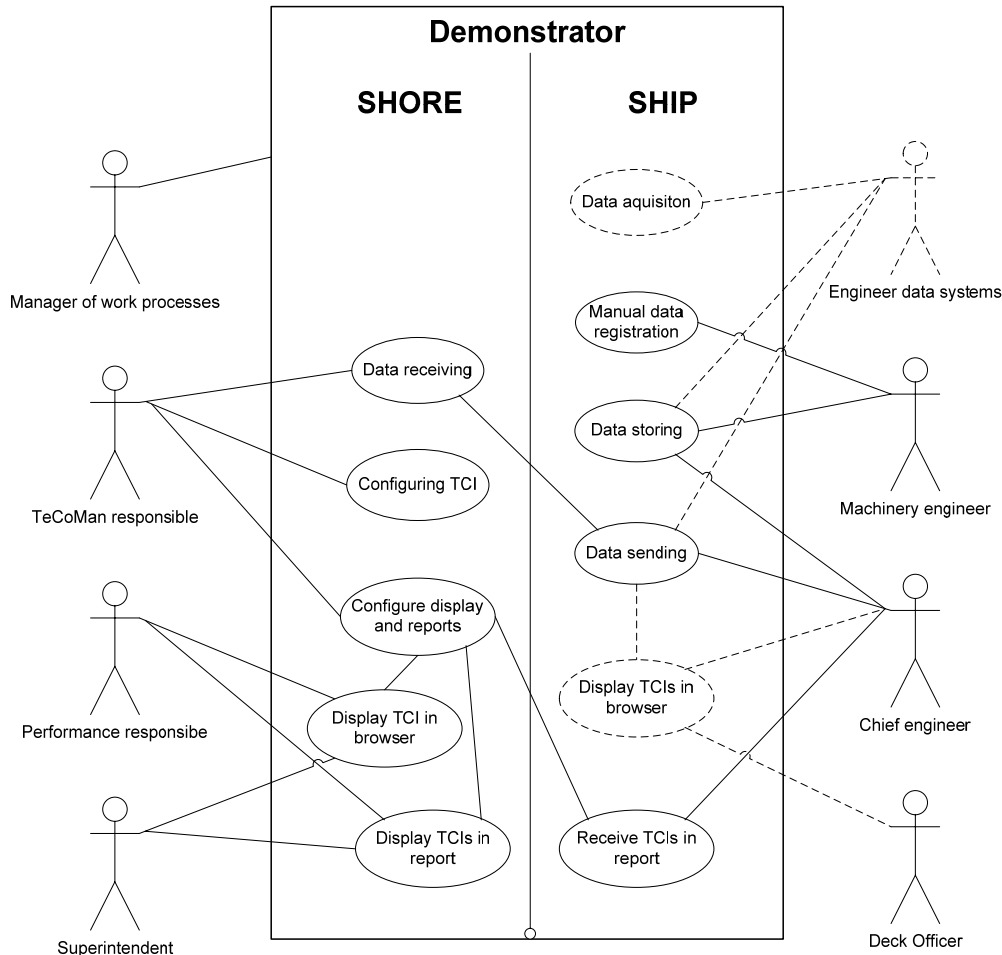
A test plan need to be elaborated, as part of work package E, to test the content of the TCI models, the reporting and the impact on performance and work processes.

The feedback during testing, demonstration with involvement and evaluation by the ship managers will reveal the feasibility, willingness and beneficial use of the TCI demonstrator and the potential for developing professional commercialised solutions.

The installation and implementation of the necessary infrastructure to integrate TCI models with work processes will be specified during task A2.3 "Implementation in performance analysis tool". Also a "story board" for testing and demonstration has to be developed when more of these pre-requisites are known.

### 3.3 Users and decisions

The users that possibly can be involved by the functionality of the demonstrator are identified in Figure 15. The main users are the ones regularly checking the TCI results.



**Figure 15 - Users connected to the demonstrator**

The TCI may be used for both short term and long term assessment and decisions.

Using the TCI for short term decisions

One type of short term decision is to initiate investigation when TCI results reveal unexpected changes in operational performance or degradation of equipment. During this investigation it is possible that the ship or the management office ashore requests consultancy or service personnel to improve the situation. It is not only the TCI results, but also the KPI results that can influenced such change in performance, refer Figure 16.

