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FOREWORD

This report is prepared in addition to the reports required to fulfil the SHIPDISMANTL consortium obligations to EC as per Project Proposal. This Technical Report summarizes the work carried out during the SHIPDISMANTL project. Each chapter of the present report makes a synopsis of the discussions, results, recommendations etc of each of the project's work-packages, with the aim of providing the interested reader with an overview of the work carried out throughout the SHIPDISMANTL project. For exactly this reason few photos, sketches, graphs, tables etc are also presented here.

CHAPTER 1: WP 2 OVERVIEW

1.1 CURRENT DISMANTLING STRATEGIES, METHODOLOGIES AND PROCEDURES

ABSTRACT

Ship dismantling is the reverse operation of shipbuilding, where the ship is taken apart into its primary components. In principle ship dismantling is an environmentally friendly activity since it is a recycling operation, supporting sustainable development. It also removed tonnage that would otherwise be left abandoned to pollute the environment. Currently ship dismantling takes place in places like India and Bangladesh where there is an abundance of cheap labour and loose environment and worker health and safety regulations. When a ship is sent for demolition, it first needs to be secured at the demolition yard. The vessel is then inspected to ensure proper waste management (to the extent required by the individual country where the yard operates). Ships are dismantled top to bottom and bow to stern using torch cutting (oxygen, acetylene, LPG). Large steel blocks are reduced into marketable sized steel scrap and plates. At the same time almost all ship equipment and machinery finds its way to the second hand market. On a daily basis worker are exposed to a variety of dangers, since ship dismantling primarily takes place in little regulated countries. The international community has recently paid a lot of attention to the matter of ship dismantling, and there are plans to develop an international framework to regulate and support ship dismantling.

1.1.1 INTRODUCTION

Ship breaking and its harmful consequences have come to the forefront of publicity in the past few years, revealing the big challenges for the environment and human health. Most ships being dismantled today were built in seventies prior to ban on many hazardous materials. It is recognized lately that if ship breaking is conducted haphazardly with little scientific and technical knowledge and with inadequate environmental, health, and safety safeguards; the work-force could be exposed to a wide range of hazards and the activity of ship-breaking would leave disproportionately large environmental footprint behind. Most of the wastes generated from ship breaking industry can be recycled, thus reducing the load on the environment and supporting sustainable development. It is necessary to critically study the ship dismantling practices so that one can identify the materials/wastes generated from ship breaking industry that can be utilized in other places.

1.1.2 THE WORLD OF SHIP DISMANTLING

1.1.2.1 SHIP DISMANTLING IN A NUTSHELL

Ship dismantling describes the process of:

- Cleaning a vessel of any/all dangerous materials which are then sent for disposal
- Removing any/all equipment that can be sold in the second hand market for re-used

Cutting of the metal part of the ship, which is then processed/recycled, either by re-rolling or by electric arc furnaces, to produce cold or hot steel products

The wastes generated by ship breaking industry can be broadly classified into hazardous and non-hazardous wastes. The non-hazardous wastes comprise of debris and mixed matrixes such as broken. In addition, unused oils and fuels, unused paints, thinners, and coatings, reusable asbestos, thermal and electrical insulations, rubber sheets and many such materials are recovered and sold for reuse.

The ship dismantling industry provides employment to both skilled and unskilled personnel. Considering that ship dismantling is primarily an industry of the less developed world, and also considering that it is a labor intensive operation, it creates jobs for people that would otherwise have little opportunity to find employment. From the developed world's point of view, the working conditions in some ship recycling countries might seem unacceptable, but it is often the case that the people employed there enjoy more welfare benefits, higher wages and a better overall life standard than otherwise possible. Hence ship dismantling also has a positive socio-economic effect on the society.

1.1.2.2 THE EVOLUTION OF THE INDUSTRY

Over the years, the ship dismantling industry has migrated to less developed countries, with lower labor costs and looser environment and safety standards. Moreover, such countries provide a deep market for secondhand equipment, components and used materials. These are the primary reasons for the current geographical allotment of the ship dismantling centers. In the mid-1900's ship dismantling was primarily performed in countries like the US and the UK. With labor costs increasing in those countries, ship dismantling eventually moved to less developed European countries like Spain and Italy, as well as in places like S. Korea, China in the Far East, with Taiwan taking a lead role. In the 1980s a new gradual shift started occurring, moving ship dismantling away from Europe and into the Far East. India's abundant labor force was a key parameter to providing the necessary foundations for putting aside Taiwan's dominant role. Pakistan and Bangladesh also followed the same path, eventually taking over from Taiwan, which turned to more advanced operations. This balance of forces still remains today, with India and Bangladesh battling for the No. 1 spot. Of course there are ships that due to damage or other undetermined reason cannot travel long distances to reach their demolition site, leading to the creation of smaller regional demolition centers. Turkey is the largest such example, primarily serving European, African and East US Coast vessels.

1.1.2.3 SHIP DISMANTLING AS A COMMERCIAL ACT

A shipowner selling a ship for dismantling has two options:

- Sell the vessel directly to the breaking yard
- Employ a so called "cash buyer"

The former, although rare, is a direct sale a purchase deal between the shipowner and the dismantling yard. The latter is more common and involves a middle man. The cash buyer makes all arrangements at his own cost and time to sell and deliver the vessel to the demolition yard. Cash buyers are people with good knowledge of the ship breaking market mechanics and have close ties with many ship breakers. In contrast to a ship owner who might only sell a handful of vessels for scrap over his life, the cash buyer has almost daily trades with dismantling companies, hence giving him a better negotiating power.

1.1.2.4 THE BUSINESS MODEL

The cost side of the equation is similar to any other major industrial activity, with labour costs, equipment investment, equipment maintenance and depreciation, consumables, and waste management taking the top spots. Based on the relative use of mechanized vs. labour force and the respect for the workers and the environment, there are two relative distinct business models, namely the "beaching model" and the "Western model". While the former is based on low unit costs, the latter is focused on high unit productivity

1.1.3 DOCKING ALTERNATIVES

The function of the docking system in the context of ship dismantling is to isolate the vessel from the water and provided a suitable environment for demolition activities. Demolition can either be performed on the docking system or started after the vessel transferred to shore away from docking platform. As a central and capital investment in a dismantling establishment, docking facilities considered as critical and bottleneck resource and optimum operational conditions are sought. Capacity utilisation of the docking hugely determines the cycle time of the operations, pace of the downstream and upstream operations, and finally, the speed of the entire demotion process.

Among the functions of docking facilities are

- Containment of releases
- Stability for the vessel

There are four main types of docking facilities;

- Floating dock
- Dry dock (graving dock)
- Slipway/Marine railway
- Shiplift

- Beaching/Natural slipway

Today India, Bangladesh and Pakistan employ the beaching method assisted by tides. Turkey also dismantles ships on the beach, but in the absence of tides, Turkey enjoys a natural slipway type of docking system. China dismantles vessels in wet basins along a dock and eventually draws the ship on a slipway/marine railway for the dismantling of the keel.

1.1.4 PRE-DEMO OPERATIONS[1]

1.1.4.1 PREPARATIONS

Once a vessel arrives at the dismantling yard - and depending on the docking mechanism to be used – it is secured, its stabilized. Safe access is established and spill containment measures and plans are considered for the particular vessel. The ship is then quarantined pending waste and custom inspections. Waste identification is done by the Shipbreakers' Association of Turkey (SBAT) licensed waste management team. During waste assessment, the radiation and gas-free condition of the vessel is accessed. Moreover, locations and approximate quantities of potentially hazardous materials are recorded and reported to the relevant national authorities.

1.1.4.2 HAZARDOUS WASTE STREAMS

Wastes generated by ship breaking industry can be broadly classified into hazardous and non-hazardous wastes. The non-hazardous waste-stream comprises of debris and mixed matrices that are deemed to be unfit for recycling and reclamation such as broken glass, broken floor pieces, packaging and polymeric scrap or broken (non-asbestos) insulation materials, *etc*. Dealing with the potentially hazardous or definitely hazardous waste streams is more tricky and requires proper correct handling and disposal in order to minimize the effect on both the workers and the environment Contamination from hazardous substances can have a severe and long lasting effect. Most common hazardous waste streams are:

- Oils and fuels
- Bildge and ballast water
- Paint and coatings
- Asbestos

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[1] This section describes the basic acceptable pre-demolition preparations and suggested waste handling and disposal options. These are primarily drawn from international norms as well as extensive experience from ship dismantling in Turkey. At the end of the Chapter, a sub-chapter exist that tries to capture the picture in the rest of the world. However, detailed information at the operational level is not necessarily available to the authors.

- PCBs

1.1.4.3 PRACTICE

Within Turkey, one can find varying levels of compliance. Overall in Turkey the major areas of improvement over the last few years are focused around:

- Fuel and oil removal and disposal
- Bildge waster collection and disposal
- Asbestos identification, removal, handling and disposal
- Cable separation, core recycling and sheathing disposal
- Battery collection and re-use or disposal

There is still more work to be done in areas like:

- PCB sampling/identification. In general PCB suspected materials are sent for high temperature incineration
- Ballast waster treatment, which today is discharged to the sea
- Pain and coating removal
- Radioactive source disposal

Heavy metals disposal

1.1.5 THE DISMANTLING OPERATION[2]

1.1.5.1 PRACTICE

Ship scrapping generates several grades and kinds of scrap metals including ferrous, brass, aluminium, copper and other alloys. These are picked up by vendors in an organized manner and sold in scrap-metals market. About 90% of a ship's body is made of steel and miscellaneous metals, such as brass, aluminum, copper and other alloys.

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[2] This section describes the basic acceptable pre-demolition preparations and suggested waste handling and disposal options. These are primarily drawn from international norms as well as extensive experience from ship dismantling in Turkey. At the end of the Chapter, a sub-chapter exist that tries to capture the picture in the rest of the world. However, detailed information at the operational level is not necessarily available to the authors.

1.1.5.2 BREAKING PROCESS

.Initially, soft furnishing, textiles are removed, stores, provisions, spares and light machinery and equipment are removed. Then the main dismantling operation start from top to bottom and from bow to stern, with removal of heavier machinery and equipment as access allows. Almost all dismantling yards have a similar layout is comprised of:

- Main docking securing area (Area A)
- Secondary docking area where keel is dismantled (Area B)
- Waste sorting and temporary storage area (Area C)
- Primary block breaking area (Area D)
- Secondary block breaking and material separation area (Area E)
- Non-hazardous material storage area (Area F)

At each area certain access restrictions and containment measures are established to ensure safe and sound operations.

1.1.5.3 REUSABLE MATERIAL STREAM

Steel is the common metal used in ships. Different types of steels are used while constructing ships including mild steel, cast iron, high tensile steel, *etc*. Other metals that form the part of the ship include aluminum, copper, copper alloys, and lead. Apart from metals, many recoverable and recyclable objects on ship have excellent market. Those objects typically include: fittings, fixtures, wood furniture and door panels / frames, and kitchen appliances. Similarly, machinery, engines and spare parts, bridge equipment, control panels, refrigerators and washing machines, too, are easy to sell. Oil and oily wastes may contain substances in concentrations, which make them hazardous, such as transformer oils, and coolants contain hazardous substances like PCBs, which make the oil hazardous. Fuels such as LDO and HSD are often encountered in some quantities on-board. Such fuel oils are typically sold directly in the market after refinement and separation. Insulation typically found on board is of two types: (a) thermal insulation and (b) electrical insulation. Thermal insulation is made up of different types of materials (*e.g.*, glass wool or asbestos). Rubber products found onboard are typically plain rubber sheets, gaskets, and liners.

1.1.6 PARTIAL SHIP DISMANTLING

1.1.6.1 FULL VS. PARTIAL DISMANTLING (REPAIRS)

If we try to place partial dismantling among a specific industry sector, we will be dealing with a double result; full ship dismantling industry on one hand and ship repairing on the other. The basis, and the origin of this particularity, is that partial dismantling does not comprise an integrated activity on its own, but it is the prior process of a latter one, or in other words a derived procedure. There is typically no other reason to dismantle a vessel partially, except for further processing, such as conversion or repairs. . Ship repair activity will be the one to underlie our analysis. Further on when referring to “Ship Repairs”, all relevant activities such as conversions, modifications etc are included in this term.

1.1.6.2 SHIP REPAIR INDUSTRY STATE OF THE ART

Repairs during surveys, mostly regard large volume of hull renewals and machinery works, as well as inspection of shafting and they take place while vessel dry-docked. Hence, considering that during her operational life a ship goes through 15 major surveys, this results in recycling of 6% of her steel weight. In case of Europe, there is a number of Shipyards undertaking exclusively repair and conversion projects. These are mainly operating in Germany, Spain, GB, Netherlands and East Europe Countries. Nevertheless, all shipyards that undertake ship building projects, undertake ship repairs as well. Vessels repaired in Greece, are almost exclusively Greek-owned and operated. Sizes are relatively small, due to limited size of docks available. Vessel types are mainly bulk carriers (40%), general cargo ships (30%), tankers (20%) and passenger ships (10%).

1.1.6.3 DOCKING METHODS

Ship repairs in Greece depending on the volume of the work, the kind of repair and availability of docking sites may take place in following docking alternatives:

- Drydock
- Floating dock
- Synchrolift & Slipway
- Afloat (side/stern berthed)

1.1.6.4 PARTIAL DISMANTLING PRACTICES

Work tasks to be carried within a ship repair project are predefined, specified and recorded by Owner's and handed over to yard in the form of specification report, prior to commencement. A main categorization mostly used, is steel, pipe and machinery works, thus having on board steel & pipe fitters and machinists. A typical categorization of locations, during scheduling a repair project is includes Open Spaces, Decks, Side Shell, Bottom Shell, Confined Spaces, Fore & After Peak, Cargo, Ballast, Fuel Tanks, Engine , Room / Pump Room, and Accommodation. In above spaces, a number of works may be required such as Steel Works, Piping Works, Mechanical Works, Electrical Works , Insulation Works, Interiors & Various Fitting works.

A typical work usually carried out during repairs, that includes lot of removals and dismantling items, is the replacement of an auxiliary engine, including side shell renewal. Generally, dismantling sequence is based on the level of access in the areas in question. In other words, one starts by removing pieces that are most easily accessible, either from outside to inside or from top to bottom. A ship repair industry is very rarely involved in the waste management procedure, except probably for the case of dedicated Yards and very large Shipyards. In most cases outsourcing is preferred. As wastes of a typical partial dismantling activity can be identified the following which are handled as described below:

- Metals
- Liquid Wastes
- Insulation
- Cables
- Rubber, Glass, Plastic, Wood

1.1.7 SAFETY AND HEALTH IN SHIP DISMANTLING

Regarding full dismantling, today's ship dismantling countries are considered poor or even unacceptable, it should be noted that there might be very few opportunities for a different and better lifestyle. Daily operations at ship breaking yards expose worker to a variety of risks that can cause accidents, ill health or even death. Because ship dismantling is often carried out at difficult to reach sites by migrant workers, it is difficult for relevant authorities to monitor and enforce applicable national and international regulations. International organizations like the ILO the IMO and the Basel Convention have issued guidelines for safe and sound ship dismantling.

Regarding partial ship dismantling, operational risks are more or less similar to full ship dismantling and involve improper use of cutting, lifting and welding equipment, and of auxiliary systems of this equipment. Also potential exposure to hazardous materials may pose risks to workers health.

1.1.8 CONCLUSIONS

Ship recycling is by definition an environmentally friendly activity. Recycling saves natural resources and energy, contributing to sustainable development while at the same time it protects the environment from rusting abandoned ships. On the other hand, current dismantling procedures make ship dismantling a dirty industry with various environmental and worker health and safety hazards. Since in principle ship breaking is a positive activity, we are hopeful that with the appropriate support from the international community both at a legislative and at a financial level, the industry can be upgraded for the mutual benefit of all parties involved.

In order to ensure universally acceptable environmental and worker health and safety conditions, the international community needs to establish a level playing field, with proper control mechanisms that will prohibit substandard players from entering the market. If this is not ensured, then another cycle of re-allotment of ship recycling activities to less developed countries with cheaper labour and less strict regulations. Will take place Therefore, prior to any substantial investing for improving conditions, educating and equipping people and in waste management, the international community needs to ensure that it can control the matter of ship dismantling at a global level.

1.2 INVENTORY OF HAZARDOUS MATERIALS ON BOARD

1.2.1 SUMMARY

Focusing the interest on the methodology of preparing a high quality Inventory, the importance of using accurate identification methods for sampling and analysing, is dealing with priority. The facts included in the material lists of this Inventory-model, concern not only the stage of ship building, the ship operation and the repairs, but even complementary records provided for example by the Classification Societies. Considering the Inventory as a critical moment of the ship recycling process, prepared as early as possible and being important even for economical calculations during the contract signing, some specific material properties and aspects associated with the removal and waste treatment methods has been included in the proposed Inventory-model, providing codified supplementary facts to the inventory lists.

1.2.2 INTRODUCTION

The removal and disposal of hazardous materials in the *Ship Dismantling* process, is a primary environmental concern, as well as a health and safety concern for the workers. One of the main steps through out this process is to *systematically prepare an inventory of hazardous materials,* including their identification, physical location onboard and marking. The definition of the Inventory, regarding its contents and form, is generally not obvious as it is depended on the purpose of being prepared and the way which is intented to be used. The proposed model of Inventory brings upp to the surface those facts about the materials and their location on board together with other material propetrties which are significant for the potential risks concerning the workers health and the environmental protection. It points out especially material related aspects which are difficult to be immediately recognized but important to know their existence prior to the start of the dismantling process. . A central point in that discussion has been whether a certain form of Inventory should be mandatory and how it should be coordinated between the national and international legislation. How to share the responsibility of preparing the Inventory between the involved parts and what is the right time to perform it, constitute some of the objects of the recent international discussion.

1.2.3 GENERAL ON INVENTORY

A general inventory of all the materials on board describing their different types, function, chemical constitution, properties, location on board, amount e t c could be a very complicated task if the work is not organized in a well structured way. Material related information concerning environmental protection and sustainable development were not matters of high priority when the ships, now destinated to recycling, were produced, in the mid of 70ies. Nowadays, the interest for safety and health and environmental related parameters of the materials has been increased, providing reasons to invent, study and classify all the materials of the ship with respect to their hazardous properties. For a given material, there is a group of properties which are significant for the ship building phase(application), another group of properties for the operational phase (function), another group of properties for the dismantling phase (removal) and another group of properties for the waste treatment phase (disposal).

What international, industrial and other organizations are intensively working with, is to develop Inventory-models, standard lists, regulations and methods for a systematic inventory work. From the side of the industrial organizations, what they are finding important discussing the identification of hazardous materials is the development of "an authoritative guidance as to ways in which such materials might be handled in a safe and environmentally sound manner" and "that the Governments should produce an authoritative list of such materials, together with advice and guidance as to how they might be properly handled within the context of ship recycling".

1.2.4 INTERNATIONAL MARITIME ORGANIZATION

A number of Inventory-lists is the result of the work done by IMO and other International Organisations during the recent years. The Inventory-lists proposed in the IMO Guidelines are on the way to be widely accepted, and they are discussed in details in the deliverable report. The intension of IMO to provide guidance to all parts interested and involved in the ship recycling process has resulted to the concept of Green Passport, considered as a central point, and the development of the standard lists. The concept of the Inventory in IMO guidelines is almost the same as the standard lits, considered to some extent as a part of the Green Passport. The Inventory-model adopted by IMO can initially be prepared at any time during the life of the ship, serving mainly as a list of materials that are inherent in the ship's structure, coming originally from the ship building time. Other materials which have been used later, for example during major repairs, must also be mentioned, by updating the Inventory.

1.2.5 INTERNATIONAL LABOUR ORGANIZATION AND THE BASEL CONVENTION

In UNEP and ILO guidelines, the interest is concentrated on the dismantling procedures and the possibility of successive improvements of the facility ant the equipment, using in principle the standard lists adopted by IMO. Even if the Inventory may starts as a very simple “single list”, it doesn´t prevent from being improved by later work. And this is probably the best way to organize the Inventory work for existing ships, proceeding with successive improvements of the Inventory-lists. What it is clear is that the international organizations agree that some kind of Inventory has to be mandatory. Independent of the development of the legislation, mandatory or not, the Inventory can be used as a consulting document in the ship dismantling process.

1.2.6 EPA/OSHA

From the practical point of view, the U.S. EPA/OSHA Guidelines are easier to follow as they use another concept of categorization of the materials using as main criteria the typical hazardous properties of the materials and discussing some practically available identification methods. Working with the Identification of hazardous materials on board on an individual ship, most of the material facts and the answers are not found in the literature, they are coming från the laboratory. Describing the life of a ship we could roughly divide it in a building, an operational and a dismantling phase, where even major renovations/repairs should be considered as a kind of “re-building”-phase. With respect to the hazardous properties of the materials, the later two phases (operational and dismantling) are often the critical point. EPA/OSHA Guidelines and some other material guides published in the U.S. are intended to provide valuable tips and practical information to the personnel, the work-leaders and other parties involved in the ship recycling process. In order to achieve that goal they use a different system of categorization, being in that way a suitable complement to the Guidelines of the three international organizations. As they refer to the (national) U.S. regulations they are not easy applicable to other countries, but for the reader who is looking for realistic methods and practical ideas the U.S. Guidelines are valuable as a literature source

1.2.7 EU REGULATIONS

Refering all the time to the three international organizations, one can wonder if there are any European rules applicable to that issue at all! Spontaneously, it is difficult to imagine that the well known regulation system of EU, having directives and rules to almost everything has totally missed that particular issue. Detailed information about the hazardous properties of the materials and the chemical products can be found in EU directiv 67/548/EEG, as for example definitions, classification system and criteria which can be used for assessment whether a material is for example explosive, flammable, oxidizing, toxic (to exposused workers), ecotoxic (to the environment) etc. Work is currently undertaken by the EC to establish a European ship recycling strategy, and to that effect there is a white paper out. Also the EC funds research programs on the issue of ship dismantling under both FP6 and FP7. In addition to above, EMSA is also closely working with other European agencies on the issue of ship recycling, we the close attention of Commissioner Dimas.

1.2.8 PREPARATION OF INVENTORY

The preparation of the Inventory in an effective and reasonably expensive way, is both a question of knowledge and experience. It has to be performed by a competent person, with sufficient knowledge, training and skill for that special work, an *Inventory-specialist*. The knowledge needed concerns, among other things, sampling and analyzing methods, number of testing points, timing matters, e t c. For newbuilding ships or for ships with detailed documents available about its history, drawings e t c, it becomes easier to prepare the Inventory. As this, unfortunately, is not always the case, the inventory has to be done considering the ship almost as a "black box" (for example cases of abandoned ships). It will probably be more usual that a *partial inventory* shall be prepared, existing at the time of the ship recycling contract, restricted for example to a single list with a few types of materials as for example asbestos and PCB:s. The Inventory seems to be a formality today but it will be a quality document tomorrow.

1.2.9 METHODOLOGY OF INVENTORY

Once the type of the ship has been defined, a number of hazardous materials are expected, with a high probability, to be found on board. The expected materials must be identified and classified (e g by standard codes), in a systematic way, using for example the standard Inventory-lists found in the Guidelines of the international organizations. However, for a complete Inventory more than the standard lists are needed. The classification criteria of a compound as hazardous, widely speaking, depends not only on the compound itself. For example Oxygen is generally not hazardous but when the concentration of it in a space becomes remarkably higher or lower than normally in the air, a very dangerous situation can appear. One of the functions of the Inventory is to serve as a warning instrument. Trying to sort the hazardous materials in a risk priority scale, the assessment depends to some extend on the type of the ship and the *green status* of the recycling facility. It means that for a given type of ship and a given recycling facility, possessing for example the right equipment and using the right methods, some known hazardous materials can be assessed to belong (placed) to the low-risk part of the scale.

The Inventory has to provide information about the location of the hazardous materials on board, clearly marked on the *general arrangement plan* (GAP) of the ship. Drawings of the ship has originally been supplied to the ship owner by the ship building yard, showing the general arrangement of decks, machinery room, cargo spaces and equipment, accommodation facilities, tank disposition, hydrostatic information, fire-fighting equipment, e t c. The present Inventory-model is suggesting that the location of hazardous materials must be indicated both on the ship drawings (giving location codes in the Inventory) and physically on board.

If the inventory work is initiated by the ship owner, the parameters which are usually known are the type of the ship and the typical ship documents available, including surveillance documents from the Classification Societies, repair and maintenance records, cleaning and disinfection reports e t c which has been done during the last years. If the inventory work is initiated by the recycling facility, for example in connection with the recycling contract, a large number of details about the removal and waste treatment methods are known. With some parameters fixed, a certain hazardous material can be assessed more or less dangerous already at the Inventory stage. The general intention is to give the Inventory the form and the function to be “a living document”, updated with all the material replacements for example during repairs, warning and at the same time encouraging to material replacements towards the right direction.