Using the TCI for long term decisions

Long term assessment of TCI results is useful to benchmark operational performance of vessels. When a vessel for a longer period has results below the acceptable performance defined by the TCIs and also worse than its sister vessels, a natural consequence is to make decisions for

investigation and corrective actions to improve the performance/ instrumentation of the ship. Making this operational performance traceable to document it is good and maintained is a quality of ship management that interest those hiring the ships.

The TCIs are based on technical measurements from calibrated sensors which give a direct and strict approach with traceability to follow-up the operational performance demanding higher quality in ship management. Other information like qualitative assessment of measurements, accident info, economic info, etc. does not provide equivalent information. TCI results might in long term be useful for more standardisation of technical quality in operations, fuel efficient operation, environmental friendly operation, etc.

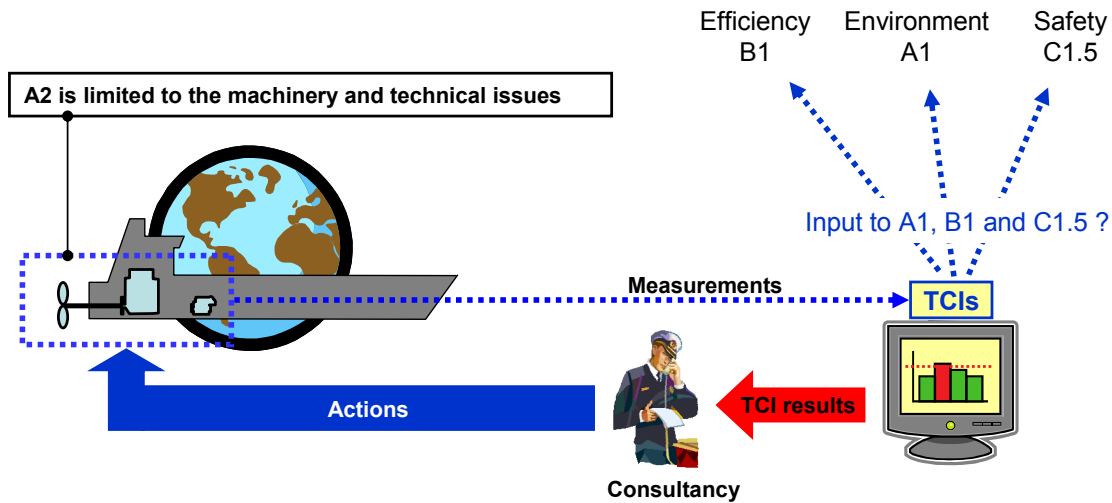


Figure 16 - The event and actions on board in case of TCI request

### 3.4 Work processes

Ships are floating enterprises. Enterprises have to be aware of the present status of their resources. To accomplish this ERP (Enterprise Resource Planning) can be used to predefine processes with standard symbols as shown below.

The two interesting objects in this context are the yellow “position” indicating the user/operator and the green one describing what “application/ transaction” will be utilised to accomplish the action. The reason for this approach is that many ship owners indicate that installing systems on board has no meaning if there is no time allocated to utilise them properly. Efficient use can only be obtained if the system is installed as a result of a process documenting the need. This will bring a new dimension to the usage of TCI in the sense that it connects the TCI use to the development of the business.