There are some time related parameters associated with the materials to be taken into account. Examples of time-dependent parameters which are significant for the Inventory follows:

- The age of the ship
- The age of the material on the ship
- The date of production banned of certain material

For instance it is widely used as a rule of thumb that no asbestos should be present on ships built after the early/mid 80s. Similarly, for PCBs the rule of thumb is mid/late 80s. In addition to being banned from the construction of new ships, certain hazardous materials were required to be removed and replaced.

1.2.10 PREPARATION OF INVENTORY

The general methodology is principally based on assumption, test/control, verification and marking.

Step 1 is to establish the type of ship under question and its history age etc, i.e. ship specific information based on plans, class documents, ship operations etc.

Step 2 is to prepare systematic list of the hazardous materials as a single list

Step 3 is to categorize the materials identified to simplify the use of the inventory

Step 4 is to classify the materials based on potential hazards

Step 6 is to approximate the quantity of the material either by using plans, testing or other approach

Step 7 which is not directly related to the inventory itself, but may be a useful tool for the end user is parameters related to management of the material (removal, handling, storage, disposal).

1.2.11 ABOUT THE MATERIALS

This extensive section covers in details the various potentially hazardous materials to be found on board ships, as well as their categories and sub-categories, dealing with a large amount of technical facts and information. This is a lexicon-like manual providing background information about the materials which are usually found on board and highlighting their hazardous properties it should be convenient to be developed.

1.2.12 CONCLUSIONS

In our opinion, the completeness and quality of the Inventory has a determining significance. The Inventory information must be based on verified facts (not assumptions) in the greatest possible extend. The accurate contents of the Inventory shall be possible to be used as input for different calculations concerning quantities, risk assessments, positive and negative values and corresponding costs.

1.3 NEW TECHNOLOGIES IN SHIP BREAKING – COST AND ENERGY PARAMETERS

1.3.1 INTRODUCTION

In the early 1970's ship breaking was a highly mechanized industrial operation that was carried out in the shipyards of Great Britain, USA, Mexico, Spain and Brazil. But as the cost of upholding environmental, health and safety standards in developed countries has risen, ship breaking has increasingly shifted to poorer Asian states. Basically a ship is being dismantled using extensively torch cutting to cut large steel pieces from the ship, pieces which are sold for scrap or re-rolling.

1.3.2 NEW TECHNOLOGIES IN SHIP BREAKING

1.3.2.1 TORCH CUTTING VS. COLD CUTTING

One of the easiest methods of cutting steel is to literally burn a slot in it using a stream of pure oxygen. This process, called torch or flame cutting, oxygen cutting or burning, is an economical method of cutting steel that provides good dimensional tolerances and it is much faster than any sawing or machining process. On the other hand torch cutting entails certain disadvantages such as flammable gas ignition and toxic fume release. Alternative proposed technologies for cold metal cutting appropriate for the particular applications in ship dismantling are abrasive water-jet cutting and mechanical scissors..

Water Jet technology has been introduced in the early 1970s or so, and abrasive jets extended the concept about 10 years later. The idea is to use the technology of high pressure water being squirted through a small hole to concentrate an extreme amount of energy in a small area to cut. Advantage related to water-jet cutting included no heat production, no need for paint removal, can cut virtually any material and leaves smooth finish. At the same time disadvantages involve limited portability, high investment and operating cost, containment of water used in cutting.

Mechanical scissors is another cold-cutting technique. It involves cutting through very large shear forces applied by hydraulically powered blades. It is considered more applicable than water-jet cutting and quite promising for ship dismantling operations. It is though not applicable to thick plates destined for re-rolling, but rather for thinner pieces destined for the steel mills. Although relatively mobile with the use of maintain cranes/excavators, mechanical shears have high investment cost and are impossible to be used in the primary cutting zone. Also no fit for processing plates destined for re-rolling. There are complete modern solutions provided by special companies that promise speed, flexibility and reliability with a complete package purchase price comes to 250 k€.

1.3.2.2 CABLE RECYCLING VS. CABLE BURNING

Cable recycling is another important process in ship dismantling. With a few exceptions cables in most ship breaking yards are burned in order to recover the copper. This is an unacceptable practice as highly toxic fumes are generated during burning which severely affect the workers health and degrade the local environment. Alternatively there are complete solutions for environmentally sound cable recycling. S Cables are recycled by means of a new system that grinds and dry-separates copper or aluminum from plastic or rubber. They are fully sound proof and equipped with a de-dusting system (no emission of dust in the environment).

1.3.2.3 PAINT REMOVAL TECHNOLOGIES

Surface preparation operations in the maritime industry involve removal of paint, rust, corrosion, and sea growth. Technology behind the processes also ranges from abrasive blasting, slurry blasting, power tools to water-based processes, whereas the main selection criteria are cost and project time frame. Surface preparation is one of the main emission sources during ship dismantling and has also a direct effect on the performance of the painting system. Current blasting methods suggested include:

- Dry-abrasive blasting (steel grit)
- Wet abrasive blasting (slurry blasting)
- High- and ultrahigh-pressure water blasting (hydro blasting)
- Dry ice blasting (CO_2 blasting)
- Soda blasting

Abrasive blasting, the most common method for coating removal is the grit blasting that consists of manually operated hoses that project against the hull. Grit, with high speed through injection of pressurised air impacts on the material and takes off the paint. The impact of the grit against the hull produces the emission of dust composed of sand, combined with paints, sea moulds and barnacles remains, that produces an atmospheric pollution. These particles are suspended in the air and will end up precipitating near the emission point depending on their size and the atmospheric conditions.

Hydroblasting, the low and high pressure water blasting has long been used as a technique for the surface preparation process, particularly during the repair and maintenance stage coating removal. The industry standard SSPC-SP 12/NACE No.5 distinguishes between "water cleaning" and "water jetting.

For dry ice blasting, Dry ice pellets are made by taking liquid CO_2 from a pressurized storage tank and expanding it at ambient pressure to produce snow. The snow is then compressed through a die to make hard pellets. Dry ice particle blasting is similar to sand blasting, plastic bead blasting, or soda blasting where a medium is accelerated to impact the surface to be cleaned. One unique aspect of using dry ice particles as a blast medium is that the particles sublimate (vaporize) upon impact with the surface.

Soda Blasting is a process where virtually any surface or substrate may be cleaned or de-coated. Blasting with soda is similar to sand blasting except that higher caliber equipment is required and that sodium bicarbonate (baking soda) is used as the blast media. Blasting soda is a non hazardous food grade material that is 100% water soluble, environmentally safe, therefore eliminates the need of using toxic cleaning chemicals. Soda blasting may also be used to clean while machines and processes are in operation

1.3.3 COST PARAMETERS

In this category we include the facility's running expenses, which may or may not include the renting of the demolition plot, leasing and depreciation costs of fixed assets, equipment and machinery, and other general overhead costs to the operation of ship dismantling. In the case of ship repair - and further partial dismantling – industry, capital costs regard, among others, buildings, dock side areas & fixed equipment (machinery & plants). Going further, we could allocate to the partial dismantling activities a portion of tax, depreciation and interest costs. Labour cost is a function of the number of people are employed, the mix of skilled to unskilled personnel and the wage requirements of the particular country. Again, the more developed a country, the smaller the total number of people employed for the same size facility. Also, the more developed the country the higher the ratio of skilled to unskilled personnel, since the facility is likely to be more technologically advanced and higher the minimum wage requirements. In contrast to labour, movement of goods is not geographically restricted and hence the price differential of consumables among the different ship dismantling countries is smaller than that of wages. Also the special handling and disposal requirements for hazardous and regular wastes has an associated cost. The cost depends on the particular country and its regulation/control for the various substances.

1.3.4 BENEFIT PARAMETERS

The benefit to the environment is two-fold: on the one hand it removes tonnage that would otherwise be left abandoned, and on the other hand it provides the steel industry and other secondary markets with recyclable/re–usable materials and equipment. The ship dismantling industry provides employment to both skilled and unskilled personnel. Considering that ship dismantling is primarily an industry of the less developed world, and also considering that it is a labour intensive operation, it creates jobs for people that would otherwise have little opportunity to find employment. From the developed world's point of view, the working conditions in some ship recycling countries might seem unacceptable, but it is often the case that the people employed there enjoy more welfare benefits, higher wages and a better overall life standard than otherwise. Hence ship dismantling also has a positive socio-economic effect on the society.

The dismantling operations yields equipment, machines, furniture etc which are sold directly or after refurbishment for re-use. The less developed a country is, more ship items are sold for re-use. However, most of the ship, in weight and volume terms, is sold for recycling. The ferrous metal parts are either sold for re-rolling or as scrap to be used instead of raw material in electric arc furnaces for the production of hot steel products. Non-ferrous metals are sold in the small industry again to be used instead of raw material for producing finished products. Most common non-ferrous metals gathered from ship dismantling are copper that comes from the core of the cables after the cable seething in removed, bronze used in certain pumps, stainless-steel used in tankers to prevent corrosion of tanks and pipes, and aluminium.

1.3.4.1 ENERGY PARAMETERS

Compared to the common process of producing steel products –from ore-, ship recycling is less costly and consumes less energy, while at the same time it reduces –in principle- environmental pollution. According to a Det Norske Veritas report on ship scrapping published in 2001, the energy balance between producing steel products from raw materials vs. recycling of scrap may differ up to 70%.

1.3.5 CONCLUSIONS

After the Second World War, the majority of ship dismantling operations took place in the US and the UK. As the relevant know how was transferred to other lower wage countries, the US and the UK were undercut primarily due to the lower wage and regulatory requirements. Ship dismantling moved to other European countries and eventually reached Turkey, the India sub-continent and China in the 80s and 90s. Today 90% of ship dismantling takes place in the Subcontinent, Turkey and China. However, there are still facilities in Western Europe and the US, which unfortunately cannot sustain themselves and hence operate with subsidies and awarded government contracts.

As expected, the cost of doing business is primarily determined by the country in which you operate. Almost all of the above analyzed costs parameters vary, maybe with the exception of consumables. However, even in that case, the different regulatory requirement might lead to indirect differences in the end cost of certain consumables, as discussed above. On the other hand, and with the exception of socio-economic benefits, monetary-energy-efficiency-environment benefits are more or less the same irrespective of where the ship dismantling operation takes place. It is the authors opinion that the net effect of ship recycling is highly positive, and that any analysis destined at comparing the relative balance between costs and benefits should quantify all of the above parameters, before making a judgment.

LITERATURE

[1] Cost Effective and Environmentally Sound Dismantling of Obsolete Vessels, Project Deliverable Report 2.1

[2] Cost Effective and Environmentally Sound Dismantling of Obsolete Vessels, Project Deliverable Report 2.2

[3] Cost Effective and Environmentally Sound Dismantling of Obsolete Vessels, Project Deliverable Report 2.3

CHAPTER 2: WP3 OVERVIEW

2.1 INTRODUCTION

Ship breaking and its potentially harmful consequences have been discussed in the past few years by highlighting the issues associated with the environment, ecology and human health. It is recognized lately that if ship breaking is conducted haphazardly with very little scientific and technical knowledge and with inadequate environmental, health, and safety safeguards; the work-force could be exposed to a wide range of hazards and the activity of ship-breaking would leave disproportionately large environmental footprint behind. Most ships being dismantled today were built in seventies, prior to ban on many hazardous materials. Most of the wastes generated from ship breaking industry today in the Indian Subcontinent can be potentially recycled; thus reducing the pollution load on environment. It is necessary to critically study the ship dismantling practices so that one can identify the wastes generated from ship breaking industry that can be utilized in other places.

India is the home of the World's leading ship breaking industry. It accounts for 47 % of the ships dismantled in the World. Around 350 empty discarded vessels (ships) cumulatively weighing approximately 27 million tonnes are broken in India every year. This sector provides employment to around 40,000 people (directly and indirectly). This sector generates huge quantities of materials that are directly reused or recycled (around 95 % the cumulative weight of vessels *i.e.* approximately 26 million tonnes) and helps in minimizing and eliminating potential waste from going into environment and consequently in protection of environment, conservation of resources (10 – 15 % of India's steel production comes from dismantled ships) as well as contributes to economy.

2.2 HAZARDOUS WASTES

Ship scrapping generates several grades and kinds of scrap metals including ferrous, brass, aluminum, copper and other alloys. These are picked up by vendors in an organized manner and sold in scrap-metals market. Some other metallic materials that are obtained on breaking different types of ships and can be easily sold on "as is where is" basis include: girders, components of structures, pipes, beams, angles, and channels. Apart from metals, many recoverable and recyclable objects on ship have excellent market. Those objects typically include: fittings, fixtures, wood furniture and door panels / frames, and kitchen appliances. Similarly, machinery, engines and spare parts, refrigerators and washing machines, cables (PVC coated, copper and aluminum cables), glass wool, oils, lead acid batteries, too, are easy to sell.

An attempt has been made to enlist various processes for identification, handling, transportation, storage, treatment, and disposal of polluting substances in ship breaking industry (part of deliverable D3. 1). In order to understand the present status of waste management practices in and around the ship breaking industry site visits were carried out in Alang yards in the State of Gujarat and Sewri yards in Mumbai in the State of Maharashtra.

Wastes generated by ship breaking industry can be broadly classified into hazardous and non-hazardous wastes. The non-hazardous waste-stream comprises of debris and mixed matrices that are deemed to be unfit for recycling and reclamation such as broken glass, broken floor pieces, packaging and polymeric scrap or broken (non-asbestos) insulation materials, *etc*. Besides solid wastes, gases such as ammonia, chlorofluorocarbons (CFCs) from the air conditioning systems, and inflammable gases may be present in pipelines of oil tankers as well as LPG/LNG carriers. However, no authentic data are available on these wastes.

Constituents of a ship, subjected to dismantling, can vary from ship to ship and will depend on several aspects including the purpose of ship and hence the waste from ship dismantling activity will also vary from ship to ship. The hazardous waste-stream from ship breaking industry consists of matrices that cannot be recycled or reclaimed due to the properties of the matter itself or the properties of coatings and contamination mixed with the matrix.

Based on the information obtained from the regulatory agencies and ship-dismantling yard owners, it was concluded that the eight matrixes namely: (1) asbestos, (2) Poly-chlorinated biphenyles, (3) oils and fuels, (4) paint chips, (5) bilge and ballast water, (6) heavy metals (7) wastewater; and (8) other hazardous materials (including glass wool, cable-coatings, contaminated mixed wastes, discarded paints and chemicals) are of greater significance from handling, transportation, and storage of polluting substances. The best applicable practices for treatment and disposal of above nine matrixes have also been identified and reported (based on our past research and work of earlier graduate students in laboratory and field).

Some of the hazardous wastes, including paint chips, asbestos and oily wastes are conventional contaminants associated with the ships. In addition, it is also possible that some of these ships might have been used for transportation of hazardous materials and wastes and as a result have become contaminated with hazardous material. Hazards associated with these wastes were identified based on our research and literature review. Compounds that can be leached out of these wastes have been identified and listed in Table 2.1.

Table 2.1: Pollutants that can be Leached out of the Wastes

Sr. No.	Waste Streams	What may be leached?
1	Asbestos	PCBs, PAHs,
2	Poly chlorinated biphenyls	PCBs, PAHs,
3	Oils and Fuels	Ni, As, Oil and Grease
4	Paints and Coatings	Cr, Pd, Zn, Cd, TBT, As, Ni and Solvents
5	Metals	Cr, Pd, Zn, Cd, TBT, Hg, As and Ni
6	Bilge Water	Oil and Grease, Heavy Metal like Cr, Pd, Zn, Cd, TBT, As, Ni
7	Ballast Water	Oil and Grease, Heavy Metal like Cr, Pd, Zn, Cd, TBT, As, Ni
8	Other Hazardous Materials	PAHs, PCBs, Petroleum Products, Oil and Grease

2.2.1 WASTE ASBESTOS

The "Asbestos" refers to a group of minerals that occurs naturally as masses of long silky fibers. and possesses excellent insulation property. Incidentally, it causes health hazard if handled without adequate care. Some known diseases caused from asbestos exposure include: (1) asbestosis (scarring of the lungs resulting in loss of lung function that often progresses to disability and to death), and (2) cancer, such as mesothelioma (cancer affecting the membranes lining the lungs and abdomen), lung cancers of the esophagus, stomach, colon, and rectum. Lumps of asbestos, ropes, panels, and sheets (if free of contamination with oil or other wastes/coatings) are sold directly in to the market for similar applications elsewhere. Fine dust of asbestos can be carefully collected and after proper treatment can be disposed into landfill.

2.2.2 POLYCHLORINATED BIPHENYLS

PCBs are toxic and persistent. They have been shown to cause a variety of adverse health effects, such as cancer in animals, as well as a number of serious non-carcinogenic health effects in animals (*e.g.*, effects on the immune system, reproductive system, nervous system, and endocrine system). Studies in humans provide supportive evidence for potential carcinogenic and non-carcinogenic effects of PCBs. The different health effects of PCBs may be interrelated, as alterations in one system may have significant implications for the other systems of the body.

The composition of a PCB mixture changes following its release into the environment. The types of PCBs that bio-accumulate in fish and animals and bind to sediments tend to be the most carcinogenic components of PCB mixtures. As a result, people who ingest PCB-contaminated fish or animal products and touch PCB-contaminated sediment may be exposed to PCB mixtures that are even more toxic than the PCB mixtures contacted by workers and released into the environment. There is also much concern about the toxicity of the chemicals produced when PCBs are heated in fire-related incidents. The chemicals produced include polychlorinated dibenzofurans and polychlorinated dibenzo-p-dioxins, both of which are believed to be much more toxic than PCBs themselves.

2.2.3 OILS AND FUELS

Oils and fuels pose potential fire and toxic hazards to workers. Also both petroleum products and non-petroleum oils can have adverse and well-documented effects on the environment. Oil and oily wastes may contain substances in concentrations, which make them hazardous, such as transformer oils, and coolants contain hazardous substances like PCBs, which make the oil hazardous. PCBs (Polychlorinated Biphenyls) belong to a broad family of man-made organic chemicals known as chlorinated hydrocarbons. Due to their non-flammability, chemical stability, high boiling point and electrical insulation properties PCBs are found in solid (waxy) and liquid (oily) forms in the equipment and materials on ships being scrapped. PCBs study shows evidence for potential carcinogenic and non-carcinogenic effects. If the oil is in “waste oil” category than it can be used as a fuel for energy recovery provided PCB contain of oil should be known. If oil / waste oil are not classified as “used oil”, then it must be tested to determine pollutant concentrations and evaluate if they are hazardous.

2.2.4 PAINT AND PAINT REMOVER

Paint and preservative coating or may contain toxic compounds, such as PCBs, heavy metals and pesticides. Such waste when gets mixed with non-hazardous waste, that waste becomes hazardous waste. Chemicals and solvents used in stripping paints or coatings emit volatile organic compounds and hazardous air pollutants to the atmosphere. Fine dust created during removal of paints cause air pollution problems, so safe removal method should be followed for this purpose. Exposure to hazardous paint fumes during metal cutting is primarily an occupational health problem, but paint fumes will also disperse through the air and may be deposited far away from their sources. Flammable paint represents a fire hazard to workers. Thermal removal must not be used on PCB-containing paint because dioxin emissions may be generated. Waste from the paint removal processes can have negative impacts on both health and the environment.

2.2.5 HEAVY METALS

The workers in ship breaking industry are exposed to metal fumes while operations like torch cutting. Apart from posing an occupational hazard thus, these fumes can also disperse into environment. In addition, metal containing waste is not stored properly; heavy metals like lead, mercury could leach to the soil and water resources. Some of the metals may contain or be coated with toxic compounds. Many toxic metals like arsenic, lead, mercury, cadmium may build up in biological systems and become a significant health hazard. In biological system, metals have wide-ranging ill effects on health. For example, high mercury exposure results in permanent nervous system and kidney damage whereas exposure to high levels of arsenic can cause death.

2.2.6 BILGE AND BALLAST WATER

Bilge and ballast water is released to the environment directly or by lack of containment during transfer operations. The aforementioned hazardous components may be dispersed to the external environment through air, water and ground. The introduction of non-indigenous species disturbs the ecological balance. The threat to local and regional biodiversity may have great economic consequences. Ballast water may also carry pathogenic organisms, which threaten human health. Oil, petroleum hydrocarbons, biocides and certain metals may have toxic effects on the external environment. Oil also causes physical damage to the external environment.

2.2.7 OTHER HAZARDOUS MATERIAL AND WASTES

Insulation find on board is of two types: Thermal insulation and Electrical insulation. Thermal insulation is made up of different types of materials (e. g. glass wool or asbestos). For onboard thermal insulation generally glass wool is used. It is a fiber like structure, which on contact with skin creates screen problems like etching. Oil spillage from the thermal equipment contaminates the glass wool, which makes it hazardous waste. The primary routes of human exposure to glass wool are inhalation and dermal and/or eye contact. Large diameter (greater than 3. 5 μm) glass fibers have been found to cause skin, eye, and upper respiratory tract irritation whereas smaller fibers have the ability to penetrate the alveoli. The glass wool, which has not contaminated can be sold in the market instead of disposing.

Electrical insulations made up of different types of polymers such as PVC, PVDC, and HDPE. After removing pure metallic wires inside the insulation, if the insulation is of pure material (PVC or other plastic material) than it can be send for recycling. If the insulation is of multi layer and cannot be separate than it should be treated and disposed into landfill.

Rubber products find onboard are consists of plain rubber sheets, gaskets, and liners. Large rubber sheets can be sold as it is in the market. If it is in shattered form and made up of diversity of compound, than cost of collection, segregation and recycling becomes un-economical. So landfill remains the disposal option for the rubber.

Plastic, which is obtained during the Ship breaking process, cannot be thrown in to landfill immediately. The materials like PVC pipes can be re-used if properly dismantle. Other plastic waste can be separated on the basis of Thermoplastic and Thermosetting plastic and can be send for recycling based on these types.

As part of Monitoring Strategy a detailed monitoring plan has been tabulated in Table 2.2. Standards/limits for each of the parameters to be analyzed are also given. The standards are specific for the media samples (air, soil, sediments, and water). It should be noted that the standards vary from country to country.

Table 2.2: Ambient Environmental Monitoring Plan for Ship Breaking Yard

S. No	Environmental Medium	Locations	Parameters	Frequency *
1	Air	Ambient Air and the Vicinity Areas	Sox, NOx, Cox, SPM, and RPM	Seasonal (Twice in a season)
2	Water	Ground Water of project site and the Vicinity Areas	Colour , Odour, Taste, Turbidity TDS, *p*H, Total hardness (as $CaCO_3$), Ca^{+2}, Mg^{+2}, Cu^{+2}, Fe^{+3}, Mn^{+4}, CL^-, SO_4^{-2} NO_3^-, NO_3^-, F^-, Hg^{+2},Cd^{+2},As^{+2}, CN, Pb^{+4},Zn^{+2},Cr^{+6}, Mineral oil, Residual Cl,	Seasonal (Thrice in a season)
3	Sea water	Coastal water as well as 2-3 km inside the sea	*p*H, DO, Colour and Odour, Floating Matters Oil, grease and scum (including Petroleum products), Fecal Coliform, BOD_3	Seasonal (Thrice in a season)
4	Soil	Sediments of Coasts and Soils of Project Site	Heavy Metals (Cr, Pd, Zn, Cd, TBT, Hg), Petroleum compounds Organic carbon	Seasonal (Twice in a season)
5	Noise	Project Site and the Vicinity Area	Noise (dB)	Diurnal (Preferably 6 times in 24 hrs)

Ship dismantling activity is prone to several potential emergencies like pollution incidents as well as accidents involving personnel and material resources. Examples are oil spills, sudden or non-sudden release of hazardous wastes, explosions, fires *etc*. Emergency and contingency plans were developed in this regards in order to reduce the damage caused by ship breaking activity.

The owner or operators must be equipped with emergency response procedures to minimize and regulate hazards to human health and environment from such emergent situations.

- ➢ The starting point to prepare emergency procedures involves a survey of potential incidents and accidents to be carried out. Based on this, a plan for response to incidents, injuries and emergencies should be prepared.
- ➢ Response to emergencies should ensure that:

  · The exposure of workers should be limited as much as possible during the operation.

  · Contaminated areas should be cleaned and if necessary disinfected.

  · Impact on the environment should be as limited as possible.
- ➢ Such emergency response procedures must be *documented* and *distributed* to entire workforce.
- ➢ Working personnel must be allocated with specific tasks to be carried out in response to emergency and must be trained accordingly.
- ➢ Communication network must be adapted to emergency response *e.g.* alarms, warning system *etc.* which makes evacuation procedures, rescue operations effective.
- ➢ All required infrastructure to response to disasters like fire fighting kits, fire extinguishers, first-aids, devices to control and recover oil spills, hazardous chemicals/ wastes release must be available and well-maintained in premixes of ship-breaking yards.
- ➢ All relevant emergency response services and local authorities (local fire fighting squad, police, medical and health facilities, district authorities *etc.*) should be consulted and their help should be availed to fight emergencies.

2.3 RESPONSE TO INJURIES AND ACCIDENTS

Based on a survey of possible injuries, a procedure for response to injuries or exposure to hazardous substances should be established. All staff should have a minimum of training to such response and the procedure ought to include the following:

- immediate first aid, such as eye splashing, cleansing of wounds and skin, and bandaging
- immediate reporting to a responsible designated person
- if possible, retention of the item and details of its source for identification of possible hazards
- rapid additional medical care from medical personnel

- medical surveillance
- recording of the incident
- investigation, determination and implementation of remedial action
- It is vital that incident reporting should be straightforward so that reporting is actually carried out (UNEP, 2002).

2.4 RESPONSE TO OIL SPILLS

Normally, spills only require a clean up of the actual contaminated area. However, for certain substances, the spill may require immediate evacuation of the area. A spill cleaning procedure which includes safe handling operations and appropriate protective clothing should be established. An example of a general procedure for spill cleaning is given as follows:

- Evacuate the contaminated area
- Immediate eye and skin cleaning of exposed personnel
- Inform designated personnel
- Determine the nature of the spill
- Provide first aid and medical care to injured personnel
- Secure the area to prevent additional exposure of persons
- Provide adequate protective equipment to personnel involved in clean up
- Limit the spreading of the spill
- Neutralize or disinfect the spill or contaminated area if necessary
- Collect and rinse the spill and the contaminated area into appropriate bags and containers
- Neutralize, disinfect and rinse the used equipment and personal protective equipment
- Determine personnel injury status. If required, seek immediate medical assistance.
- Monitoring and follow -up of the program
- Reporting (UNEP, 2002).

2.5 CONTROL AND RECOVERY OF OIL SPILLS

There are a number of advanced response methods available for controlling oil spills and recovering oil while minimizing their impacts on human health and the environment. The key to effectively combating spills is careful selection and proper use of equipment and materials best suited to the type of oil and the conditions at the spill site. Most spill response equipment and materials are greatly affected by such factors as conditions at sea, water currents, and wind. Some kinds of response methods include:

- Mechanical containment or recovery in which containment and recovery equipment include a variety of booms, barriers, and skimmers, as well as natural and synthetic sorbent materials. Mechanical containment is used to capture and store the spilled oil until it can be disposed of properly.
- Chemical and biological methods can be used in conjunction with mechanical means for containing and cleaning up oil spills. Dispersants and gelling agents are most useful in helping to keep oil from reaching shorelines and other sensitive habitats. Biological agents have the potential to assist recovery in sensitive areas such as shorelines, marshes, and wetlands.
- Natural processes such as evaporation, oxidation, and biodegradation can start the cleanup process, but are generally too slow to provide adequate environmental recovery hence must be assisted with other methods effectively (EPA, 2000).

We are in the process of seeking expert opinion from Maritime Board and regulatory agencies on our proposed approach.

Based on our earlier studies and visits to ship breaking yards, an attempt was being made to develop an "assessment format" obtaining relevant information on preparedness of ship breakers in the matters of workers' health and safety. The assessment format is a comprehensive list of 62 items grouped into six heads *namely*: regulatory requirements, documentations, emergency preparedness, workers safety, waste management, and training and education. It is necessary that each ship breaker duly fills and maintains this assessment format. It is expected that the regulatory agencies will use this assessment format as an administrative tool to obtain relevant information on preparedness of ship breakers in the matters of workers' health and safety as well as waste management.

Guidelines for waste management plan were developed as part of deliverable D3.2. Ship owner after acquiring the relevant permissions calls for auction of the cabin. The cabin, which has materials such as furniture, doors, kitchen appliances, *etc.* , can be sold to the dealers whose bid is the highest. It is the responsibility of the scrap merchant who purchases the cabin to remove the material from the cabin. The scrap merchant further auctions the material removed from the cabin to the retail scrap shop owners.

2.6 DEVELOPMENT OF A RE-SALE PLAN

Materials that are obtained on breaking different types of ships vary with size and type of ship. The percentages of weight of recoverable items obtained on breaking different types of ships are given in the Table 3. About 90% of a ship's body is made of steel and miscellaneous metals, such as brass, aluminum, copper and other alloys. Ship fittings and stores include engines, boilers, furniture, electronics items, *etc*. The reusable items are taken off whole, intact – as far as possible; so that they can be sold in market. There can be organized market and show rooms for selling the objects recovered / removed from scrapped ships. The engines and parts can be resold after providing suitable maintenance and repairs.

Apart from metals, many recoverable and recyclable objects on ship have excellent market. Those objects typically include: fittings, fixtures, wood furniture and door panels / frames, and kitchen appliances. Wooden furniture and fixtures contribute up to 0.5 to 8% of the total weight of ship (LDT). The "Wooden Furniture and Fittings / Fixtures" are relatively easy to sell in second-hand market because several ship-repairing small-scale units and low-cost ship/motor-boat builders can use them on "as is where is" basis.

Some other materials that are obtained on breaking different types of ships and can be easily sold on "as is where is" basis include: girders, components of structures, pipes, beams, angles, and channels. Similarly, machinery, engines and spare parts, refrigerators and washing machines, too, are easy to sell. Also, items such as cables (PVC coated, copper and aluminum cables), glass wool, thermocole, oils, lead acid batteries *etc.* have good market.

Table 2.3: Materials Recovered on Breaking Different Types of Ships in Weight % on LDT Basis

Material Recovered	General Cargo	Bulk Carriers	Oil Tankers
Re-Rollable Ferrous Sheets	56-70%	61-75%	72-81%
Meltable Ferrous Scrap	10%	8-10%	5-7%
Cast Iron Scrap	1. 5-5%	1. 5-2. 5%	1. 5-3%
Non-ferrous Metals	0. 5-1%	0. 5%	0. 5-2%
Weight Loss	9-15%	10-16%	10-12%
Machinery	4-8%	1-6%	0. 5-2%
Wooden Furniture and Fittings / Fixtures	5%	1-5%	1. 5-2%

Re-manufacturing/re-processing of steel is the major objective of dismantling of a ship in India. Steel is the common metal used in ships. Different types of steels are used while constructing ships including mild steel, cast iron, high tensile steel, *etc.* Major portion of steel is recovered in the form of plates that are suitable for re-rolling mills. Depending on the type of ship, the re-rolled steel recovered various from 50-80% of the LDT.

Figure 2.1: Steel plates recovered after dismantling of ship

Other metals that form the part of the ship include aluminum, copper, copper alloys, and lead. Aluminum is mostly used in partitions, ventilation systems and other services. Copper and copper alloys are used in electrical systems and piping. These other metals contribute to about 1 –2 % of the total tonnage. Metals that cannot be sent to re-rolling mills can often melt as scrap. These include broken metal pieces generated while cutting and trimming of the metal sheets, molten burs and fused metals while gas-cutting, connecting and reinforcement rods and coupons, rivets, unusable nuts and bolts, *etc*. This ferrous meltable metal scrap contributes about 5-10 % of total tonnage.

Recycling program being used in India was studied get insight of the recycling process. Insulation typically found on board is of two types: (a) thermal insulation and (b) electrical insulation. Thermal insulation is made up of different types of materials (*e.g.*, glass wool or asbestos). For onboard thermal insulation glass wool is commonly used. The glass wool, which has not contaminated can be sold in the market instead of disposing. Thermal insulation material of special concern is generally of asbestos (ropes, panels, shells, *etc*.). Asbestos is a mineral that occurs naturally as masses of long silky fibers and possesses excellent insulation property. Incidentally, it causes health hazard if handled without adequate care. Lumps of asbestos, ropes, and sheets (if free of contamination with oil or other wastes/coatings) can be sold directly in to the market for similar applications elsewhere. Electrical insulations are made up of different types of polymers such as PVC, PVDC, and HDPE. After removing pure metallic wires inside the insulation, if the insulation is of pure material (PVC or other plastic material) than it is sent for recycling. If the insulation is of multi-layered and cannot be separated than it is committed to hazardous waste landfills.

Rubber products found onboard are typically plain rubber sheets, gaskets, and liners. Larger rubber sheets can be sold on “as is where is” basis in the market and there are several takers. The materials like PVC pipes can also be re-used if properly dismantled.

Blasting sand used for removal of paints can be recycled after proper treatment. The best applicable practice for treatment of such sands can be solidification/stabilization. Such solidified/stabilized blocks can be used for industrial construction. The wastewater that is generated at the ship-breaking yard can be treated and recycled for cleaning up of floors, wetting of ground and for developing green belt around the yard.

The best applicable practices for treatment and disposal of waste matrixes have been identified based on our past research and reported as given in Table 2.4.

Table 2.4: Processes for Treatment and Disposal of Polluting Substances in Ship Breaking Industry

Sr. No.	Waste Stream	Treatment and Disposal
1.	Poly-chlorinated biphenyles (PCBs)	**All waste oils** and depleted oils contaminated with PCBs (irrespective of concentration) can be incinerated and the heat recovery system can generate power / steam to improve economic feasibility. To save the environment, the facility can be fitted with appropriate post-incineration air-pollution control system. The ashes from incinerator and the slurries from the air-pollution control system can be sent to properly engineered hazardous waste landfill site after stabilization of the solids/slurries. **All contaminated solvents** having concentration 500>PCB>50 ppm, derived from washing of equipment, should be treated to recover the solvent and the remaining concentrated waste should be incinerated with appropriate environmental safeguards (as described earlier). Effort can be made to minimize downstream environmental problems by employing appropriate non-ionic, non-chlorinated solvents. Solvent fractions from the initial stages of washing having high concentration of PCB may be directly incinerated (since recovery from such concentrated streams may not be cost effective).
2.	Asbestos	**Treatment:** In-situ wetting of asbestos and containerizing it for disposal or solidification and stabilization of powders, lumps, and slurries **Disposal:** Disposal of containers or bricks of the non-recyclable waste in an engineered landfill. All appropriate environmental safeguards should be ensured in land filling (as described earlier).

Sr. No.	Waste Stream	Treatment and Disposal
3.	Oils and Fuels	**Aquatic wastes** contaminated with fuel oils or petroleum products should be subjected to oil and grease separation and thereby some oils / greases can be removed. Further, the aquatic stream should be subjected to secondary and (if required) tertiary treatment system to enable recycle of the water stream. The solids, slurries, and any adsorption matrices used during the secondary and tertiary treatment should be incinerated in the engineered incinerator facility or should be sent to properly engineered hazardous waste landfill site after stabilization of the solids/slurries. All appropriate environmental safeguards should be ensured in incineration and land filling (as described earlier). Cakes of sludges or any solids/ slurries containing traces of fuel oils or petroleum products should be blended with coal powder or any appropriate filler and sold as low-grade fuel briquettes.
4.	Paint chips	**Treatment:** Solidification / Stabilization of paint chips separated from spent iron shots using cementations material. The queried briquettes can be sent to engineered landfill. The stabilized paint wastes should be sent to properly engineered hazardous waste landfill site. All appropriate environmental safeguards should be ensured in land filling (as described earlier).
5.	Heavy Metals	Recovery and reuse of Elemental mercury should be the first priority. In case, any solids or sludges are encountered baring mercury based compounds they should be solidifies / stabilized and sent into engineered landfill. In case of refrigerants and ODSs, upon collection of these substances in pressurized vessels these substances should be sent to authorized sites.

Sr. No.	Waste Stream	Treatment and Disposal
6.	Ballast water	**Treatment:** Ballast water treatment plant should be properly designed to handle such waste water with the help of primary, secondary and tertiary treatment **Disposal:** The treated wastewater can be used for cleaning and other low-grade applications in a close loop fashion in the process of ship breaking. The excess quantity of treated wastewater can be discharged into ocean only after ensuring that it conforms to the consented water quality parameters issued by the Pollution Control Board. The chromium sludge and other sludges generated as a result of primary, secondary and tertiary wastewater treatment should be disposed into engineered landfill. All appropriate environmental safeguards shall be ensured in land filling (as described earlier).
7.	Bilge water	**Treatment:** Wastewater treatment plant can be done in be properly designed to handle such waste water with the help of primary, secondary and tertiary treatment **Disposal:** The treated bilge water can be used for cleaning and other low-grade applications in a close loop fashion in the process of ship breaking process. The excess treated bilge water shall be discharged into ocean only after ensuring that it conforms to the consented water quality parameters issued by the Pollution Control Board. The chromium sludge and other sludges generated as a result of primary, secondary and tertiary wastewater treatment should be disposed into engineered landfill. All appropriate environmental safeguards shall be ensured in land filling (as described earlier).

Sr. No.	Waste Stream	Treatment and Disposal
8.	Other hazardous material (*e.g.* glass wool used as thermal insulating material, cables, contaminated waste, PCBs, and other homogenate solvents, and discarded paints and other chemical containers)	**Treatment:** Glass wool, friable asbestos waste and other solids and slurries contaminated with PCBs can be stabilized / solidifies and sent for secured land filling. **Disposal:** **All contaminated solids/ slurries** can be stabilized to ensure minimum leaching/mobility and sent to engineered landfill. All appropriate environmental safeguards should be ensured in land filling (as described earlier). Shredded cable insulation waste and other similar waste having low potential of leaching should also be sent for land filling upon carefully enclosing in bags.

2.7 OCCUPATIONAL SAFETY AND HEALTH MANAGEMENT PLAN

The high number of occupational accidents and the work-related diseases which could potentially occur if the ship dismantling activities are conducted in irresponsible manner. To minimize the potential safety and health-related damages *Occupational Safety and Health Management Plan* needs to be instituted - whose quality must meet very high standards. The strategy, methodology and measures presented here are based on a preventive philosophy addressed to all kinds of ill-health caused by the work conditions and are intended to be applicable to all possible types of ship dismantling facilities, both those mainly based on manual work and those using mechanical methods in a larger extend, taking even in account social parameters related to local conditions.

The general rule governing the analysis of the system, the identification and assessment of risks, the improving proposals and the follow-up is that the preventive work has to be done in a systematic way. European industrial requirements and experience have inspired the described OSH Management system, where ideas from the Swedish ship repairing industry have in several aspects been used.

2.7.1 THE STRUCTURE OF THE SHIP RECYCLING SYSTEM

A ship recycling system consists generally by three parts,

a) The ship recycling facility,

b) The interface and

c) The object to be dismantled, the ship.

a) The ship recycling Facility

For a given ship recycling yard, a first approximation on the way to prepare a OSH Management Plan, is to be aware of the lay out parameters that are significant for the Safety and Health and the work conditions. The competent person aiming to prepare the OSH Management Plan can easily identify details of the design of the facility which are going to cause difficulties and risks through the ship recycling process as for example the lack of enough area, uneven ground, inadequate internal traffic conditions, absence of arrangements for weather protected work places, irrational material flow, limited storage spaces, poorly functioning transports *etc*.

Proceeding further, the type and condition of the equipment and the working tools, the design of the workplaces, the production methods *etc* have to be analysed by taking in account not only the technical aspects but even the economical and social conditions in the country and the particular region where the facility is situated. If for example it is obvious that the lack of investment capital is the main reason for using old equipment, buy used machines and make often the choice to work manually instead of investing in mechanized systems, the aim of the OSH Management Plan will be to accept the economical facts and provide instructions, training and other means that ensure the safe performance of the manual work. That view is in principle applicable in case of beaching-type facilities, where the main question should be to determine what conditions can be accepted to remain the same, still manually based, and identify the parameters that have to be changed from the S&H point of view.

To expect a sudden mechanization of the existing beaching-type facilities seems to be unrealistic making reasonable that the preparation of a S&H M-Plan plan for the manually based facilities should be equally oriented towards Human and Organizational factors as on Technical and hardware ones. The social, cultural and market aspects that in great extend and in a unique way affect a large part of the existing ship recycling industry have not been analyzed and taken into account in the known Guidelines of the International Organizations nor in the forthcoming legislation. It is therefore our hope that our long experience of the way in which the ship recycling activities are organized and operates in Alang coast of India enables highlighting in the present discussion of WP3 some aspects of the traditional beaching method that may be considered as advantageous being at the same time not merely technical.

Once the pieces of the ship, in blocks or in smaller pieces and components, have reached the onshore area, the primary zone of the facility, the work tasks are similar to those occurring in many land-based workshops where disassembling and welding operations are taking place as well as those occurring in waste management facilities dealing mainly with industrial waste. One can easily find many similarities with, for example, automobile and electronics scrapping industry and it seems natural to expect similar risk-profiles and frequency of occupational accidents. Increased rate of exposure to hazardous materials can be expected in connection with e g dismantling of asbestos and PCBs contained structures and materials and metal-cutting of painted and coated steel plates. A reasonable conclusion might be that in comparison with the above-mentioned industrial activities, the Occupational & Safety Management Plan for the onshore part of the Ship Recycling System, the Facility, it could not be found any difference worth to notice.

b) The Interface

A large number of the pictures that have been circulated through the media and have mobilized the public opinion against the non-acceptable work conditions that exist in the ship recycling industry in Asia show often activities in the area between the ship and the land, the so-called interface, typical pictures coming mainly from Bangladesh. Transport operations and difficulties in accessing the ship through the shallow sea water and the muddy sea bottom consist today classic images of the inhumane and risky manual operations along the large distance between the vessel and the facility and has outraged environmental groups giving the existing ship recycling industry its bad reputation.

Although it has not been possible to find official statistical data on the type and frequency of the occupational accidents and diseases and even less any kind of systematic accident investigation, it has been possible to read stories about several individual cases and base on them some useful arguments for the WP3 discussion. The principal question is whether it is meaningful and how it would be possible to prepare an OSH Management Plan applicable on the very special conditions as for example the ones in Bangladesh. Fair spontaneously, the conclusion that an EU expert in industrial safety could draw could be that these work conditions are unacceptable and such industrial activities should be wound up. Such a proposal would not do the thousands of poor workers who survive themselves and support their families through that employment happy. They are not opposed to deal with tasks based on manual work, but they certainly are against to destroy their health because of risky working conditions.

The fundamental rule when preparing an OSH Management Plan is to primarily ensure that risks to human health and safety are eliminated, and if this is not possible to reduce them to the maximum extent possible. In our case is the latter option that is possible and the aim could be not to achieve a EU standard but to succeed in creating better working conditions possible to assess as acceptable. Through closer study of actual accident cases, one can see that several of the accidents are caused by events that have not been serious from the beginning, such as a mild wound injury on the arms or the legs. The final impact of the event, in many cases devastating, that may be had caused disability or in some cases death, was not due to the event as such but to the lack of good hygiene and lack of care, leading to subsequent infections. In this way, an accident that in the EU could lead to a few days of work absence could have been fatal in Bangladesh.

It is very usual in the literature to address proposals aiming mainly to technical improvements. The solutions in S&H problems are tried to be achieved by searching and choose optimal technical solutions. This is a good idea when dealing with ship recycling systems governed by a SHE-friendly policy and the ambition of compliance with the existing legislation, as for example could be the case when designing a modern ship recycling facility in one of the OECD countries. The strategy to prepare a OSH Management Plan when dealing with ship recycling systems of a very bad quality, some of them in European eyes almost non-acceptable, should be to include and emphasize the importance of the transparency and the use of environmental and exposure measurements. The number and the type of accidents, the medical confirmation of occupational diseases and the reliable reporting of the ill-health statistics are facts that even the cash buyers that are solely thinking on business profit are prepared to take in account when they choose ship recycling companies to let their ships to be dismantled.

It should be a part of the competence of the competent person whose task is to prepare an OSH Management Plan to point out the main S&H risks inherent in the system and suggest the right type of preventive measures. When he will find that the existing deficiencies in occupational Safety are not due to lack of technical skills or of economic resources, but to a conscious desire by the employer to exploit poor people being in a weak and sometimes defenceless position, this must be indicated in the OSH Management Plan. Otherwise, the information provided by this plan is defeating its own purpose by claiming that the problem is technical in origin, while the reasons are attitudes and policy issues behind. In the light of the coming new IMO Convention, based on facts, control requirements and certifications, the OSH Plan is an important part of the general SR Plan demanded by the convention.

c) The object to be dismantled, the ship

The ship is the variable in the ship recycling system. If the ship recycling facility and the interface define a basic risk level, the type and the condition of the ship can bring about an adjustment of the risk level, usually upwards. What distinguishes the risks that are directly related to the ship from the other risks that can be related to the facility and the interface is the great opportunity that the ship owner has to affect them. In this perspective, comes into the picture the role and the responsibilities of the ship owner in the process of preparing a OSH Management Plan, by clearly showing the vessel-related parameters that may cause risk situations arising during the ship recycling process.

The better and cleaner condition the end-of-life vessel can be delivered to the dismantling facility, the lower the risk level that it will generate during the dismantling process. For the competent person preparing the OSH Management plan, hopefully before the signing of the recycling contract, it is very important to be sure that the vessel has been prepared by the ship owner in the best possible way. By the expression “better and cleaner condition” we do not mean the same thing as the expression “properly emptied” used by the EU Waste Shipment regulations being associated to the pre-cleaning preparations of the ship. We mean any kind of information about the ship, which can facilitate the planning of the recycling process as SHE-friendly as possible, in order to avoid surprises and to prevent unexpected risks that may appear, as for example by providing detailed drawings, documentation from surveys and major repairs, the last years cargo, reports from occupational accidents and incidents onboard, during both the operation and repairs of the ship.

The importance of the high quality of The Inventory of Hazardous Materials has been emphasized once again in WP3. Considering the “Inventory” as a passive form of an informative list of hazardous materials, which can sometimes be difficult for people without chemical knowledge to understand and use for risk assessment, we have proposed to extend it to a dynamic form by adding additional information on the situations about when and where the toxic and dangerous properties of the various Hazardous materials can be activated during the dismantling process of particularly this vessel by including warning notes. Giving the Inventory that form, namely to use it as an safety instruction manual, it could serve as the Green Passport of the end-of-life ship, a concept which has not been yet clearly defined in the International Guidelines.

The technical aspects of pre-cleaning of the end-of-life ships have been discussed with experts from the Swedish ship repairing industry. Advantages and disadvantages of the possible two-step process has been considered and the available experience comes mainly from the recycling of war ships, but for commercial vessels should such procedures be subject to further research in the light of the requirements of the new Convention and the availability of green recycling capacity within and outside the EU. Also in this case, risk assessment models could be developed based on calculation of the increase of the risk level of a given ship recycling facility if a contaminated ship would be received for dismantling with or without a certain type of pre-cleaning.

Although considerable efforts have been devoted to the chemical risks, we were aware of the fact that even if the facility could manage to receive the ship completely clear from all hazardous materials, the recycling process would still continue to be a risky operation, especially under certain manual disassembling and transporting operations that take place onboard. The dismantling work onboard has different characteristics compared with the tasks performed at the facility and it has been suggested in WP3 as an advantage to be aware of that when preparing and later implement the OSH Management Plan.

It depends on the significant difference between the workplaces onboard and the ones existing at the facility. For the workplaces located onboard, the actual part of the ship is at the same time work place and work object, continuously changing through the ship dismantling process. Most of the workplaces onboard have a large number of varying parameters and almost all the used installations including most of the safety function and barriers have a temporary character. It means that the risk factors to be taken into account are closely related to the quick changes of the workplace, almost from one day to another.

The updating of the parameters and assumptions needed for the risk analysis must be done after very short intervals, depending on the need to take new risk factors under consideration. Considering the whole dismantling object, –the ship, as a cohesive workplace, it becomes often difficult to have an overview over all the activities and the related risks at the same time. Chartered companies and sub-contractors work often simultaneously onboard with different tasks without always taking regard to each other, which could easily create unforeseen risk situations. The definition of the limits and boundaries of a workplace is many times not obvious (possibly not for every member of the work-team). To define the workplace does not only mean just to determine the physical borders of it; to describe all the activities and responsibilities within is also important. The working group can visually realize that the workplace today is not the same as the day before; the question is whether they had the time to realize the degree that the risk factors have been changed. And even more important, if the work leaders, managers and supervisors, and the persons responsible for the safety had the time to do it. The coordination of the work is an important issue for the effective production but more important for the safety. For this reason, and with experience from the ordinary industry, we have proposed the role of a trained "dismantling coordinator onboard" as a preventive measure.

It would be desirable to have access to statistical data on occupational accidents occurred and near misses, but in the absence of such, we do the general assessment that the workplaces onboard are the part of the ship recycling system in which the risk level is highest. Thus, from the S&H point of view, in case there is a choice, we should prefer to conduct a certain work task at the facility where the risk level is lower than to do it onboard.

However, it is onboard the ship the first contact with the different structures and materials to be dismantled occur and where the chain begins of the dismantling process. The way to organize the work onboard is significant for the S&H and from this point of view it would be interesting to compare the dismantling procedures based on manual methods with the corresponding mechanical ones as for example methods that are used by tradition in India with proposed rational ones in the EU. A closer study shows not only benefits from the use of the mechanised methods and highlights especially the superiority of the manual methods when working with non-hazardous materials. The experienced eye of the skilled Indian disassembler can decide on the spot which are the components that have a 2nd market value and must be removed carefully that also means safer. Before the modern industrial thinking will force mandatory changes, it should be worth exploring the positive sides of the successful recycling know-how that has been built up over decades in India and, instead of replacing that with some completely new (mechanised), try to develop the existing ship recycling systems in a still manual but SHE-friendly direction.