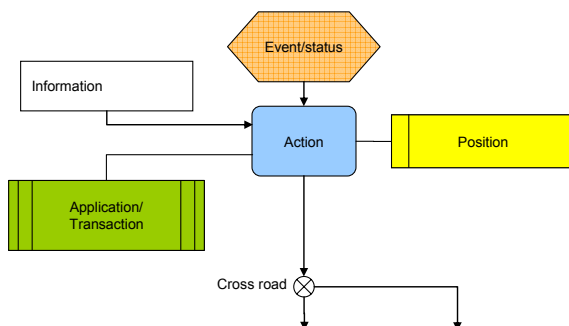
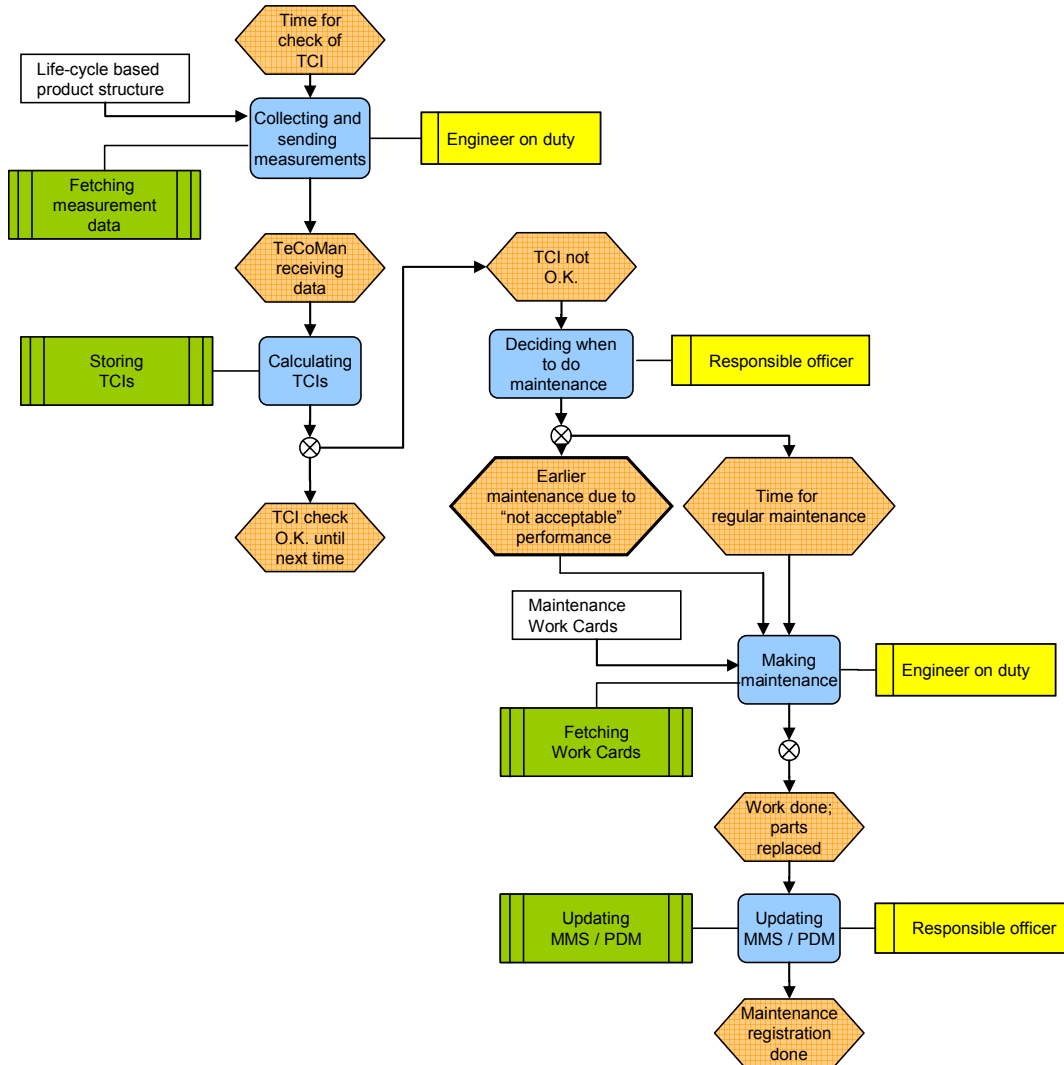


Figure 17 - Standard process symbols.

An advantage of the ERP approach and development of applications based on processes is the possibility to ensure proper end results by linking processes. For example to ensure that the TCI process is related to the Maintenance Management System, MMS and the Product Data Management, PDM. Such an example of a connection between the TCI process and the maintenance process is shown in Figure 18. This will place the demonstrator in a context where important transactions are listed by the “green” boxes.



**Figure 18 - The TCI connected to the maintenance process**

If implementation of the TCI checking system is only concerned about installation and training and not about integration with the daily work processes, only minor benefits will be obtained. To benefit from the ERP principle the demonstrator can facilitate for identification of where the ship managers can include better decision support by using TCI results inside their work processes.

#### 4. Functional Requirements to the Demonstrator

This chapter, concerns the individual 'Functional Requirements' of the TCI Demonstrator and describes the necessary pre-requisites to test and demonstrate the usage of TCIs in the direction of the project objectives. Together with the documents 'Software Requirements' and 'ICT Infrastructure Requirements' the "Functional Requirements" describes the requirements identified in the task "A2.1 Identify requirements to TCIs".