2.7.2 HAZARDS AND RISK SITUATIONS

Examples of typical hazards and risk situations that are possible to arise through a sequence of ship dismantling procedures have been described and attempts have been done to sort these hazards into different categories one of which concern those related to the hazardous materials on board. Using as a starting point the lay out and the main equipment of the facility to produce a model for a given production system, a number of steps through the dismantling process have been studied, and methods have been suggested to identify and assess the risks that may appear in each one of the steps. Special attention has been given to the dismantling object, the type of the ship and the inventory of the hazardous materials on board, based on the above assumption that the risk level is generally higher on board.

The type of accidents that have disastrous consequences and, unfortunately, are not unusual in the ship recycling industry, the explosions and fires, have been thoroughly studied. Such accidents usually occur during the work tasks taking place onboard and are due to the extensive volume of "hot work" in connection with the de-coating and the metal-cutting procedures. Inadequate cleaning of the confined and enclosed spaces that have not been certificated as "gas free" and the use of oxy-acetylene metal-cutting near combustible materials have been some of the common causes. The same type of accidents happen also in the ship repairing industry but in the case of the ship recycling industry, responsibility issues between the seller, the ship owner, and the buyer, the recycling facility, can often be very complicated.

Discussing the high-profile problem of asbestos exposure in the ship recycling industry, we have made an attempt in WP3 to consider this problem in a broad social perspective in the ship recycling countries and not as a special problem for the ship recycling industry. It seems unreasonable to impose stricter rules on just ship recycling yards which handle, re-use and re-sale asbestos containing materials when the same thing is allowed to happen in the rest of the industry, the open market and the society of the country.

As mentioned before, other types of risks such as "fall to lower level", "falling object" *etc* are of great importance for S&H, although they have not been paid as much attention as these related to hazardous materials such as asbestos. They deserve to pay more interest when preparing the OSH Management Plan because they dominate by number the accidents occurring at the beaching-type facilities and could be prevented by reasonable costs.

Aiming to present methodology for production and protection which are applicable both to existing, often low technological, and to high technological ship dismantling facilities, some of them being possibly under design, the needed methods and tools have to be flexible enough for being adapted to the particular object under consideration. Taking in account the differences in legislation, local industrial standards and culture between the regions where the facilities exist, the methodology have been based on a “minimum requirement” philosophy where criteria for “non-acceptable” risks always have to be followed.

Any particular risk analysis method suitable for the ship recycling system is not suggested in WP3 but description of the advantages and disadvantages of several established methods is presented for a number of applications, stressing the importance to develop a suitable one as a product of adjustment of one or several industrially established methods. One of the main criteria for development and proposal of a suitable risk analysis method should be the simplicity for using it. The technically oriented risks are treated by priority, including requirements and methods for machine safety and the principles for CE-marking. Additional analysis would need to be made in case of application on many facilities of beaching-type by using simple human and organizational oriented methods.

Requirements and methods for controlling the exposure of workers to hazardous materials during a number of typical work tasks have been discussed concerning especially the exposure to air contaminants and the use of exposure limits. Monitoring systems and exposure measurements are very important for the OSH Management Plan as they provide the information, which is needed to define the risk groups corresponding to given toxic substance(s). Based on this information, technical measures, safety functions and barriers and rehabilitating programs can be initiated by priority. For industrial exposure such as the one occurring through the ship recycling activities, the risk for chronic effects caused by several hazardous materials needs measures to be taken at as early stage as possible.

2.7.3 IDENTIFICATION AND ASSESSMENT OF RISKS

Safety parameters concerning fixed or mobile installations, stability matters, machines and working tools, vehicles, *etc* have been in principal distinguished from the Health parameters concerning exposure to dust, fibers and toxic substances, bad whether conditions, explosions and fires, heavy ergonomic loading, noise, vibrations, infective materials, *etc*.

The risk level when trying to access the ship and move from one workplace onboard to another, sometimes carrying equipment, loads or waste materials, depend as well on the lay out of the facility as on the transportation systems available. Risk situations related to transporting operations taking place in the interface area between the ship and the facility, as for example at some type of facilities based on beaching and manual work, have been worth much attention.

When a new project is about to be received to the facility and an OSH Management Plan to be completed, it is best to assume that there will always be some unknown risks in the new ship recycling system. It is essential to identify these in the early stage before a surprising event will happen and in case of doubt, one should not shy away from a bubble control. In a risky industry such as the ship recycling one, when receiving information and facts coming from outside and being significant for the safety, as for example certificates that do not have fresh date such as "gas free", verbal assurances from the last owner, *etc*, it should be best to follow the Swedish expression "to know is to measure". Non identified risks can not be controlled.

When serious hazards are existed potentially in a system, it should be advisable to conduct a quantitative risk assessment. Such a type of assessment requires measurements and statistical data which are rarely available in most of the practical cases and for that reason attempts have been done to make assessments on the basis of experience from the ship repairing industry and similar industrial activities. Another way to proceed when a quantitative assessment of risks is not possible, is to make conclusions on the basis of scenarios. Even if downloading of similar work conditions from the ship repairing industry can provide a good approximation, the special conditions occurring in the ship recycling industry must be studied, in a number of cases, under real conditions.

Stressing the need for detailed and accurate documentation for assessing the risks and for finding optimal solutions as well as for producing pedagogic material for information, education and training, the real-time method PIMEX-PC has been presented. Generally, the circumstances for generating occupational hygiene reports at the workplace have changed dramatically. Digital pictures and recordings offer means for gathering 10–100 times more data than written methods. For example, workroom dimensions and shapes, exhausts, cooling and controls and lighting can easily be documented in a single picture during occupational surveys or measurements.

With no extra effort 20–50 photos can be taken in a workday. Detailed information about the work, chemicals, ventilation and preventive measures *etc*. can be studied later and can be combined with written reports using digital pictures, videos, PIMEX videos and CAD drawings. In addition, the structure of an electronic report is flexible. Supplementary to the report, a variety of presentations for different groups of personnel is available. This is one of the cornerstones of risk communication and the participatory process.

In the case of ship dismantling, where a very large number of parameters have to be taken under consideration, PIMEX method can be used for several purposes, as for example planning, documentation, risk analysis, development of safe work methods, exposure control, suggestion and evaluation of measures and education.

In order to obtain a balanced picture of the existing situation and get an idea of the trends, based on facts and expert opinions, we have engaged in dialogue with both representatives from the existing ship recycling industry in Alang in India and the ship repairing as well as the waste management and recycling industry in Sweden.

2.7.4 IMPROVING MEASURES

The use of Safety Functions, barriers, ventilation systems and other protecting devices have been discussed combined when needed with the use of Personnel Protective Equipment (PPE). For every ship recycling system a system of safety functions can be defined, consisting of a fundamental part of the Risk Management Plan. The know how and technology needed for designing the Safety Function System is as important as to know how to design the production system itself. Production systems where it is not easy to find solutions based on mechanizing the process, as for example in the case of beaching, special protecting technologies must be applied and in that field there are a lot of possibilities to develop and introduce innovations. The traditional industrial thinking of the i-countries may be not be able to provide functional solutions ready for application.

Trying to introduce S&H improvements in an existing ship recycling system and decide in the system, the type of the measures and in what order the protection measures are to be implemented, is to conduct a systematic risk analysis.

The more accurate the diagnosis of the problem the greater chance succeed with the proposed measures. If the cause of the problem is the lack of capital, there is no point to suggest high technology. If the workers can not read it is no idea to share tables with the "Inventory of Hazardous Materials".

2.7.5 THE OCCUPATIONAL SAFETY AND HEALTH SERVICES – AS A PART OF THE SAFETY SYSTEM

In our days it is difficult to find industrial activities where the working conditions and the related risk assessments are so complicated issues as in the existing ship recycling industry. The competence needed to design an appropriate OSH Management Plan can usually not be covered by the recycling company´s internal resources. To organize a certain type of local OSH-Services should be a better idea, a matter thoroughly discussed in WP3. The OSH-Services can be considered as a part of the Safety System of the recycling facility, which in turn will be a part of the OSH Management Plan, being probably the most cost-effective investment to achieve continuous improvements of the work conditions.

The OSH Services can play a fundamental role in the successive improvement of the S&H standard of an existing ship recycling facility, under condition that they can be organized in a proper way. The different ways to organize the Occupational Safety and Health Services have been discussed as well as the kind of consulting assistance that the OSH Services can provide to a particular ship dismantling facility and the degree that such an assistance is needed. As higher is the level of risks in a certain industrial production as better has to be the quality of its OSH system. The type of risk situations and the level of risks that appears within ship dismantling activities are often so serious and complex that consultation of persons with special competence is necessary.

A minimum level of knowledge in S&H matters should be necessary for the employees in general, the special working groups, the work leaders and supervisors and the managers. A higher level of S&H education is normally needed for safety delegates and members of the safety committee, if such a committee exists. Personnel playing a key-role in the internal S&H work of the company, should have sufficient assistance from S&H experts in all cases that such an assistance may be needed. Whether the above S&H network is going to function or not, is a matter of organization.

For a particular ship recycling facility is possible to draw a map with minimum S&H knowledge requirements for every one of the above mentioned groups and prepare a suitable education and training plan. Lack of competence on S&H matters has to be considered as a risk factor to take in account in the risk assessment procedure. As the purpose is to develop routines that are workable in practice a proper way to organize the OSH system is suggested giving the OSH Services a central role.

Aiming to organize the OSH Services as a part of the Safety System of the facility, a number of medical(M) and technical(T) functions of the OSH Services can be considered as a set of *safety functions*, providing the possibility to be used as a set of parameters in the risk analysis. How effective the M and T functions are can be systematically studied if the risk analysis method selected by the analyst, is the "Safety Function Analysis", mentioned in WP3.

When the competence of the facility´s own personnel is not enough, assistance provided by the experts occupied in the OSH Services has to be available. Prevention of work-related accidents, incidents, physical and psychical diseases means to act with *the right measure at the right time*. To know what is *the right preventive measure* for a particular risk needs both competence and experience. For taking measures *at the right time* needs, moreover, policy and insight about what are the long-term benefits of the company. That kind of competence is usually missing in small companies of the size that is common for most of the ship dismantling facilities.

Even higher competence is needed to introduce a policy for early rehabilitation and to establish methods and routines for an active search and remediation of ill-health phenomena at their beginning. According to the principals of risk analysis, when preventive measures are not effective enough to avoid health impacts, it is of great importance to "reduce the consequences" which has the same meaning as to activate mechanisms for early rehabilitation. When active OSH Services are available to lead the process of identification and assessment of risks it will reasonably result to a clear identification of a number of risk groups. Even if the main purpose of the Safety system is preventive, for current situation of the ship recycling industry to arrange measures for rehabilitation is equally important, and should be considered as a "first aid measure". A realistic idea to succeed in building up the above described pyramid of competence, should be as a pilot-project, aiming to create a center of OSH Services to serve a group of existing ship recycling facilities within an area.

Possessing the role of an independent consultant, the OSH Services will be given the possibility to be involved in several decision making steps, as for example under the planning stage, the choice of work methods and new equipment, the assessment of risks and the identification of the risk groups, the measurement of the occupational exposure and the program for early rehabilitation, the proposal and evaluation of safety measures *etc*.

Independently whether the OSH Services are organized as internal or external services, they should participate when critical decisions are making and stand as a guaranty that OSH issues are handled in a proper way, with high quality and treated by priority.

As a practical way to organize the active roll of the OSH Services as a part of the company´s Safety System, is to define a set of OSH-actions in a standard list, considered as safety functions (SF) of the system. They can further be divided into, for example, “medical SF”, “technical SF”, *etc*. Such a list of safety functions related to OSH-Services, has to be adjusted before it will be applied on a particular ship recycling facility. The type and the number of SF included in the list depends on the competence level in S&H matters of the personnel of the facility. As higher is the competence of the facility’s ordinary personnel and resources, as more limited shall be the number of SF in the OSHS-list. It means that the OSH Services represent a supplementary volume of expert knowledge that does not already exist in the facility. The purpose is to always be sure that assessment of difficult and complicated OSH-matters shall be made by a competent person or group.

Reportedly, concerted efforts were made in India at the Alang ship-recycling yards (State of Gujarat in India) by starting a training centre for training and capacity building of workforce and yard owners as well as managers. Over the four-years several thousand workers were repeatedly trained. These efforts started showing beneficial results during the past two years. Interesting data were reported from Alang ship-recycling yards “zero fatal and major accidents” during calendar year 2008 (January to December).

2.8 CONCLUSIONS

The existing ship recycling industry is about to change and seems to be on the way to a dualistic development. On the one hand by following the “manual track” and on the other hand “the mechanized track”, with both of them needed to wrestle with risks that are difficult to overcome like explosions, accidents, exposure to high level of hazardous substances, chronic diseases *etc*. A large number of workers allegedly suffered in the past because of risky work-environment and their exposures. Today’s workforce must be protected and the repetition of past mistakes should be avoided. Already there are data from Alang ship-recycling yards (State of Gujarat in India) reporting “zero fatal and major accidents” during calendar year 2008 (January to December).

For the new yards that have shown interest and are about to enter the market is the use of modern but relatively expensive technology, the only option, as dictated by existing legislation in *e.g.* the EU, USA *etc*. For the existing ship recycling companies is their dilemma either to disappear in the long run or turn against a SHE-friendly direction. Both these categories of ship recycling yards can be supported by the "Shipdismantl" in their inevitable need to choose proper SHE-friendly technologies and type of organization and make their right decisions.

In order to ensure that the OSH Management Plan fulfil its purpose, by constantly guiding the activities of the facility towards SHE-friendly direction, it must be designed as a *living document*. This can be achieved by continuous adjustment of the OSH Plan to the current conditions, preferably day by day, following the progress of the dismantling process. If we want to go a step further and make the OSH Management Plan to a market driver for the sustainable development of the entire ship recycling industry, we must ensure that the activities and the results achieved through this OSH Management Plan will be characterized by openness and transparency. The facilities using well-organized OSH Management Plans shall be rewarded by goodwill response of the market while those who miss that deal will be condemned. In this context, the ship owners get an excellent chance to perform a *voluntary action*, according to the appeal of the EU as it is expressed in the *Green Papers for Ship Recycling*, by requiring the facility which will dismantle their ships to declare openly facts about their OSH Management Plan.

Summarizing, the report on WP 3 deals with the identification, handling, and storage of hazardous wastes on board. Ambient environmental monitoring plan for ship breaking industry along with standards / limits for each of the environmental parameters have been specified. Further, emergency plan was developed that will help the owners or operators of the ship breaking facility to minimize and regulate the hazards to human health and environment. Studies related to waste recycling/ reprocessing and resale have been studied and reported. Also, guidelines for waste management were developed that delineates treatment and disposal options for hazardous wastes that are generated during ship dismantling. Thus, the study carried out in WP 3 will help in identifying the hazardous wastes and managing these wastes in environmentally friendly manner. The strategy, methodology and measures for Occupational Safety and Health Management Plan are also reported based on a preventive philosophy addressed to all kinds of ill-health caused by the work conditions and are intended to be applicable to all possible types of ship dismantling facilities, both those mainly based on manual work and those using mechanical methods in a larger extend, taking even in account social parameters related to local conditions.

CHAPTER 3: WP4 Overview

3.1 SUMMARY

Efficient use of industrial facilities is affected by facility design characteristics and decisions made at the earlier stages of plant development. In shipdismantling literature, the current discussion on facility layout is limited by the basic block layouts, or model layouts, of main operational zones.

In the first part of this study, a systematic approach to planning of a generic shipdismantling facility is presented. The multi-dimensional and multi-objective nature of the problem is discussed for facility design at a detailed level. A hierarchic representation of layout objective criteria is developed. Layout modelling framework for layout variants also presented in the report. Based on the available docking, cutting and de-coating technologies, a template for development of technology-mix scenarios to be sued in the facility design and development is created. Finally, a "layout scorecard", a matrix form evaluation tool has been developed in order to guide the user to select most cost effective, environmentally friendly and safe technology mix for dismantling of the vessel.

The second part aims to facilitate development of necessary infrastructure, redesign and re-organisation of the full shipdismantling yard by identifying the optimum mixture of technology alternatives by ranking currently available technologies in order to address complex set of decision criteria such as health and safety, environmental, financial and other internal and external factors.

In order to reflect the complex, multi-criteria and multi-attributive nature of the shipdismantling problem, expert opinions from a group of experts collected via a survey forms which is based on the preceding Task 4.1 reports and available information.

In the study, developing a framework for evaluation of technology alternatives and design criteria, as well as collection and analysis of expert opinions has been performed. At the end of the analysis of expert opinions, and justification and validation of assumptions with aid of sensitivity analysis, a ranking of technology alternatives for optimum shipdismantling facility is obtained. As part of the study, expert participants are asked to indicate their opinions about the combination of technology alternatives that is considered under each scenario group. Results from that survey represented for each participant group for correlation analysis. Later, overall results are presented and compared with small-expert group's initial mapping.

3.2 INTRODUCTION

In this consolidated report, Generic Guidelines for the optimisation of design, construction, and operation of ship dismantling facilities presented, where details of the content are available in Deliverables D4.1 and D4.2.

The report starts with review of shipdismantling facility studies, and presents the state-of-the-art of the facility and layout studies for shipdismantling operations. Various sample models with varied detail level presented. In addition to physical facility aspects, operational and procedural aspects of the facility design discussed with references to available literature. Although most of the references provide generic guidelines, some detailed studies with specific scope are also available.

Facility and layout design and development problems are unstructured decision-making problems and also considered as multiple-objective problems. Although there are a number of theories and algorithms in operations research studies in this field, majority of those tools and techniques deal with detailed level of modelling, and hence considered not feasible for the objectives of the current study. Therefore, the study discussed in the report follows a systematic approach in planning of industrial facilities and models the shipdismatling facility at the general overall layout level.

In order to represent and assess the multi-objective nature of the facility problem, objectives of the shipdismantling facility development problem has been discussed in the report, and hierarchy of shipdismantling specific objectives prepared. Hierarchy of the objectives is presented in two levels, and can be expended with further detail level in future studies. Current high level objectives considered are: Health & Safety Risk mitigation, Environmental Risk mitigation, Financial, Technical Performance, Internalities, and Externalities. Objectives at each level are further discussed for their parameters and performance indicators.

In the study, modelling approach used for the development of shipbreaking facility is also presented. Modelling of the facility is based on zone concept and terminology defined by previous studies assumptions were made within the scope of the current study. Following the simplification of modelling detail, a number of facility layout variants that represents typical combinations of principal modelling elements has been developed and schematic models has been prepared. Main components of schematic models are listed as follows:

- primary zone and type of docking system
- secondary zone
- interface between sea and shore
- position of spill containment barrier
- vessel (contained within the primary zone)

Initial list of possible layout variants has been reviewed with group of industry experts and based on the expert opinions eight different candidate layout variants have been short-listed as a potential workable combinations for a dismantling facility. Guidelines for selection of candidate layouts for generic ship-dismantling facilities are also presented.

In a parallel study, in order to select the best suitable technology mix for the principal dismantling zone of the facility, a systematic selection process has been introduced and mapping of number of technology scenarios prepared. In order to reduce the complexity of the model, the scope of the study is also limited to key zones within a facility. Those zones are identified as a) primary dismantling, and b) secondary dismantling zones. Due to the relatively trivial effect of zones beyond the secondary zone on overall operation of the facility, this approach was deemed to be valid by ShipDismantl yard experts.

Capacity evaluation and dynamic simulation modelling of the facility is also presented in the report. In connection with these tasks, detailed product and process analysis has also been performed and presented. With the same purpose, description and characteristics of plant and areas, material handling systems, and manning levels have also been discussed.

Finally, guidelines for evaluation of ship-dismantling facilities have been discussed. In order to assist user to evaluate the layout and facility design effectively, a “Scorecard” template has been developed. The layout scorecard is a summary matrix of various criteria against a number of factors used during the facility development. The main criteria listed in the layout scorecard matrix are; product, facility interface, operations and major risk factors. Sample scorecards have also been demonstrated for shortlisted layout variants, namely web basin, pier, and dry-dock.

3.3 BACKGROUND OF THE SHIP-DISMANTLING FACILITY PROBLEM

3.3.1 MODEL LAYOUT FOR DISMANTLING FACILITIES

Development of overall layout is one of the major elements of facility design and development studies. Gaps between current shipdismantling practices and environmentally sound principles have been analysed by various organisations and suggestions for planned transition between these are documented. One of the technical guidelines was prepared by the Basel Convention and outlines the "environmentally sound management (ESM) of the full and partial dismantling of ships". The guideline provides information and recommendations on procedures, processes and practices in shipdismantling. Key functionalities of the model ship-dismantling yard listed by the guideline are as follows:

- containment of hazardous materials
- secondary dismantling of components
- temporary storage areas for hazardous and metallic materials
- secure storage areas for hazardous wastes
- proximity to proper disposal facilities

The Guideline, with its current content and scope, does not extend the knowledge of requirements from model facilities to various ship-dismantling site types or critical technologies such as docking. However, the introduced zone sub-divisions are deemed to provide an applicable reference and starting point for further studies.

Within the scope of this report, a similar concept layout designs for generic ship-dismantling facilities have been discussed. Development guidelines for alternative layout designs and main design and selection criteria have also been examined.

3.3.2 FACILITY AND LAYOUT DESIGN

A facility development and layout problem are unstructured decision problems. Layout design, in particular, is one of the areas of operations management that attracts extensive research interest and is studied under the category of assignment problems. Facility layout problems are influenced by quantitative and qualitative factors and considered as multiple-objective facility layout problems.

One of the widely-used systematic approaches is a method that suggests four stages in a Systematic Layout Planning of Industrial Facilities (SPIF):

1. Location
2. General overall layout
3. Detailed layout
4. Installation

Throughout the progress of stages, there is an overlapped of activities between each stage. Amount of information required for the layout project gradually increases with the progress of stages. Although rough estimates and general considerations are sufficient in the early stage of the planning, details of the information to be used in the later stages should be more accurate.

The presented study mainly focuses on Phase-2 and 3 of the layout development of ship-dismantling facility.

Although the main focus of the study is to model and analyse the overall layout of the facility, some further analysis performed at the detailed layout stage. At the detail level, the systematic process of optimising a layout requires an understanding the relationships between the various work-centres within the facility.

Hierarchy of Objectives in Shipdismantling Facility Development

In this section, a case study of a generic ship-dismantling facility is presented using a systematic layout development approach. A set of template yards has been developed and a Layout Scorecard for summary data introduced. A hierarchical approach is adopted for development of objectives hierarchy. The top level objective is set as “identification of best candidate facility” with a set of lower-level criteria with objectives as follows:

- health and safety risks (minimise)
- environmental risks (minimise)
- cost and earning (minimise/maximise)
- technical performance (maximise)
- business impact (maximise)

Due to the comprehensive nature of the criteria, each of the Level-1 criteria is further broken down for Level-2 criteria. This hierarchy is presented in Figure 3.1.

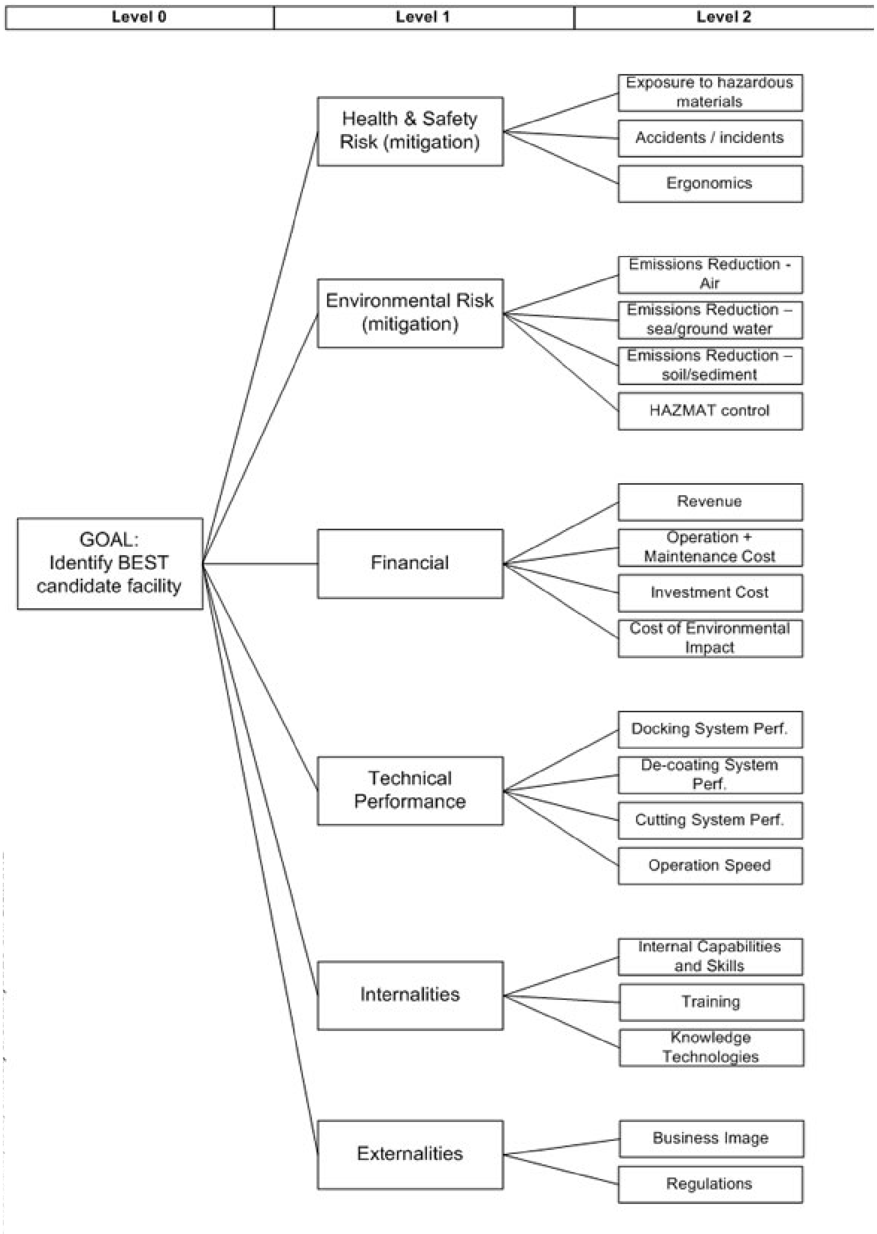


Figure 3.1: Hierarchy of Objectives for Shipdismantling Facility Development

3.3.3 MODELLING THE SHIPBREAKING FACILITY

In this section, modelling approach used for the development of ship-breaking facility in the study is presented. Following the discussion with industry experts, a number of layout design variants has been developed and discussed in detail in the following sections. Finally, selection criteria of alternatives have been discussed.

3.3.3.1 Modelling Levels for the Ship-dismantling Facility

Based on the initial analysis of facility needs and logical dependencies, a modelling hierarchy for the layout development has been established. Modelling of the facility is presented in four different levels as follows:

Modelling Level	Description
Zone	these are the high level area which is formed by groups of work-centres that perform similar functions or handle similar product stages.
Main Facility/Area	represents an individual work-centre, or storage area within a zone
Equipment	represents an individual equipment or tool (including material handling equipments) which can be associated with Main Facility/Area
Sub-area	identifies an internally subdivided area within the Main Facility/Area, and usually used for segregation of operations with different type of materials

3.3.3.2 Development of Layout Variants for the Ship-dismantling Facility

The generic layout concept development has been performed and a number of alternative layouts and their variants have been prepared. In this high level development, the main focus is given on docking system alternatives in primary zone the adjacent secondary zone. Due to operational requirements related to primary and secondary dismantling zones that limit the scope of initial block layout model development, it has been assumed that transport within those two zones is similar in volume and distance and is not included in this stage of the study.

During the study, review of generic model facilities with industry experts indicated that the main differences of alternative facility layouts are essentially occurred within the first two zones of the facility, namely primary dismantling zone (docking area) and secondary dismantling zone (major block breaking area).

Following the simplification of modelling detail, a number of facility layout variants that represents typical combinations of principal modelling elements has been developed and schematic models has been prepared. Main components of schematic models are listed as follows:

- primary zone and type of docking system
- secondary zone
- interface between sea and shore
- position of spill containment barrier
- vessel (contained within the primary zone)

Initial list of possible layout variants has been reviewed with group of industry experts and based on the expert opinions eight different candidate layout variants have been short-listed as a potential workable combinations for a dismantling facility. Comparison of short-listed layout alternatives is presented in Figure 3.2.

The main characteristics of layout variants are as follows:

- *V0 Baseline*: natural slipway as current practice
- *V1 wet-basin*: wet basin as the primary dismantling zone
- *V2a Pier*: pier for primary zone processes, with natural slipway approach
- *V2b Pier with central zone*: same as V2a, but secondary zone processes are performed on a reclaimed area
- *V2c Sideways Pier*: same as V2a, however, sideways oriented pier

- *V3 Drydock*: fully enclosed primary zone with drydock
- *V4 Floating dock*: floating dock with on-board primary dismantling zone
- *V5 Slipway*: marine railway with adjacent secondary dismantling zone.
- *V6 Ship-lift*: ship-lift system with shore-side primary dismantling zone.

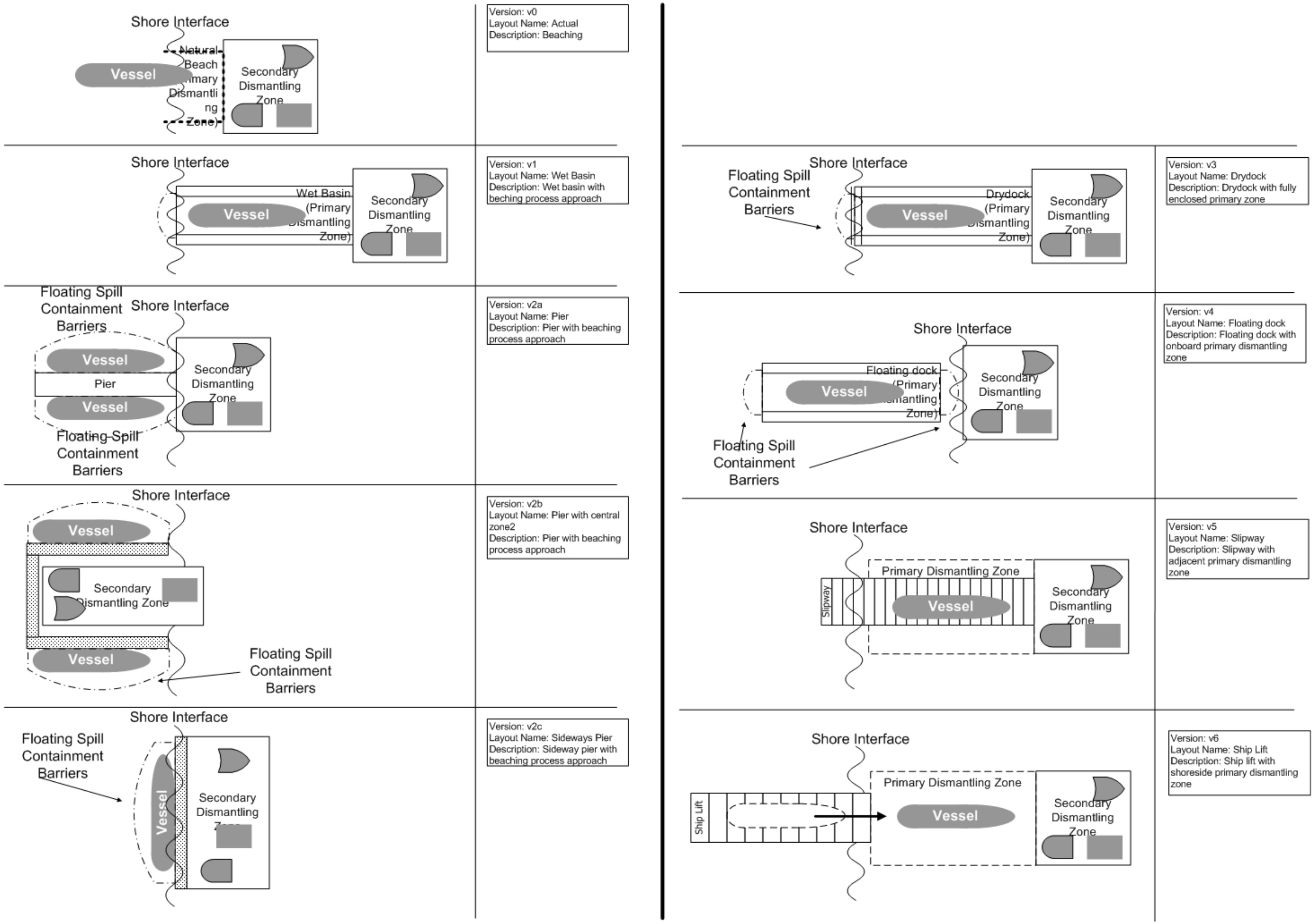


Figure 3.2 - Comparison of layout variants

3.3.3.3 Selection of Candidate Layouts for Generic Shipdismantling Facility

Following the development of principal layout variants, the short-listed alternatives have been further evaluated by users from the industry, and four candidate variants have been nominated as feasible alternative and listed for further analysis. Among the factors considered during the outranking are:

- *area of land required*
- *approach of vessel to yard*
- *applicability of layout to various cases*

After the evaluation of eight variants, the selected layout variants are as follows:

- Variant 0 (non-tidal beach; baseline layout)
- Variant 1 (wet basin)
- Variant 2a (pier)
- Variant 3 (dry dock)

Comparison of layout factors for full and partial ship-dismantling facilities and their relative importance ratings are identified by yard experts and presented in Table 3.1.

Table 3.1 - Layout Factor Analysis - Comparison of dismantling facilities

		Importance Weights (*)	
No.	Factors	Full SD	Partial SD
1	Ease of future expansion	3	5
2	Adaptability and versatility	3	4
3	Flexibility of layout	3	3
4	Movement effectiveness	2	3
5	Materials handling	3	3
6	Storage effectiveness	4	4
7	Space utilisation	4	2
8	Supporting service integration	3	4
9	Safety and housekeeping	5	4
10	Working conditions	3	2
11	Ease of supervision and	5	2

	control		
12	Community relations	3	3
13	Quality of product or material	3	2
14	Maintenance problems	3	2
15	Fit with company structure	2	2
16	Equipment utilisation	5	5
17	Plant security	2	3
18	Utilisation of natural conditions	5	4
19	Ability to meet capacity	4	4
20	Compatibility with comp. strategy	3	4
21	Investment cost	5	5
22	Operating cost	5	5
23	Maintenance and repair cost	5	4
24	Contamination control	4	3

(*) (0=none, 1=very low, 2=low, 3=medium, 4=high, 5=very high)

Variant No.0 – Baseline Layout

This is a baseline variant and corresponds to a facility layout widely used in "natural beaching" practice. Natural beaching, in contrast to tidal beaching, is occurred in non-tidal waters and damage to environment during beaching is less compared the tidal one. In this practice, dismantling object, i.e. vessel is in floating position totally in the water near the shore. There is no restriction to the size of the vessel, apart from draft of the vessel in this alternative. Approach of vessel to yard is restricted with depth of the beach.
Natural beaching is specifically applicable for full-shipdismantling operations.

Variant No.1 – Wet Basin

In this semi-confined variant, wet-basin, a basin which is excavated from the main land is the primary dismantling zone. Vessel is in fully floating position before and throughout dismantling operation. Since primary dismantling activities is performed afloat, there is no need for full-depth gate at the sea-basin interface and emissions to the sea can be prevented by floating barriers that covers the entire opening of the basin, and contact length of primary zone containing the vessel is very short compared to other layout variants. Wet basin can be used both for partial and full-dismantling operations.

Variant No.2a – Pier

In this variant, primary zone processes are performed around a pier along the vessel length, usually using the top-down method. Dismantling in the pier area follows the same approach as natural slipway and two vessels can be berthed at each side of the pier. Length of the pier determines the maximum length of the vessel to be dismantled, and can be extended to accommodate longer vessels. Pier type facility design is particularly favoured in partial-dismantling operations due ease of access to vessel.

Variant No.3 – Dry dock

This design is similar to wet basin variant and presents similar characteristics in terms of dimensions and dismantling approaches. However, primary zone operations are performed in a totally waterless environment with dock being totally isolated from the sea by aid of full-depth gate, and with the vessel lied on the bottom of the dock. Among the main advantages of the dry dock to wet basin are the total containment of operations with substantially reduced damage and risk to marine environment. Due to prepared surface of the dock, i.e. concrete base and side walls, this variant has the superiority of contamination control over all other layout variants.

3.3.4 SHIPDISMANTLING TECHNOLOGY SCENARIOS

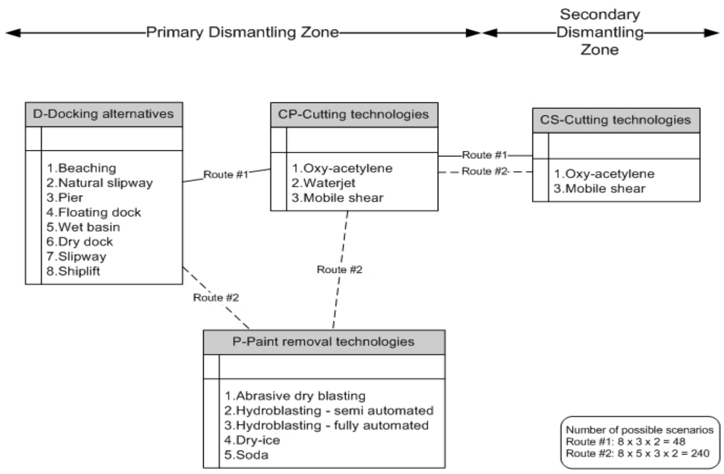
In order to select the best suitable technology mix for the principal dismantling zone of the facility, a systematic selection process has been introduced.

3.3.4.1 Development Of Initial Scenarios List And Short-Listing

The first step of development of the generic concept is to prepare a list of available technologies that can potentially be used during the analysis. For this purpose, a number of Best Available Environmental Technology (BAET) options that can be used for principal processes have been identified. The scope of the study is also limited to primary and secondary dismantling zones. Due to the relatively trivial effect of zones beyond the secondary zone on overall operation of the facility, this approach was deemed to be valid by yard experts. Critical elements of the layout for primary zone are a) docking system, and b) cutting processes and technology, whereas for secondary zone the critical element is “type of cutting processes and technology.” Zones and processes used in the study are presented in Figure 3.3.3.

3.3.4.2 Main Technology Scenarios

Details of the main technology scenarios deemed to be most likely alternatives in a full dismantling facility are presented in this section. A summary of above scenarios is presented on a scenarios map in Table 3.2.



De-coating scenarios
Route #1 : Coated metal dismantling (current practice)
Route #2: Surface-prepared metal dismantling (including partial/strip de-coating for torch cutting)

Figure 3.3: Template for facility development scenarios analysis – technologies and processes

Table 3.2 - Summary of Technology Scenarios

Scenario Code	*BAET*	*BPET*	*BECE-1*	*BECE-2*	*BCET*
Scenario Name	*Best Available Environmental Technology*	*Best Practicable Environmental Technology*	*Best Environmentally -friendly and Cost Effective-1*	*Best Environmentally -friendly and Cost Effective-2*	*Best Cost Effective Technology*
Description	this is considered the best alternative that can be selected for a highly environment-friendly dismantling yard	This is a second best combination to the BAET. Some trade-offs and concessions are made from BAET.	This is a compromise solution, balancing the environmental considerations with financial factors. This can be regarded as a first step to depart from today's standard practices.	Similar to BECE-1	This scenario mainly refers to the status-quo.
Technology Components					
Docking system	Drydock	Drydock, wetbasin, pier	Drydock, wetbasin	Drydock, wetbasin	
De-coating technology	hydroblast de-coating (entire hull)	hydroblast de-coating (de-coating/ line-strip)	None	None	no de-coating.

Cutting technology (Zone 1)	waterjet cutting	oxy-acetylene cutting (Primary Zone)	waterjet cutting (Primary Zone)	oxy-acetylene cutting (Primary Zone)	oxy-acetylene cutting (Primary Zone)
Cutting technology (Zone 2)	mobile shear	mobile shear (Secondary Zone)	oxy-acetylene cutting (Secondary Zone)	Mobile shear (Secondary Zone)	oxy-acetylene cutting (Secondary Zone)
Advantages	advanced technology and processes	Proven technology and processes,	Balances the environmental considerations with financial factors.	Compared to BECE-1, added tasks of water containment and disposal at waterjet is eliminated	Marginal improvement from the baseline case
Disadvantage	cost and need for skilled workers	may need additional cost	No major disadvantage	No major disadvantage	May not lead to environmentally and worker friendly alternatives in

3.3.5 SHIPDISMANTLING FACILITY EVALUATION

In this part of the study, guidelines for evaluation of ship-dismantling facilities have been discussed. In order to assist users to evaluate the layout and facility design effectively, a “Scorecard” template has been developed.

3.3.5.1 Layout Scorecard

The layout scorecard is a summary matrix of various criteria against a number of factors used during the facility development. A sample layout scorecard for the alternative facility discussed in the case study is presented in Figure 3.4.
Currently there is no study in the literature presenting a facility development framework aimed at shipdismantling. This report attempts to fill that gap. Use of generic layout evaluation and scorecard framework for shipdismantling provides user a quick reference in facility factor evaluation.

The main criteria listed in the layout scorecard matrix are;

- Product
- Interface
- Operations
- Personnel
- Environmental conditions
- Financial
- Major risk factors
- Other

Those factors are scored by users as "expert-judgements and opinions with consensus" for the following items;

- Applicability of criteria
- Ranking of main risk and performance areas

In the second part, values of "scoring" or evaluation should be as numeric as possible. That part also facilitates using weight factors for different user groups. Due to the suitability of analytic studies, initial version of the scorecard focuses mostly measurable technical factors. Criteria that can be used for quantifying environmental impact (e.g. CO_2

emissions, or kWh energy used), and health and safety impact (number of accidents etc.) are provided in a similar document. Those criteria are not directly relevant to conventional problems of layout design. Factors considered related to layout design are as follows:

a) design parameters (or variables)

b) operational conditions

c) decision criteria

Part 1 – Sketch of Layout Variant

This section of the scorecard aim to provide quick visual reference for user and based on the modelling abstraction levels as described in the previous sections of the report. The layout sketch contains following main components of the facility model:

- vessel
- primary zone
- secondary zone
- sea-shore interface

Each modelling component is further defined by set of primary parameters and this is also shown on the layout sketch.

Part 2 – Layout Scorecard

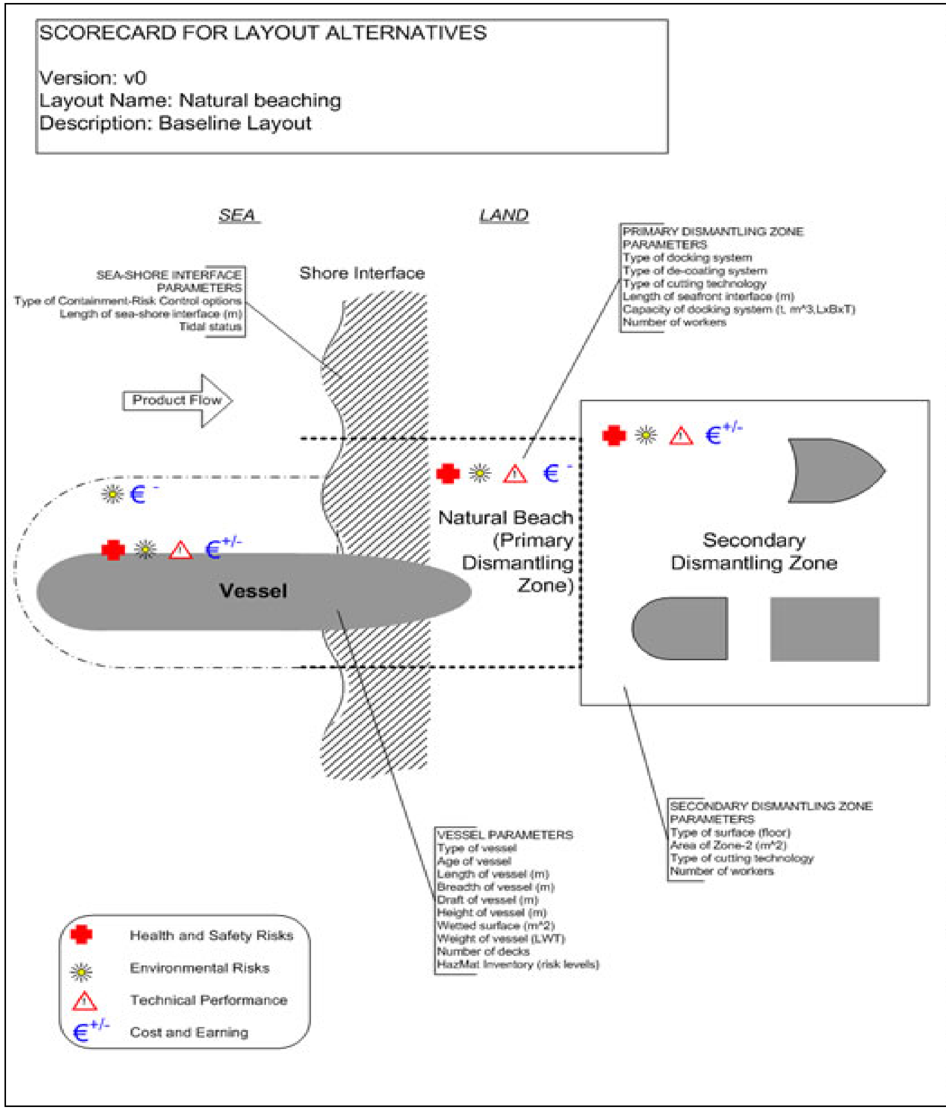
The scorecard mainly refers to operational aspects and do not take into account health and safety, and environmental factors in a comparable detail. The reasons for that are:

1) to avoid a lengthy list with additional, and mostly unquantifiable elements

2) to prepare a summary list for technical performance aspects.

This section of the scorecard is built on main parameters as follows and provides baseline for elaborate analysis:

- Product
- Interface
- Operations
- Personnel
- Environmental conditions
- Financial
- Other



Design Paramaters (Variables), Operating Conditions and Objectives of Layout Variants

No.	Item	Unit	Primary Zone Operations	Secondary Zone Operations	Technical (SD) Performance	Environmental Risk	Health and Safety Risk	Cost	Revenue	Business Impact	Total Score	Weighted Total Score	Layout Design Parameter	Operational Condition	Decision/selection Criteria (*)	Simulation Data Status (I/O)	Simulation Data Priority	V0-Baseline	V1-Wet basin	V2a-Pier	V3-Dry dock
			Wt.Factor		2	4	5	3	3	1			Layout Design					Variants			
A	PRODUCT																				
1	Type of vessel	value	5	3	3	4	4	4	4	4	19	66		+		I	2				
2	Age of vessel	integer	3	2	4	5	4	4	4	4	21	72		+							
3	Length of vessel	meter	5	1	2	4	3	5	4	4	18	62		+		I	1		+	+	+
4	LWT of vessel	ton	5	5	2	4	3	5	5	4	19	65		+		I	1		+		+
5	Number of decks	integer	5	2	3	2	3	3	1	4	12	41		+		I	2				
6	Hull material specs.	value	3	3	3	3	2	3	5	4	16	52		+							
7	Type of HazMat	value	5	3	4	5	5	5	2	4	21	74		+							
8	Weight of HazMat	ton	5	3	4	5	5	5	2	4	21	74		+		I	1				
9	Complexity of vessel	value	5	5	5	3	4	5	3	4	20	66		+		I	2				
B	INTERFACE																				
10	Length of sea-vessel interface	meter	5	0	2	5	3	2	1	4	13	48	+					+	+	+	+
11	Length of sea-shore interface	meter	5	0	1	5	4	1	1	4	12	48	+					+	+	+	
12	Type of containment system	value	5	0	4	5	0	4	0	4	13	40	+								
C	OPERATIONS																				
13	Type of docking system	value	5	2	5	5	3	4	3	3	20	66	+			I	1		+		+
14	Length of docking system	meter	5	1	2	4	1	4	4	3	15	49							+		+
15	Capacity of docking system	ton, DWT	5	3	2	3	1	4	4	3	14	45	+						+		+
16	Type of cutting technology	value	5	5	5	5	5	5	5	3	25	85	+	C		I	1	+	+	+	+
17	Type of de-coating technology	value	5	3	5	5	5	5	3	3	23	79	+	C		I	2		+	+	+
18	Type of material handling eqpt.	value	5	5	4	3	5	3	0	3	15	54	+			I	2	+	+	+	+
19	Max. capacity of matl.hand.eq.	m3	5	5	5	2	3	2	0	3	12	39	+			I	1	+	+	+	+
20	General storage capacity	m3	2	4	3	5	1	2	3	3	14	46	+					+	+	+	+
21	HazMat storage capacity	m3	5	5	3	5	4	5	2	3	19	67	+					+	+	+	+
22	Productivity rates	value	5	5	5	1	1	5	4	3	16	46	+	C		I	1	+	+	+	+
23	Cycle time (per vessel)	man-hours	5	5	5	2	2	3	4	3	16	49			+	O		+	+	+	+
24	Number of workstations	m2	4	5	5	5	5	3	3	3	21	73	+	C	+	O		+	+	+	+
25	Area of workstations (total)	meter*2	5	5	4	2	3	2	4	3	15	49				O		+	+	+	+
D	PERSONNEL																				
26	Number of workers	integer	5	5	5	0	4	5	4	3	18	57	+	C							
27	Skill of workers	value	5	5	5	5	5	4	4	3	23	79		C							
E	ENVIRONMENTAL																				
28	Env.cond. (sea state) (*)	value	5	0	1	4	1	0	0	3	6	23		+				+	+	+	
29	Env.cond. (tide/current) (*)	value	5	0	1	4	0	0	0	3	5	18		+				+	+	+	
30	Env.cond. (wind) (*)	value	5	0	4	4	1	0	0	3	9	29		+				+	+	+	+
F	FINANCIAL																				
31	Investment (set-up) cost	€ ($)	5	4	3	5	5	0	4		17	63			+						
32	Operating cost	€ ($)	5	5	2	5	5	0	3		15	58		C	+	O					
33	Maintenance cost	€ ($)	5	4	5			0			5	10			+	O					
34	Cost of env. Protection	€ ($)	5	5		0		0			0	0		C	+						
35	Earning potential	€ ($)	3	5					0		0	0		C	+						
G	OTHER																				
36	Regulations	value	3	5	2	5	5	3	4	2	19	70									
								Min =			0	0									
	Scale							Max =			25	85									
0	None, or not applicable							Avg =			15	52									
1	very low impact or importance							St.Dev =			6.1	22									
2	low impact or importance		C: Conditional; dependent on the vessel type or project																		
3	moderate impact or importance		(*): Technical-performance based criteria only																		
4	high impact or importance		I/O: (I)nput data or (O)utput																		
5	very high impact or importance																				

Figure 3.4 - Layout Scorecard – Layout Variant 0 (Sample)

3.3.6 DEVELOPING A FRAMEWORK FOR EVALUATION OF TECHNOLOGY ALTERNATIVES AND DESIGN CRITERIA

Ship-dismantling is an activity where multiple decision makers whose expertise on design attributes are not uniform. Decision maker has to deal with selection of optimum or feasible solution from the finite set of technology alternatives, where cumulatively constitutes a working facility. Moreover, the decision is subject to objectives and multiple criteria. Therefore, multiple attribute decision making methods are suited to evaluate and select best alternatives from the finite set. As in similar engineering and design decisions, the ill-defined nature of the ship-dismantling problem emanates from the following:

- unquantifiable information
- incomplete information
- non-obtainable information

In this study, developing a framework for evaluation of technology alternatives and design criteria, as well as collection and analysis of expert opinions has been performed. At the end of the analysis of expert opinions, and justification and validation of assumptions with aid of sensitivity analysis, a ranking of technology alternatives for optimum shipdismantling facility is obtained.