##### Requirement Number (Identification)

TCI requirements are identified by a 'Type - Group - Number' convention by a sequence like 'SR-03-10'.

Types:

'FR' identifies a Functional Requirement for Demonstrator.

'SR' identifies Software Requirements

'IR' identifies ICT Infrastructure Requirements

The groups defined are used to sort requirements. The groups are specific for the different types of requirements. Groups within Functional Requirements (FR) are:

01. Installation/setting to work
02. Operation (normal and emergency)
03. Maintenance/upgrade
04. User interface
05. User (ship owner/operator) requirements
06. Interface to software
07. Interface to ICT infrastructure
08. What to measure
09. How frequently to measure
10. Test plan
11. Reporting
12. Partner expert knowledge

Requirements within Type-Group are numbered with two digits from '01' up to '99' to make identification of requirements unique for reference.

#### 4.1 Requirement Template

<b>Requirements Template Guide</b>	
Unique Requirement Number	Each requirement should have a unique reference number. Reference number can incorporate number and letters in its syntax to identify types and groups of requirements.
Requirement	The requirement is a clear and simple statement. The requirements should be singular. Complex requirements must be split in two or more requirements. Requirements should be defined so that it is possible to verify them through testing.
Version	Version control is required as requirement statements will be modified over time.
Date revised	Enter the date of original issue or revision.
Priority	<b>Mandatory</b> , Requirements with this priority has to be fulfilled to provide the demonstrator with the essential functionality. <b>Useful</b> , Requirements that significantly improve demonstrator, project or user objectives. <b>Nice to have</b> , Requirements that not significantly improve demonstrator, project or user objectives.
Owner	The partner that is responsible for the requirement.
Source	Identifies the origin of the requirement. Origin can be a written source, a company or a person. Origin is important in cases where interpretation or description need to be improved.
Proposed Compliance Method	Proposed method shall demonstrate compliance with the requirement. The method to be proposed at the time of raising or revising the requirement.
Actual Compliance Method	A statement describing how compliance with the requirement actually was demonstrated. The statement is entered at the time of testing and evaluating the requirement.
Comments (including reasons for revisions)	Free text field for narrative comments.

**4.2 Functional Requirements**

<b>Unique Requirement Number</b>		<b>FR-01-01</b>	
Requirement	The demonstrator shall implement the necessary infrastructure to transfer measurement data in XML format to shore by satellite communication.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Mandatory	Owner	
Source	Marintek		
Proposed Compliance Method	Tested by checking that TeCoMan application onshore receives data from ship.		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-01-02</b>	
Requirement	The demonstrator shall contain the necessary algorithms for TCI calculations.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Mandatory	Owner	
Source	Wärtsilä		
Proposed Compliance Method	Tested by using TCI test models and checking that the calculated TCI results are correct.		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-01-03</b>	
Requirement	The demonstrator shall implement the TCI models		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Mandatory	Owner	
Source	Wärtsilä		
Proposed Compliance Method	Tested by implementation of TCI models developed by NTNU, Rolls-Royce and Wärtsilä into TeCoMan.		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-02-01</b>	
Requirement	The demonstration shall demonstrate where the TCI results fits into ship managers work processes		
Version	1	Date revised	
Priority	Mandatory	Owner	
Source	Wärtsilä		
Proposed Compliance Method	Tested by use of a Story board		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-02-02</b>	
Requirement	The measurements for the TCIs should be collected under normal acceptable operational conditions with respect to weather conditions and load on equipment.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Mandatory	Owner	
Source	Wärtsilä		
Proposed Compliance Method	Verified by checking that the measurement identifying operational condition is within ranges defined for acceptable operational condition.		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-02-03</b>	
Requirement	The use of TCI to obtain an acceptable state shall be demonstrated.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Mandatory	Owner	
Source	Wärtsilä		
Proposed Compliance Method	Tested by import of measurements making TCI unsatisfactory and then through the work process/ story board improving the measurements so that TCI condition improves to an acceptable condition.		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-02-04</b>	
Requirement	The demonstrator should not affect any other ship board systems from a safety point of view.		
Version	1	Date revised	09 <sup>th</sup> September, 2008
Priority	Mandatory	Owner	
Source	BV and RINA		
Proposed Compliance Method	Evaluation which concludes that the demonstrator has no influence on other systems and processes with respect to safety.		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-04-01</b>	
Requirement	The system shall have a configurable user-interface		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Nice to have	Owner	
Source	Wärtsilä		
Proposed Compliance Method	Through a selection of options preferred information to be presented at start up can be decided, and also what information shall be accessible.		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-05-01</b>	
Requirement	It shall be possible to view the analysed TCI results on board.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Mandatory	Owner	
Source			
Proposed Compliance Method	The TCI results can be observed onboard in reports received from shore in email and as an option in the application TeCoView if installed onboard.		
Actual Compliance Method			
Comments (including reasons for revisions)	Check at start-up of demonstrator is enough.		