The problem, as defined in the Project scope, is **selection of most appropriate technology alternatives and optimisation according to generic principles**. In the context of current study, the term "the most appropriate" refers to a optimum alternative under the consideration of main design criteria i.e. health and safety, environmental, financial, internalities, and externalities. The process flow developed and adopted in the study is presented in Figure 3.5.

3.3.6.1 Adopted Methodology

<u>Step-1: Population of Decision Matrix:</u> In this first step of the study, expert opinions from Project Partner organisations have been collected in the standard format. In the first form, experts are asked to assign a ranking for each technology alternative and design criteria pair, under four main criteria categories. List of technology alternatives and design criteria has already been developed in the earlier Tasks of the Project and its details are known by Project Partners.

Step-2: Calculation with expert weightings: In the study, multiple experts with non-uniform expertise on different design criteria have been consulted. Therefore, expert opinions need to be normalised using an “expert weighting” process. In the survey, each respondent has been asked to declare his/her expertise area. Based on this self-declaration of expertise area, Moderator has assigned a weighting for each expert following a simple scale, and calculated the decision matrix again.

Step-3: Application of cost/benefit factors: In this step, both subjective and objective design criteria is divided into either “cost” (or input) or “benefit” (or output) category. The higher values of cost elements are less preferable, whereas the higher values of benefit elements are more preferable. Therefore, criteria items associated with cost elements are multiplied by (-1), and benefit elements are multiplied by (+1). Cost and benefit categories are taken from the previous deliverables of the Project.

Step-4: Aggregation for criteria weights: In any design and selection study, there are two type of criteria; 1) objective, 2) subjective. In principle, is an assessment for an alternative with respect to criteria is quantifiable, the attribute is objective-type. Quantification is usually a result of measurement or calculation, and is independent of expert opinion, such as number of accidents or cost of investment. On the other hand, if criteria result is based on expert opinions and involves subjectiveness, the criteria are called subjective-type.

Step-4A: Aggregation for homogenous criteria weightings: Homogenous criteria weightings represents a condition where all main criteria groups and all criteria sub-groups are considered “equally” important (or weighted) for the evaluation, ranking, and selection of the optimum technology alternative.

Step-4B: Aggregation for heterogeneous criteria weightings: Heterogeneous criteria weightings represent a condition where each criteria group are considered of different importance for the evaluation and ranking. In this study, the main conclusions about the technology alternatives ranking is based on a selected combination of criteria weights where each criteria is important in varied degrees. Although criteria groups are considered unequally weighted, sub-criteria level weightings are considered as equal for simplicity of analysis.

3.3.6.2 Expert Weightings

Determination of components of optimum Shipdismantling facility is subject to complex set of subjective attributes for decision making. Similarly, performance rating and ranking of each alternative includes various dimensions (e.g., heath and safety, environmental, finance) which result in different expert opinions. As part of the Task 4.2/T4.3, a heterogeneous group of experts employed to reflect a balanced view of opinions in the study. Each respondent is asked to name up to three expert fields which they think suit best in their current role.

3.3.6.3 Criteria Weightings

Selection and use of Design Criteria is one most important factor which affects the performance result of the selected alternative. In the study, five major design criteria groups have been used, with varied number of sub-criteria. In a real-life problem, importance of each criteria and sub-criteria for the decision maker is not equal. In this study, in parallel to Project discussions around ship-dismantling scenarios and critical issues, non-equal criteria weighting approach has been used.

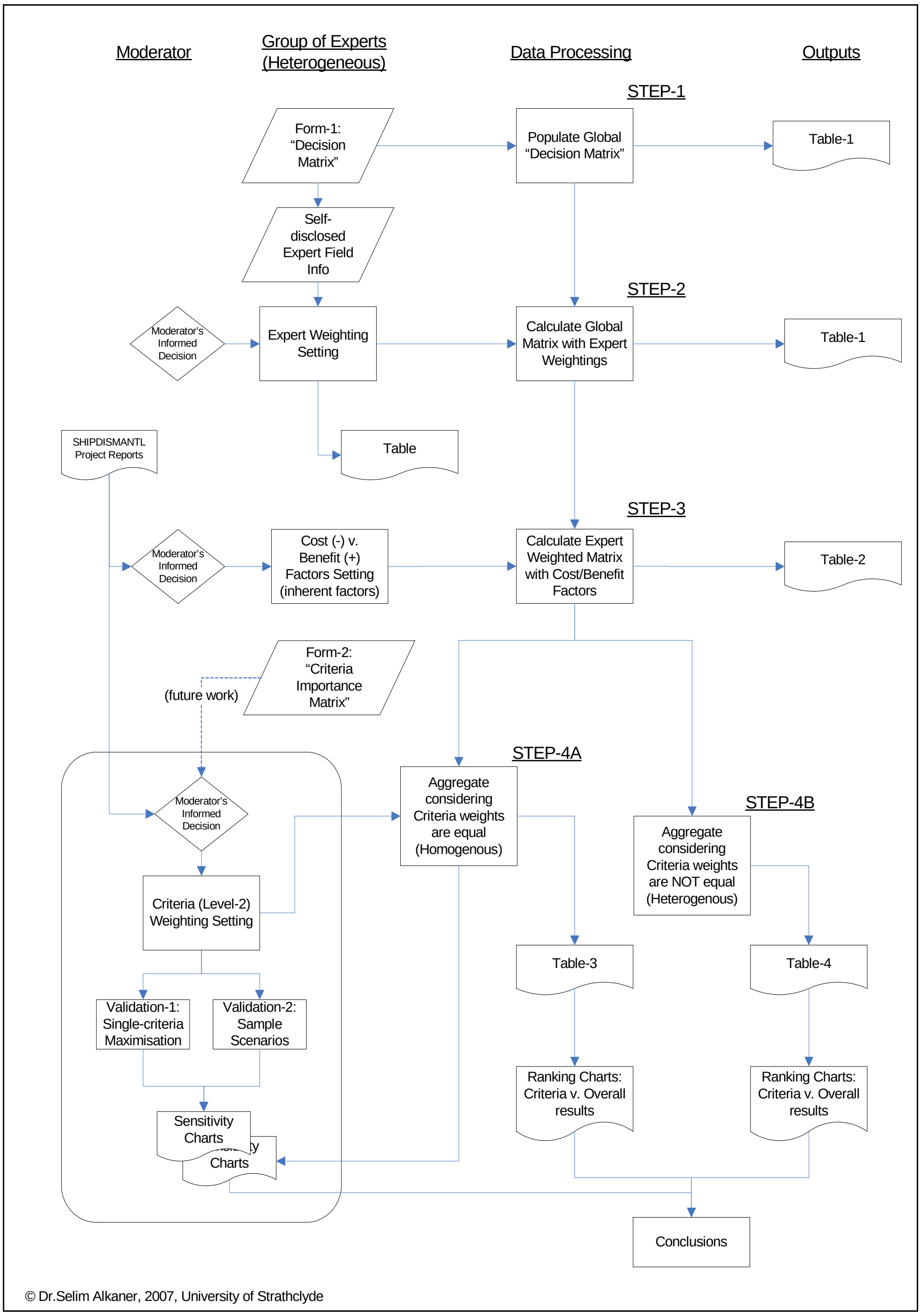


Figure 3.5: Process flow for optimisation according to generic principles – Full/Partial Ship-dismantling yard

3.3.7 ANALYSIS OF EXPERT OPINIONS

3.3.7.1 Ranking of Technology Alternatives

The objective of analysis of survey results is to provide decision makers a ranking of alternatives that he/she can base his/her decisions while selecting from a number of competing alternatives. In order to obtain a rational ranking of available technology alternatives, a set of expert, and criteria weightings identified. Sensitivity analysis of selected weightings has also been performed.

Table 3.3 - Summary of Scenario Settings for Sensitivity Analysis

No:	Scenario Name	Health & Safety	Environmental	Financial	Internalities	Externalities	Total
		Scenario Settings (weighting %)					
Single Criteria Maximising Scenarios							
0	None	-	-	-	-	-	-
1	Mono-Health&Safety	100	-	-	-	-	100
2	Mono-Environmental	-	100	-	-	-	100
3	Mono-Financial	-	-	100	-	-	100
4	Mono-Internalities	-	-	-	100	-	100
5	Mono-Externalities	-	-	-	-	100	100
Mixed Scenarios							
6	0-Baseline	20	20	20	20	20	100
7	1-Balanced	30	30	20	10	10	100
8	2-Extrovert	35	30	20	5	10	100
9	3- Worker friendly	40	30	20	5	5	100
10	4- Business	30	30	25	5	10	100
11	5-Likely	35	30	25	5	5	100

Single Criteria Maximisation

In order to assess the full effect of individual criteria, each Level-1 criteria set to 100% level while leaving remaining criteria weights set to 0%. Results of Single Criteria Maximisation sensitivity analysis is presented in Figure 3.6 . Summary of Analysis results by criteria are as follows:

Health & Safety (weighted 100%): Full weighting of H&S introduced changes in ranking of docking system alternatives and resulted in **wetbasin** at highest ranking. Similarly, **mechanical cutting** (Z1) re-ordered with highest ranking compared to oxyacetylene for the Baseline (homogenously weighted criteria). For containment, **oil skimmer** tops the range while baseline result rank impermeable floor first. There is no sensitivity to H&S criteria for de-coating systems.

Environmental (weighted 100%): Represents a similar profile of sensitivity for the following: Docking alternative (**drydock**), as well as cutting technology ranking is sensitive to environmental criteria in a similar way in H&S ranking. **Mechanical cutting** is ranks as top among the cutting technologies. There is no sensitivity for de-coating and containment systems.

Financial (weighted 100%): Financial 100% weighting is observed as a criteria which has less sensitivity on ranking, and only affects change in ranking in containment system.

Internalities (weighted 100%): This setting represents a similar profile to a Baseline ranking order with the exception of sensitivity on ranking of the beaching and de-coating alternatives.

Externalities (weighted 100%): Similar sensitivity profile as in "environmental 100%" alternative has been observed.

Mixed Scenarios

In order to assess the sensitivity of heterogeneous criteria weighting on ranking of technology alternatives, a number of scenarios identified for the analysis by the \moderator. Each scenario reflects a unique expert viewpoint by emphasising a certain criteria in the selection. Results of Mixed scenario sensitivity analysis are presented in Figure 3.7.

Overall comparison of "mixed" scenarios indicates a significant degree of consistency in the raking order of alternatives. Therefore, selection of "balanced" criteria weighting scenario can be justified, and considered suitable for the further analysis. Summary table with ranking results from each scenario is presented in Table 3.4.

Based on individual Technology Alternatives, following additional observations made:

- Docking: Ranking of wet basin is the most sensitive to scenarios, i.e. criteria weighting changes, whereas drydock and floating dock alternatives show no sensitivity.
- Cutting: Ranking of oxy-acetylene is most sensitive to scenarios whereas no sensitivity observed for other alternatives.
- De-coating: This technology area is not sensitive to any scenario.
- Containment: Floating barrier and oil skimmer show sensitivity for scenarios whereas other technologies observed as insensitive.

Table 3.4: Technology Alternative Ranking results for scenarios

	Beaching	Natural slipway	Pier	Wetbasin	Drydock	Floating dock	Oxy-acetylene –Z1	Water-jet (Z1)	Mechanical cutting (Z1)	Oxy-acetylene –Z2)	Mechanical cutting (Z2)	Abrasive dry-blasting	Hydro-blasting (line-strip)	Hydro-blasting (entire hull)	Oxy-ice	Soda-blasting	Floating barrier	Impermeable floor	Drainage	Oil skimmer
Baseline	5	**1**	2	2	3	6	**1**	3	2	**1**	2	4	5	3	**1**	2	3	**1**	2	4
Balanced	6	4	3	2	**1**	5	**1**	3	2	**1**	2	4	5	3	**1**	2	3	**1**	2	4
Extrovert	6	4	3	2	**1**	5	2	3	**1**	2	**1**	4	5	3	**1**	2	3	**1**	2	4
Worker frndly	6	4	3	2	**1**	5	2	3	**1**	2	**1**	4	5	3	**1**	2	3	**1**	2	4
Business	6	4	2	3	**1**	5	**1**	3	2	**1**	2	4	5	3	**1**	2	3	**1**	2	4
Likely	6	4	2	3	**1**	5	**1**	2	1	**1**	2	4	5	3	**1**	2	3	**1**	2	4

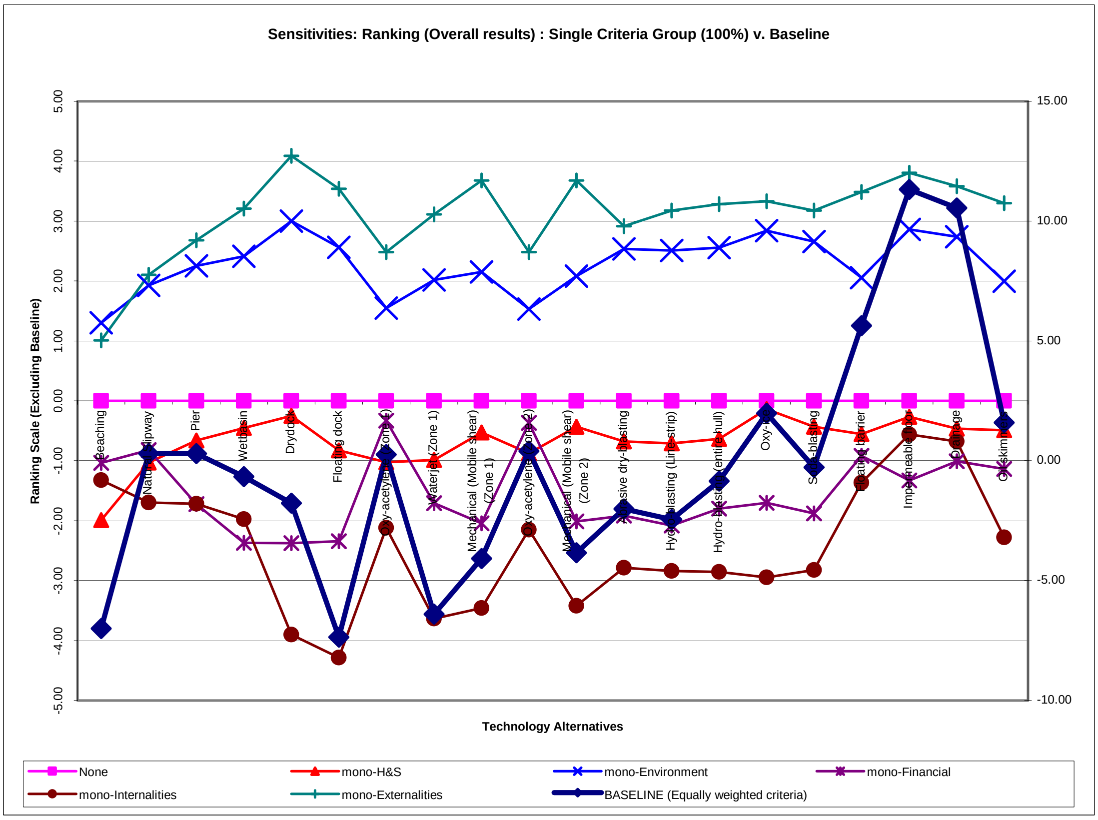


Figure 3.6: Sensitivities - Single Criteria Maximisation

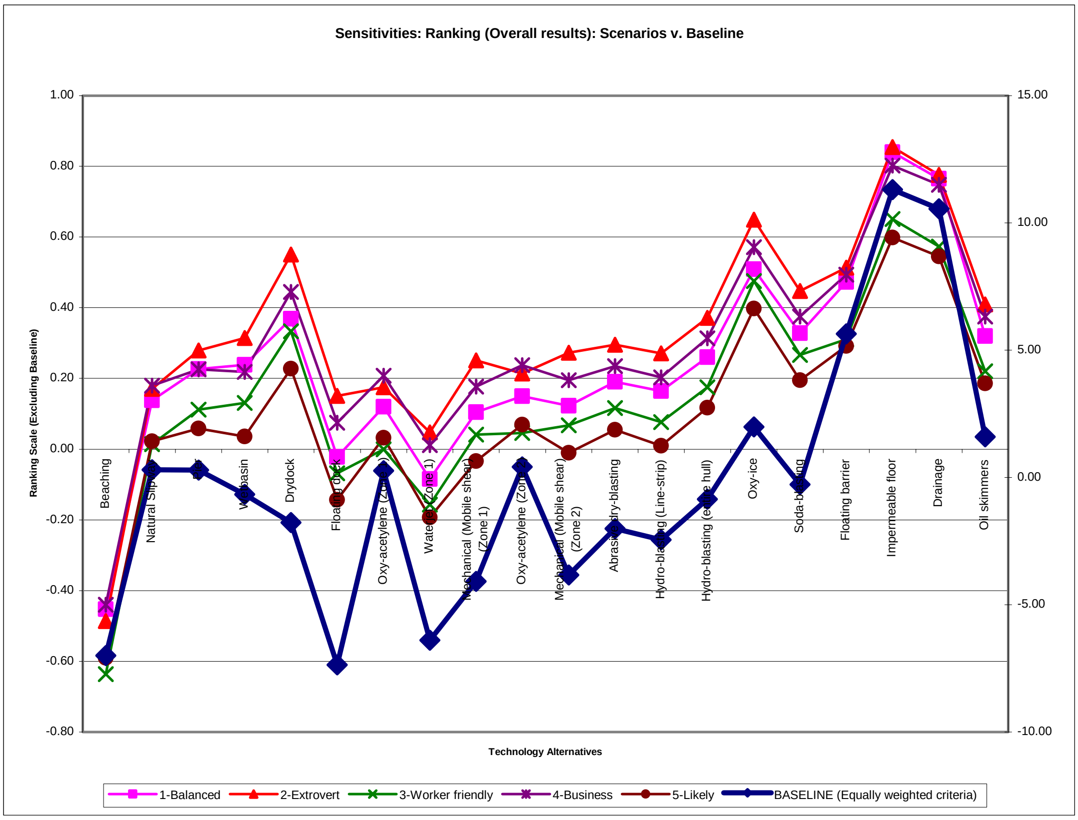


Figure 3.7: Sensitivities - Mixed Scenarios

3.3.7.2 Analysis of the Selected Scenario

In this Section, detailed analysis of the survey results for the selected "balanced" scenario (heterogeneously weighted criteria) is presented. In addition to scenario results, results from homogenously weighted criteria are also presented as baseline for comparison. Baseline scenario presented for reference purposes only. Overall results for homogenously and heterogeneously weighted criteria calculation are presented in Figure 3.8 and Figure 3.9 respectively. Outline results for each criteria by technology groups are presented as follows:

<u>Docking Technologies</u>

Comparison of scenario and baseline results indicates sensitivity of technology group to selected criteria. Rankings based on individual criteria groups are as follows:

- H&S criteria: drydock > wetbasin > pier > floating dock > natural slipway
- Environmental criteria: drydock > floating dock > wetbasin > pier > natural slipway
- Financial criteria: natural slipway > pier > wetbasin = drydock = floatingdock
- Internalities: natural slipway = pier > wetbasin > drydock > floatingdock

Cutting Technologies

Comparison of scenario and baseline results indicates sensitivity of technology group to selected criteria. Rankings based on individual criteria groups for Zone-1 are as follows:

- H&S criteria: mechanical cutting > waterjet > oxy-acetylene
- Environmental criteria: mechanical cutting > waterjet > oxy-acetylene
- Financial criteria: oxy-acetylene > waterjet > mechanical cutting
- Internalities: oxy-acetylene > mechanical cutting > waterjet
- Externalities: mechanical cutting > waterjet > oxy-acetylene

De-coating Technologies

Comparison of scenario and baseline results indicates insensitivity of technology group to selected criteria. Rankings based on individual criteria groups are as follows:

- H&S criteria: oxy-ice > soda > hydro (hull) > abrasive dry-blasting > hydro-blasting (line)
- Environmental criteria: oxy-ice > soda > hydro (hull) > abrasive dry-blast > line-blasting
- Financial criteria: oxy-ice > soda > hydro (hull) > abrasive dry-blasting > line-blasting
- Internalities: oxy-ice = soda > hydro (hull) = abrasive dry-blasting = hydro-blasting (line)
- Externalities: oxy-ice = soda > hydro (hull) = abrasive dry-blasting > hydro-blasting (line)

Containment Technologies

Comparison of scenario and baseline results indicates insensitivity of technology group to selected criteria. Rankings based on individual criteria groups are as follows:

- H&S criteria: impermeable floor > drainage > floating barrier > oil skimmer
- Environmental criteria: impermeable floor > drainage > floating barrier > oil skimmer
- Financial criteria: impermeable floor > drainage > floating barrier > oil skimmer
- Internalities: impermeable floor > drainage > floating barrier > oil skimmer
- Externalities: impermeable floor > drainage > floating barrier > oil skimmer

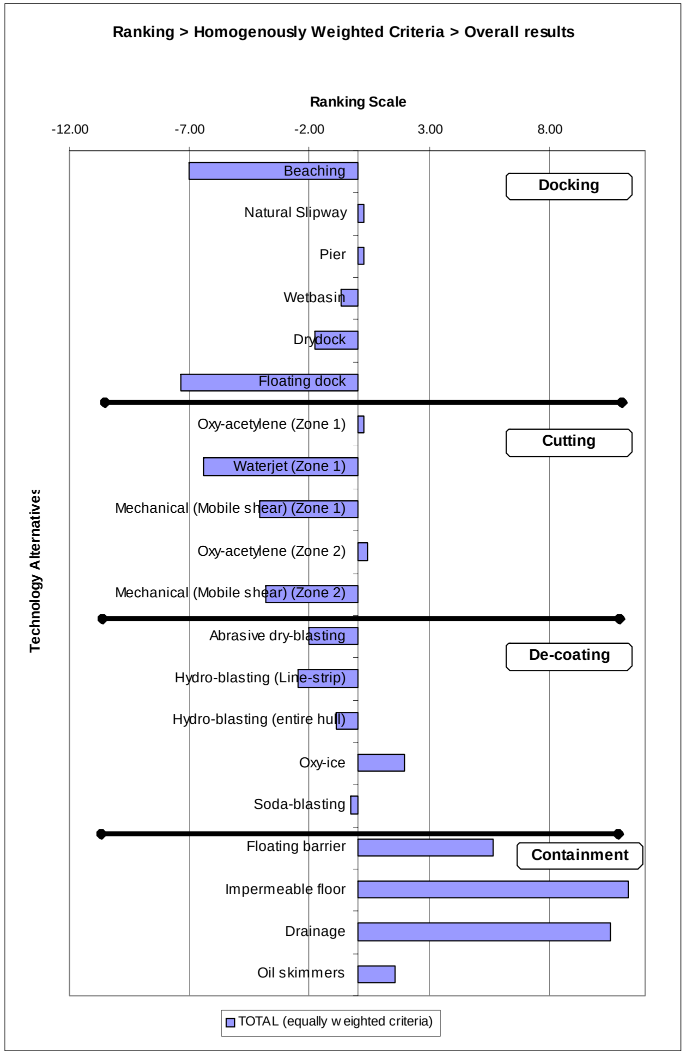


Figure 3.8: Overall rankings for homogenously weighted criteria

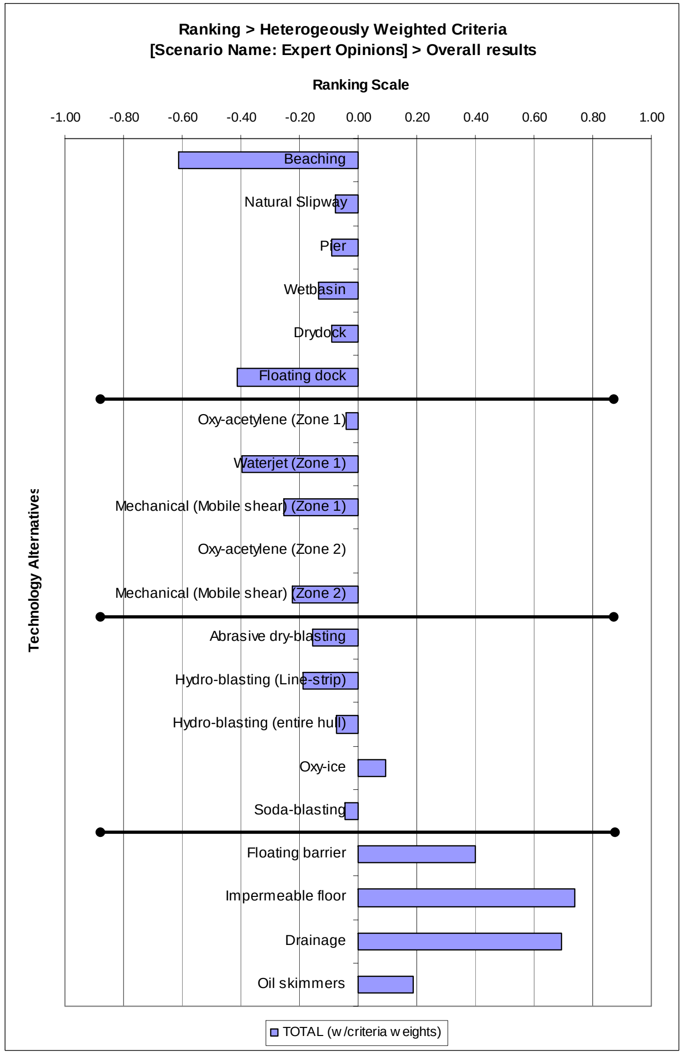


Figure 3.9: Overall rankings for heterogenously weighted criteria

3.3.7.3 Analysis of Technology Categories

Ship-dismantling technology categories and individual technology elements used in the survey are largely based on small-group expert opinions collected during the earlier Tasks of the Project (T4.1). In the study, combinations of individual technologies in each technology group are clustered in "technology scenarios" are as follows:

- BAET - Best Available Environmental Technology
- BPET - Best Practicable Environmental Technology
- BECE - Best Environmentally-friendly and Cost Effective Technology
- BCET - Best Cost Effective Technology

As part of the Survey, expert participants are asked to indicate their opinions about the combination of technology alternatives that is considered under each scenario group. Results from that survey represented for each participant group for correlation analysis.

<u>Comparison between expert group and initial mapping</u>

Ranking of technologies form the results of "balanced" criteria weighting scenario concludes that there is no pre-defined technology scenario mapping that fully corresponds to results obtained from the technology rankings from survey. However, the combination of technologies listed as rank-1 and rank-2 according to survey results represents a mixture of BAET and BPET groups with varying degree of likeness based on the selected ranking order.

In terms of suitability to overall research objectives of the Project the BECE scenario is the most important one. However, results of expert survey represent a divided opinion in the technology elements to be included in this scenario. Expert opinions in this category are both widely spread and in opposite ends, particularly in docking and cutting technologies. This divide in opinion is greatly attributed to highly specific and complex nature of alternatives available. Mapping of technology groups based on rank-1 and rank-2 alternatives are superimposed on original mapping chart and presented in Figure 3.10.

	Rank-1 (survey)	Included in technology scenario	Rank-2 (survey)	Included in technology scenario
Docking	Drydock	BAET, BPET, BECE	Wetbasin	BPET, BECE
Cutting-Z1	Oxy-acetylene	BPET, BECT	Mechanical cutting	n/a
Cutting Z2	Oxy-acetylene	BECE, BCET	Mechanical cutting	BAET, BPET
De-coating	Hydroblasting (entire hull)	BAET, BPET	Hydroblasting (line)	BPET
Containment	Impermeable floor	BPET	drainage	BPET

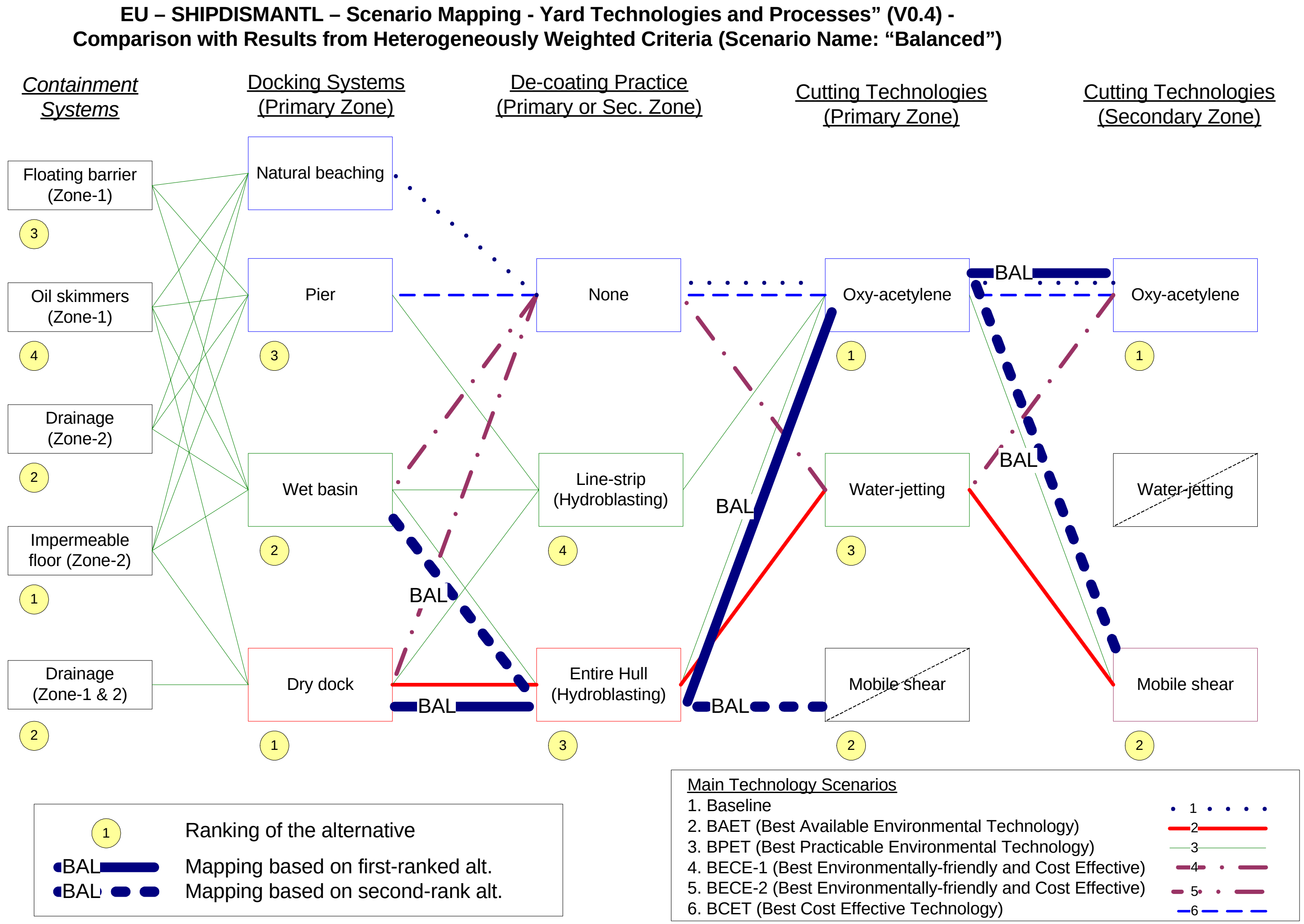


Figure 3.10: Scenario Mapping: expert survey results update

3.4 CONCLUSIONS AND RECOMMENDATIONS

Efficient use of industrial facilities is affected by facility design characteristics and decisions made at the earlier stages of plant development. In ship-dismantling literature, the current discussion is limited to basic block layouts, or model layouts, of main operational zones. In this study, a systematic approach to planning of a generic ship-dismantling facility has been presented. Developed layout alternatives and layout scorecard has been discussed within a case study.

In the study, a systematic approach to development of layout variants adopted. With focusing on the selected critical facility zones and available docking technologies, a number of principal layout variants developed for future evaluation and detailed development.

Development of guideline and selection of technology mix to be used in the ship-dismantling facility is another output of the study. Based on the available docking, cutting and de-coating technologies in the facility, a full-factorial list of possible design variables and relations are prepared. However, for practical reasons, total number of scenario alternatives has been reduced with further fractional-factorial analysis. With the baseline provided by obtained feasible candidate technology mixtures, further evaluation of the facilities can be performed for single or multiple-objectives. Some of the significant applications of technology scenarios are cost evaluation, health, safety and environmental performance assessment of alternative facility designs.

The other major contribution of the report to the ship-dismantling literature is the introduction of “layout scorecard”. With quick-reference approach to selected layout variant, this matrix assists to reflect users’ view used in scoring and evaluation of facility designs.

Ship-dismantling is a field of activity where multiple decision makers whose expertise on design attributes are not uniform. Decision maker, has to deal with selection of an optimum, or feasible solution from the finite set of technology alternatives, where cumulatively constitutes a working facility. Moreover, the decision is subject to objectives and multiple criteria. Therefore, multiple attribute decision making methods are best suited to evaluate and select best alternatives from the finite set. As in similar engineering and design decisions, the ill-defined nature of the ship-dismantling problem emanates from the following:

- unquantifiable information
- incomplete information
- non-obtainable information

In this study, developing a framework for evaluation of technology alternatives and design criteria, as well as collection and analysis of expert opinions has been performed. At the end of the analysis of expert opinions, and justification and validation of assumptions with aid of sensitivity analysis, a ranking of technology alternatives for optimum ship-dismantling facility is obtained.

Main conclusions of the study, as well as recommendations for future work are presented for four main areas:

<u>Ranking of Technology Alternatives for the ship-dismantling yard</u>

- Sensitivity analysis of results indicate a degree of sensitivity in docking and cutting technologies for criteria weighting
- De-coating and containment technologies indicate no or very low sensitivity for criteria weighting
- A “balanced” weighted criteria justified as a Moderator selected scenario for the calculations
- Docking technology alternatives ranking: dry-dock is the highest ranked alternative with a considerable variance compared the other alternatives. Wet-basin and pier are closely ranked 2 and 3 respectively. Floating dock is the lowest ranked docking alternative, excluding the beaching)
- Cutting technology alternatives ranking: Oxy-acetylene cutting is the highest ranked alternative in both Zone 1 and Zone 2 operations, followed by mechanical cutting. Both technologies are ranked closely. Water-jet technology is the lowest ranked alternative
- De-coating technology alternatives ranking: oxy-ice is the highest ranked alternative with major difference compared to other alternatives. Soda-blasting ranked 2nd, whereas hydro-blasting (entire hull) ranked 3rd. Abrasive blasting and hydro-blasting (line-strip) are closely valued with former one ranked as 4th and the later as the lowest ranked alternative

- Containment technology alternatives ranking: Impermeable floor is the highest ranked alternative followed by drainage alternative. Floating barrier and oil skimmer is 3rd and 4th ranked alternatives. In this technology category, there is no sensitivity to criteria weighting, and ranking values of technologies are distinctively distributed.

Technology Scenarios

- Current version of Technology Scenario Mappings which is based on the previous small-group expert opinions proved to be valid by highly correlated results with recent wide-group expert opinions.
- BECE technology scenario is weakly correlated with the small-group expert opinions scenario mapping from the earlier Task, and should be investigated further.
- Docking alternatives' ranking are highly sensitive to various criteria (e.g. health and safety, environmental, financial), and further investigation of that particular technology group would be useful.
- Mapping of various technology alternatives and criteria-based main technology scenarios are developed in the earlier Tasks of the Project with a small-group of experts. Furthermore, it was possible to review existing scenarios and compare with wider expert group's opinion in Task 4.2.
- It is concluded that there is no pre-defined technology scenario mapping that fully corresponds to results obtained from the technology rankings from survey.
- However, the combination of technologies listed as rank-1 and rank-2 according to survey results represents a mixture of BAET (Best Available Environment Technology) and BPET (Best Practicable Environmental Technology) groups with varying degree of likeness based on the selected ranking order. That emphasise a need for additional technology scenario in the study.

IS Framework

Some elements of the decision and selection process of optimum dismantling yard involve design criteria which can be classified as “numeric”, “quantifiable” or “directly measurable.” In the current analysis, due to lack of available quantifiable data, values of such criteria are based on expert opinions. In the Project, decision making relevant quantifiable data should be included in the shipdismantling Decision Support System, and available for the decision maker. Therefore, degree of uncertainty during system selection would be reduced.

The following criteria are typical examples that can be backed by quantifiable data:

- number of accidents and incidents (H&S category, typical unit=”number of accidents”)
- emission reduction potential (environmental category, typical unit=”kg CO2 emissions”)
- revenue potential (financial category, typical unit=“EUR per project”)
- operation and maintenance cost (financial category, typical unit=”EUR per vessel”, or “EUR per annum”)
- investment cost (financial category, typical unit=”EUR per vessel”, or “EUR per project”)

Methodology and Future Work

From the analysis of survey results, the following ideas for the future work can be listed:

- Extension of survey population to cover non-Project Partner organisations
- Criteria weighting and Sensitivity analysis based on geographical locations of the survey respondents
- Heterogeneous weighting of criteria within criteria groups
- Sensitivity analysis of Expert Weightings on ranking results
- Developing criteria weighting by analysis criteria importance matrix from the survey
- Elimination of subjectivity in criteria groups by providing a quantified data, e.g. number of accidents, or costs, ideally retrieved from the Decision Support System
- Large scale and systematic use of different approaches such as Fuzzy Set Theory to deal with linguistic variables

For concurrent evaluation of multiple views of the facility study and selecting the best facility design alternative, an integrated fuzzy multiple-attribute decision support system for facility design evaluation for ship-dismantling is needed. Such a method will allow users to take into account subjective preferences and assessments and to compare design alternatives with respect to several conflicting attributes such as technical performance, environmental, and health and safety risks, as well as cost. In the approach, an attribute-based aggregation technique for a group of experts will be employed and used for dealing with opinion aggregation for the subjective attributes of the facility design evaluation problem.

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CHAPTER 4: WP5 OVERVIEW

4.1 INTRODUCTION

WP5 consists of 5 tasks concerning the analysis, design, implementation and verification of a Decision Support system, against existing data and the development of a Safety-Health /Environment Management Information System (SHE-MIS). The system analysis constitutes the first task of WP5: "Development of a Decision Support System for Ship Breaking Processes (DSS-SBP)". The proposed overall framework supports a collaborative modelling activity, populated by input data, further enhanced with simulations executed by a technical facilitator. Prior to the system design and implementation, all requirements and specifications must be defined.
System's design is the second task of WP5: "Development of a Decision Support System for Ship Breaking Processes (DSS-SBP)". In this task, the development phase is presented in detail. More specifically we present the system's prototype (see www.shipdismantl-project.org/dss) and the basic system's components.

As part of the third task of the WP5, a manual is prepared in order to inform prospective users about the system's purposes, features, capabilities, limitations and administration. The user and reference manual is a detailed documentation of the system able to provide a step-by-step explanation of the various tools and all the functions of them within the ShipDismantl toolset. To avoid distinct separation between the reference and the user manual, a single document is created separated in two main parts.
Task 5.4 includes the outline of metrics to be used in evaluating the DSS that is developed within the framework of the ShipDismantl project. It comprises two parts: the first one (Part A) presents an overview of methods and approaches in evaluating related information systems; the second one (Part B) puts forward metrics for both the DSS and the dismantling process per se.

4.2 SYSTEM ANALYSIS

The system has been analysed in terms of its users, data structure, features and functions. The system analysis was further divided into two subtasks:

Subtask 5.1.1: Study of the overall decision making setting to be supported

Subtask 5.1.2: Detailed requirements specification

More specifically, we first list here a set of scenarios of use of the foreseen system. we then report on the different types of users involved and we provide a structured and detailed list of the data needed to be captured and exploited. Next, we specify the system's features and functionality, paying particular attention to user interface and the decision support mechanism.

4.3 SCENARIOS OF USE

This section provides two potential scenarios of the system's use. These scenarios led to a better understanding of the underlying organizational context, referred to the different types of users and sketched the required functionality.

Scenario 1: A vessel owner, who wishes to dismantle a company's vessel, is under consideration of locating the appropriate dismantling yard. By logging into the system, this owner will be able to view the database of several dismantling sites, find the existing technologies and equipment that can support the environmentally breaking of the specific ship,

Scenario 2: A dismantling owner has agreed to break a large double deck ship that has just arrived in the yard. Due to the size and complexity of the ship dismantling yard managers seek assistance in better estimating types and quantities of materials, as well as dismantling times. By inserting both the data for the ship and the attributes of the yard, a model of the proposed process, subject to environmental and cost parameters, is created. The managers can, now, see which steps to follow, the amount of resources they will need during each stage, as well as the associated costs (at each stage and in total). They can also estimate the required time and manage to give out to their customers the right amount of goods, on the right time.

4.4 TYPES OF USERS

The types of users are listed below. For each type, we specify the input expected by them as well as the output provided to them by the system. Other than input and output there will also be a “Select” option available for users who do not wish to insert any data, but instead they want to select from already inputted data. To summarise, a user will have the ability to:

(i) Input data: Populate the databases
(ii) Select: Choose the appropriate data and models from the already inputted data
(iii) Obtain output :Receive results based on selected inputs

- *Dismantling site owners:*

They provide data regarding the attributes of the yard, the workforce, the ongoing operations and all the existing dismantling conditions. They receive suggestions of optimum dismantling processing (with respect to the indicated guidelines)

- *Vessel owners:*

They provide information regarding the characteristics, properties and functions of the vessels. They can give technical characteristics, drawings, licenses and any related description. The expected outcome for this category is the

(i) The price offered to them by the dismantling yard
(ii) The capability of a yard to safely dismantle a vessel.

Additionally the vessel owner would find potential value in the a system that assists with the development of the “Ship Recycling Plan”. In that way, the system can help these users both at the dismantling and building/maintenance process, if needed. The dismantling yard owners as well the broker companies and the vessel owners should be entitled to access all data.

- *Third-party official delegates:*

The users of this category want to assure a vessel's dismantling process in compliance to environmental, safety and energy guidelines. Parties, such as the European Committee support the cooperation among all parties involved. The authorization of these users will be dependant upon their individual attributes. All these parties have a very important and active role since they regulate on a global level. They are particularly interested in the green dismantling processes and their main task is to provide a base of guidelines and legislations. Some of them are entitled to enforce regulations and restrictions or issue particular licences (i.e. green passport). Therefore their contribution will be of great importance.

- *Environmental and Energy organizations*:

These organizations should provide any information available related to environmental and energy issues. Their role is rather supportive, since they will be providing the system with useful data.

- *System administrator:*

The system administrator has the responsibility of actions such as:

  - Create a new user
  - Create / Update / Delete a user profile
  - Change user permissions
  - Assign / Update permissions to users
  - Backup the system
  - Maintain the system's integrity
  - Secure and update the system

- *Simulation facilitator:*

The simulation facilitator will be responsible for the dynamic modelling of the process. Based on the input data, the facilitator will be structuring a model and running the simulation. The results of the simulation process will be presented on appropriate interfaces (depending on the type of user), in the form of output data. Depending on the needs of each case, the facilitator will be adapting the model.

4.5 DATA ANALYSIS

The simulation based DSS for effective ship dismantling consists of two interconnected modules that interoperate over the Internet:

- Repository Database (RD)
- Discrete-event simulation modelling

RD consists of two main databases:

- the Ship Database, which contains detailed information about vessels;
- the Dismantling Site Database, which contains detailed information about the dismantling yards;

The purpose of the Repository Database (RD) is to help stakeholders of the dismantling process. Its core element is a decision-supporting environment designed for the dismantling processes by means of discrete-event simulation modelling.

4.6 SECURITY ISSUES

- Identification and authorization features should be provided. Trust level should be easily adjusted from low to high level of security.
- Selected data should be accessed only via security password. All passwords are saved in database via strong cryptographic method. Password recovery process is anticipated.
- The data should be stored in a trusted server. The system should guarantee data integrity and prevent unauthorized access.

4.7 SYSTEM DESIGN

The *system design was divided into four subtasks:*

- ***SUBTASK 5.2.1: INTERFACE DESIGN (FOR THE SYSTEM'S INPUTS AND OUTPUTS)***
- ***SUBTASK 5.2.2: PROBLEM PROCESSING MODULE DESIGN***
- ***SUBTASK 5.2.3: KNOWLEDGE BASE DESIGN***
- ***SUBTASK 5.2.4: DATABASES DESIGN (VESSELS, MATERIALS, AND DISMANTLING METHODOLOGIES DATABASES)***

Starting with the first subtask, we outline all the interfaces (of both inputs and outputs) for all four user categories, as already identified in D.5.1. Depending on the type of user, the login page is associated to different pages, where the user can fill the form with data and automatically see the results that he/she is authorised to view. Thanks to the user-friendliness and functionality of the interfaces the user has only few and easily understandable fields to fill; he/she thus can easily get results without needing any modelling or analytical skills. A detailed explanation of the interfaces gives a good understanding of the way the users use the system.

The problem processing module is analysed together with the system's architecture for its specifications and technical characteristics are sketched. Knowledge-driven, data-driven and process-driven DSS approaches will be integrated into the proposed approach. The knowledge base is designed to store data in the form of articles/documents regarding safety, environmental and cost related issues and practices. On the other hand, the databases store data concerned with vessels, materials and dismantling methodologies. An interesting feature of our system is related to the interconnection of these databases with a simulation software tool, allowing the modelling of dismantling processes through dynamic simulation.

As part of the development of a fully operational Decision Support System for Ship Breaking Processes (DSS-SBP), appropriate interfaces have been designed in order to provide support towards particular actions related to a vessel dismantling. The first step before filling the databases is the login stage, where every validated user with a given password can login and be directed to the appropriate interface. As already mentioned in the system's analysis, users will be navigated into different interfaces, where the data required and the outcomes vary from user to user. The analysis of the interfaces has been made according to the four user categories.

4.7.1 INTERFACE DESIGN

There are four input and four output interfaces, respectively, for all four types of users (see fig. 4.1). Information related to a vessel such as characteristics, technical data, inventory of materials, vessel type, etc. are filled in the input data. These data are then processed, either by matching instances or by running dynamic simulations, along with stored information for the specific dismantling site (existing facilities and dismantling methodologies, work practices, cost and time consuming estimations, etc.).

This chapter deals with the DSS special features associated with the system‘s users. Two pages are designed for each user: an input page where all data are inserted and an output page where the system displays the results after the data processing. Given that the expectations for each user are different, some pages are designed to simply display information and provide guidance and some others have a stronger decision making role, such as in the case of the *Dismantling site owner*, where special features have been added (simulation tools) in order to perform more complicated analysis.