<b>Unique Requirement Number</b>		<b>FR-06-01</b>	
Requirement	It shall be possible to update the TCI model from the product structure of the equipment onboard.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Nice to have	Owner	
Source	Wärtsilä		
Proposed Compliance Method			
Actual Compliance Method			
Comments (including reasons for revisions)	Requirement more relevant for an industrial system.		

<b>Unique Requirement Number</b>		<b>FR-06-02</b>	
Requirement	The TCI system shall be able to communicate with Office applications for easy making of reports.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Useful	Owner	
Source	Wärtsilä		
Proposed Compliance Method	It shall be tested that a TCI report is produced by selecting a node in the TCI hierarchy in TeCoMan.		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-07-01</b>	
Requirement	TCI System shall be able to import measurement data from ship board systems.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Mandatory	Owner	
Source	Marintek		
Proposed Compliance Method	Measurement data requested from ship systems will be stored in XML format prior to export to the TeCoMan application. Manually registrations of data from shipboard system is performed before storage in xml, optionally automatic acquisition can be used if feasible.		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-07-02</b>	
Requirement	Ship communication via Ethernet		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Mandatory	Owner	
Source	Wärtsilä		
Proposed Compliance Method	Tested by use of web browsers and sending of email/ xml messages.		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-07-03</b>	
Requirement	Equipment communication via field-bus		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Useful	Owner	
Source	Wärtsilä		
Proposed Compliance Method	Tested by receiving information from field-bus system for auxiliary or main engines.		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-07-04</b>	
Requirement	The Ship hardware shall have collector compatible data communications/transmitting capabilities.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Nice to have	Owner	
Source			
Proposed Compliance Method	Confirming connectivity between ship boards systems and the data collector.		
Actual Compliance Method			
Comments (including reasons for revisions)	Requirement more relevant for an industrial system.		

<b>Unique Requirement Number</b>		<b>FR-08-01</b>	
Requirement	The demonstrator shall monitor operational performance measurements.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Mandatory	Owner	
Source			
Proposed Compliance Method	Checking that correct type of data are registered/ received.		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-08-02</b>	
Requirement	The demonstrator shall degradation measurements.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Useful	Owner	
Source			
Proposed Compliance Method	Checking that correct type of data are registered/ received.		
Actual Compliance Method			
Comments (including reasons for revisions)			

<b>Unique Requirement Number</b>		<b>FR-08-03</b>	
Requirement	The measurement data shall be time-stamped into a common database.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Mandatory	Owner	
Source			
Proposed Compliance Method	Checking that data are time stamped.		
Actual Compliance Method			
Comments (including reasons for revisions)	Checking at start-up of demonstrator is enough.		

<b>Unique Requirement Number</b>		<b>FR-08-04</b>	
Requirement	The ship shall provide the registrations that the TCI model requires.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Mandatory	Owner	
Source			
Proposed Compliance Method	Testing that the collector and the TeCoMan application are receiving all measurements as specified in the TCI model specification.		
Actual Compliance Method			
Comments (including reasons for revisions)	The list of needed measurements will be defined when developing the TCI models and investigating which measurements are available.		

<b>Unique Requirement Number</b>		<b>FR-09-01</b>	
Requirement	It shall be possible to collect series of data within a specified time frame.		
Version	1	Date revised	26 <sup>th</sup> March, 2008
Priority	Mandatory	Owner	
Source			
Proposed Compliance Method	Checking that a defined series of data is time stamped within a specified time frame.		
Actual Compliance Method			
Comments (including reasons for revisions)	The data series defined will be determined after selection of demonstrator hosting ship. The length of the specified time frame will be determined with reference to the TCI model definition. Check at start-up of demonstrator is enough.		