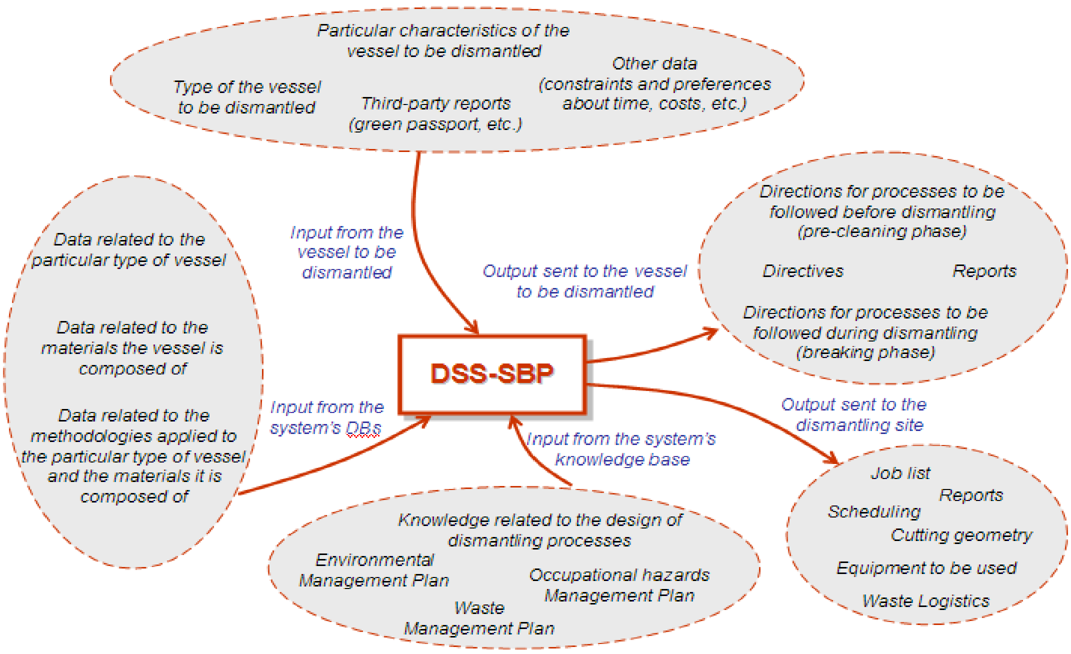


Figure 4.1: Inputs and Outputs of the proposed DSS

4.7.2 VESSEL OWNER

The role of this interface is to help a vessel owner decide on the appropriate and available dismantling site that could dismantle a specific vessel in a safe and cost effective way. Given that a large database of several dismantling sites is built in the system, the user's only task is to input the vessel id and three elementary characteristic of the vessel in order to see all the available and suitable dismantling sites.

The system compares all the technical, environmental, occupational, and recycling characteristics of the existing yards (stored in the database) with the characteristics of the vessel that needs to be dismantled. The results with the most and best matches are presented in the output interface. At the same time, information on the possible hazardous materials, that a vessel might have are displayed below the generic information of the vessel. This information will help later on the user to decide on the yard that has the appropriate technologies to process the existing materials. Additional information can be obtained by clicking on the site of the selected yard, right next to the list menu (see fig. 4.2).

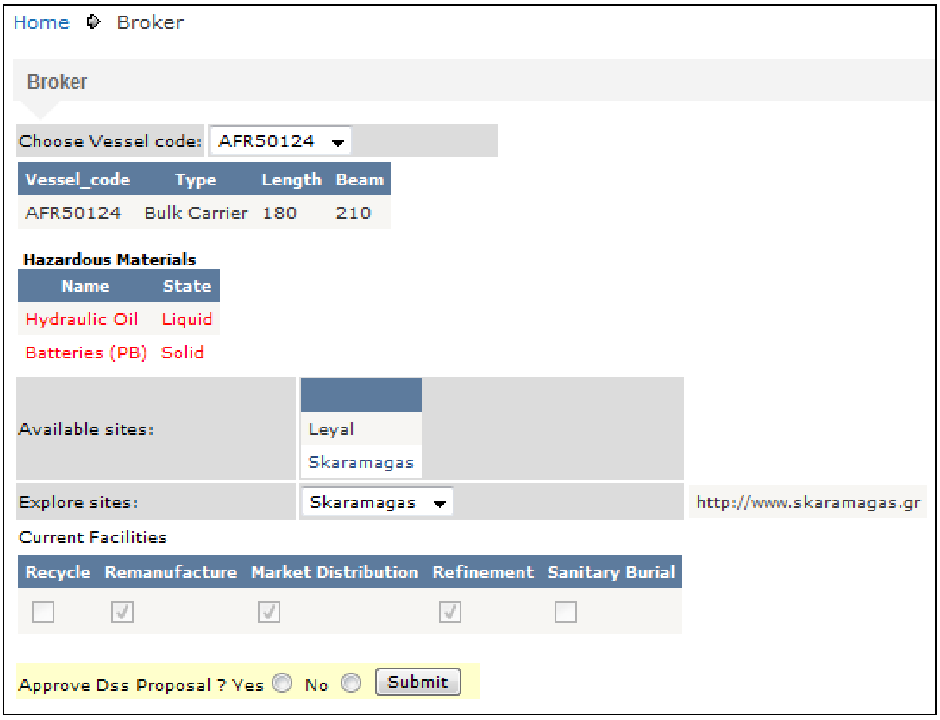


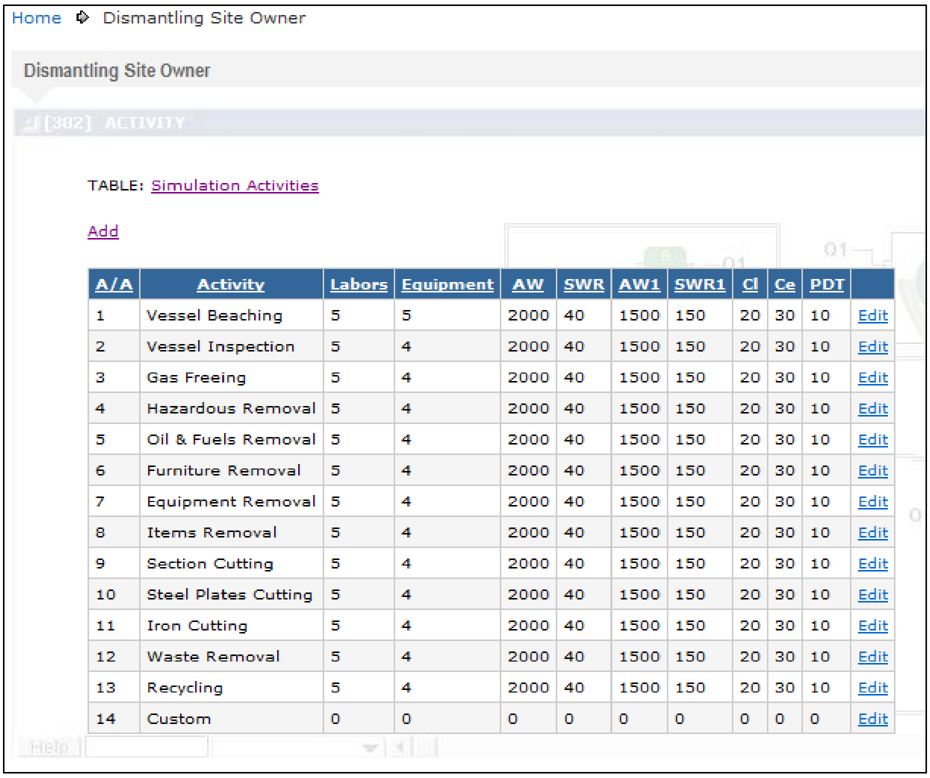
Figure 4.2: Vessel Owner output page

Once the user decides on the preferred yard, the output page, allows the user to inform the system of his final yard selection, by approving or not the DSS proposal. In that way, reference is kept for the specific vessel breaking, which is then stored in the database and become easily visible by other users. If no yards matched the preferred criteria, the user can modify the parameters and find the next closest good choice. The interface is also expected to present, in further versions, more technical characteristics of the yard, such as existing technologies, manpower capabilities, equipment availability and so on.

4.7.3 DISMANTLING SITE OWNER

Most of the times, a yard owner needs to calculate some critical vessel parameters such as the total cost of the dismantling process and the total time the process is about to last. Other parameters of high interest are each activity's cost and lead time. Provided that these parameters are known, it becomes easier to identify critical activities which need improvement or seem to be extremely costly. This information can be obtained through a specific section of the dismantling website, which is connected directly with the Extend simulation model.

In order for the DSO to test hypothetical scenarios concerning the environmentally healthy and cost effective dismantling of a vessel prior to any practices implementation in his dismantling yard, he is encouraged to log into the Dismantling Web Site and run the scenarios in a friendly environment, using the Extend simulation software. The DSO comes across a table where he logs in the website. In this table he has the ability to change specific parameters regarding the technical and financial aspects in the dismantling yard. The Table is consisted of thirteen rows and twelve columns. Each row corresponds to a specific ship-breaking activity during a vessel breaking process.


Home ➜ Dismantling Site Owner

Dismantling Site Owner

TABLE: Simulation Activities

Add

A/A	Activity	Labors	Equipment	AW	SWR	AW1	SWR1	Cl	Ce	PDT	
1	Vessel Beaching	5	5	2000	40	1500	150	20	30	10	Edit
2	Vessel Inspection	5	4	2000	40	1500	150	20	30	10	Edit
3	Gas Freeing	5	4	2000	40	1500	150	20	30	10	Edit
4	Hazardous Removal	5	4	2000	40	1500	150	20	30	10	Edit
5	Oil & Fuels Removal	5	4	2000	40	1500	150	20	30	10	Edit
6	Furniture Removal	5	4	2000	40	1500	150	20	30	10	Edit
7	Equipment Removal	5	4	2000	40	1500	150	20	30	10	Edit
8	Items Removal	5	4	2000	40	1500	150	20	30	10	Edit
9	Section Cutting	5	4	2000	40	1500	150	20	30	10	Edit
10	Steel Plates Cutting	5	4	2000	40	1500	150	20	30	10	Edit
11	Iron Cutting	5	4	2000	40	1500	150	20	30	10	Edit
12	Waste Removal	5	4	2000	40	1500	150	20	30	10	Edit
13	Recycling	5	4	2000	40	1500	150	20	30	10	Edit
14	Custom	0	0	0	0	0	0	0	0	0	Edit

Figure 4.3: Activities Configuration

All input data are inserted in the model through the web interface, where the user can select activities and enter numerical values (see fig. 4.3). The simulation blocks which are parts of the model, marked in the red circle, draw data from appropriately structured files (which are filled in through the web interfaces. Data resulted from simulation runs are similarly transferred to the user's interface.

A generic dismantling process consisted of nine activities (namely, ship beaching, identifying hazardous materials, gas freeing, removing hazardous materials, initial item removal, emptying bulk, primary section cutting, waste removal, secondary section cutting) is modelled in Extend. These activities can be customized according to each yard breaking processes. An exemplary part of the model (initial item removal sub-activity) is shown in figure 4.4. The dismantling process has been designed to be as generic as possible, in order to include all possible dismantling activities a yard might perform.

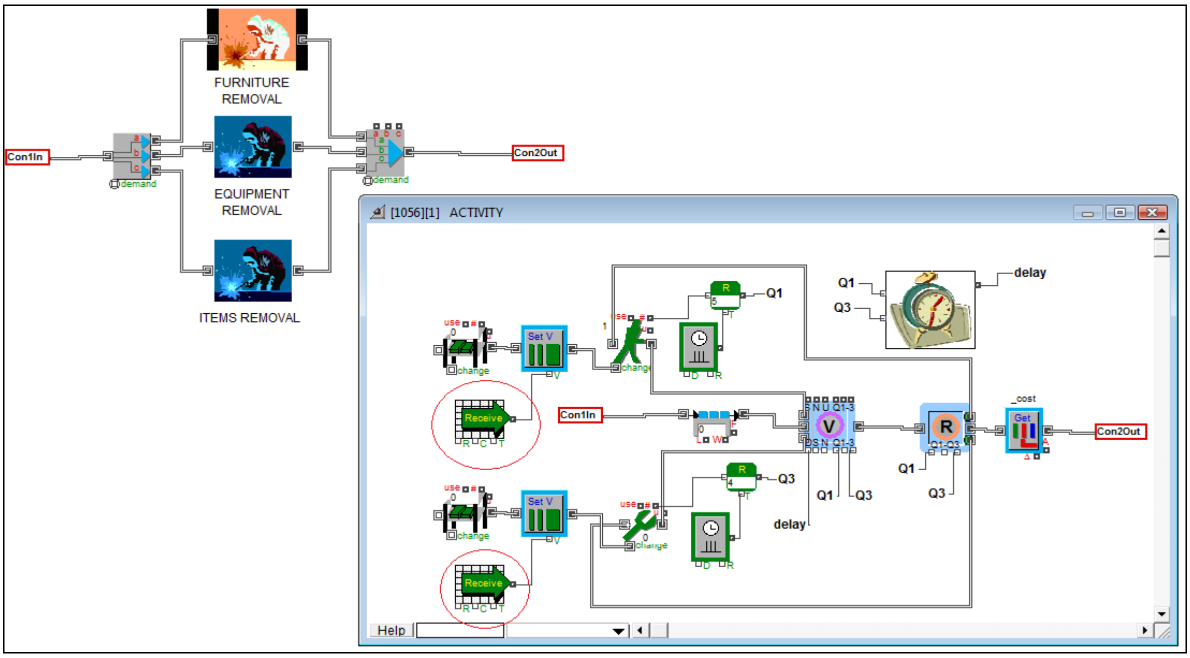


Figure 4.4: Model in Extend Software

Due to different dismantling activities among yards, the user has option to add an activity, name it and then fill the numerical fields, required to fill the simulation blocks. At the time the user has filled up the table with the activities he must notify the facilitator to run the model (due to operating system constraints at the time being he is not capable of running directly the model). In a future version of the software the simulation execution may be omitted.

The simulation model can, dynamically, calculate resources, time and cost for selected activities, sub-activities and whole processes. Further calculations on simple software (Excel) can evaluate more complicated metrics, able to give more detailed process analysis. Descriptive tables and charts can demonstrate graphically the performance of the metrics in interest, and give information necessary for the user's decision making. According to these results, the user can reconfigure the input values, run again the model and obtain new updated results. Changes on the sequence of the activities or indication of new activities, resources or other critical parameters can be accommodated in the model only through cooperation with the simulation facilitator.

The results of the simulation modeling are displayed in figure 4.5. The only result presented on this page is the process delay time. The cost for each activity and the overall process will be very soon available in the next version.

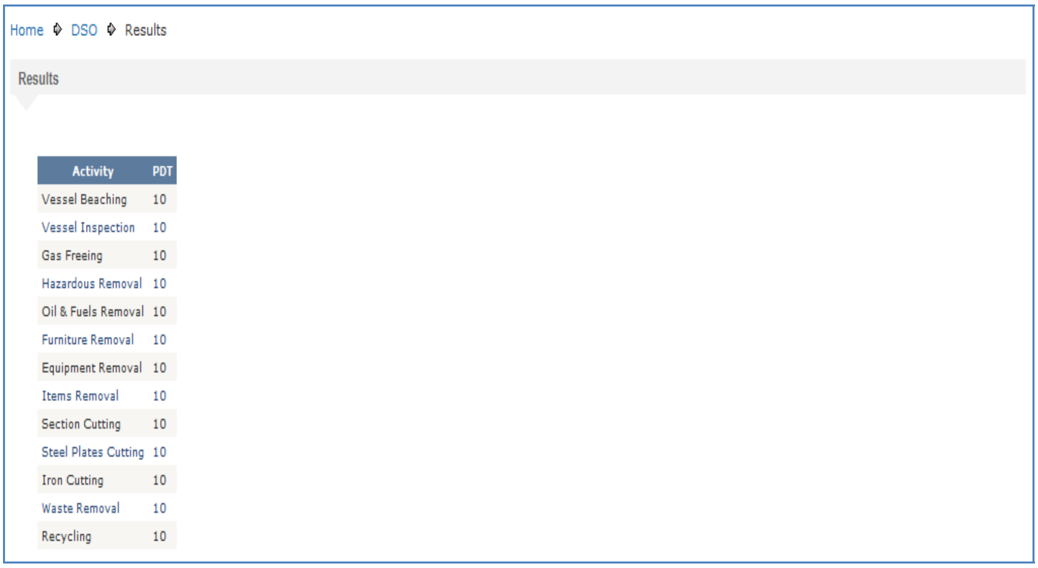


Figure 4.5: Dismantling site owner output page

4.7.4 THIRD PARTY DELEGATES

Third party (official) delegates (European Commission, IMO, ILO, etc.) are mainly interested in ensuring the occupational safety and the application of cost and energy effective methodologies in dismantling processes. Towards this direction, the desired outputs concern working conditions, materials treatment and safe disposal. Since their rights are rather limited, they can only have access to historical data and see records from previous vessel breakings.

Other than viewing data stored in the knowledge database, they can also make scenarios and input new parameters such as the materials and the components in a vessel and their characteristics. The user will only need to select from drop down lists where all instances are predefined. If a name of a material or component is not included in the list, the user has the option of clicking on custom command (shown as the last option in the related drop-down list) and entering any instance he wants.

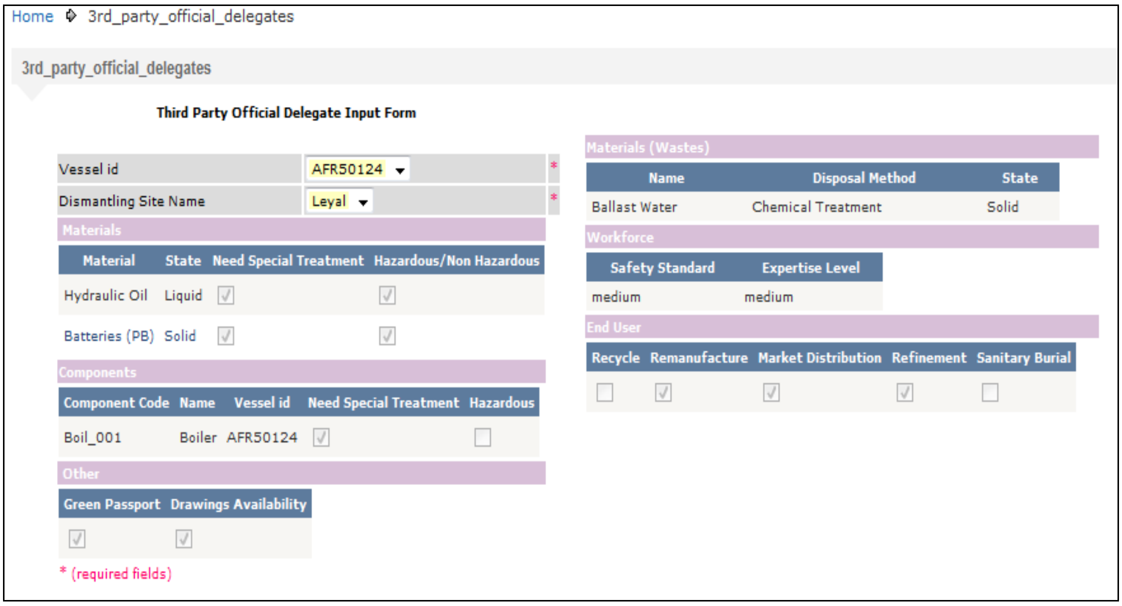


Figure 4.6: Third party official delegate output page

Data related with the dismantling yards and vessels, stored in the Knowledge Base, are compared along with new inputs that a user defines. An organisation (third-party) can now see whether a specific yard has experienced staff to undertake a dangerous or high skilled technology. In the same way, someone can know, in advance, if wastes in a yard can be safely treated and disposed. Although, general information, concerning a specific yard, is accessible by all users, certain information is protected from public view, for privacy reasons.

4.7.5 NON-GOVERNMENTAL ORGANIZATIONS

The last category of users has many similarities with the *third party official delegates*. These users are also restricted in viewing limited historical records and making hypothetical scenarios. Since they do not have access to private and detailed data, their inputs are usually generic and so are their outcomes.

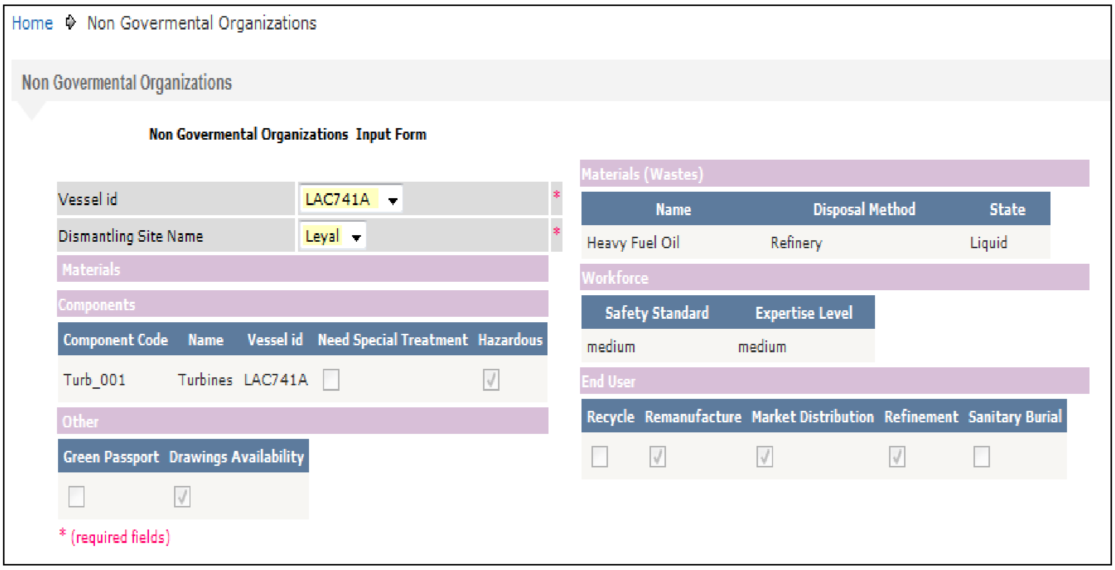


Figure 4.7: Non governmental output page

Despite their limited access in the system, they can still check on health and environmental safety and keep track of wastes disposal. The final destination of all wastes, materials and components can be traced in the treatment history box, provided that it has been previously filed by the liable yard user.

4.8 PROBLEM PROCESSING MODULE DESIGN

4.8.1 SYSTEM ARCHITECTURE

The server of the system is a reliable computer with fast processing capabilities. The core module of the DSS is a simulation model built in Extend simulating software, which is installed on the main server. The system utilizes discrete-event simulation models to produce generic guidelines and rules for scheduling the dismantling process of vessels with respect to environmental and occupational safety, health, cost and energy effective issues. The runtime development kit allows the model to run on the background, without user interference.

Components of the model are connected through ODBC (Open Database Connectivity) technology with the database. The DBMS (Database Management System) is built in Microsoft® Access, with all databases being linked with Microsoft® Excel tables, which in turn are exploited by the Extend simulation software. Microsoft IIS (Internet Information Server) is an additional web service installed on main server. Figure 4.8 demonstrates the interconnection among the web pages (IIS server), the databases and the simulation modelling module.

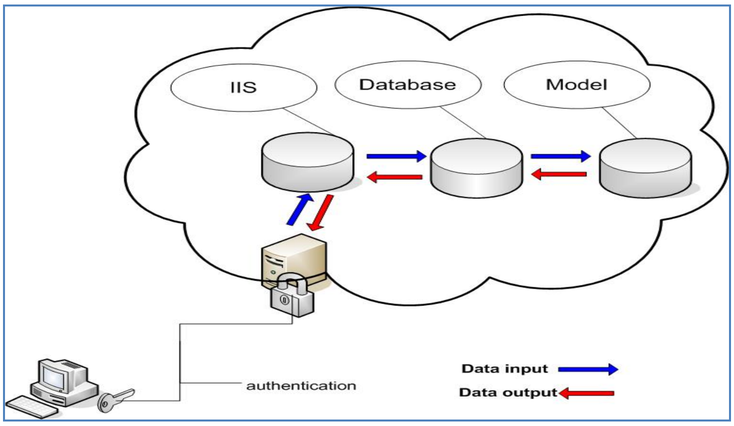


Figure 4.8: System Architecture

The system's interfaces have been designed by exploiting an open source Content Management System (CMS). Their content consists of html pages, dynamic asp pages, forms, icons and forums to support communication among users. Moreover, other features offered through them include document repositories, and support for information search. The underlying CMS is responsible for managing the system's users and complies with the Web 2.0 standards.

The link between the end user and the database is accomplished by means of an asp web page. Depending on a user's requests, some outputs can be the outcome of simple data processing (e.g. comparisons, matching, etc,) and some others will be the result of modelling simulations. In any case, all results are displayed in a way that aims to assist the end users obtain the appropriate information and make the right decisions.

Records can be easily withdrawn from a data repository, while new documents, guidelines and regulations can be uploaded or downloaded in the database through an appropriate link. A search tool helps users to navigate among existing documents (e.g. documents describing ship dismantling standards and regulations). Suggestions for choosing an appropriate dismantling yard can be instantly obtained, just by simply inserting a vessel code. Even in the case of more complex scenarios, where simulation is integrated, the user is only required to enter the necessary data. In most cases, a vessel code or the name of a yard will be enough to generate knowledge about the appropriateness of selecting a yard or the balanced planning of a dismantling process

4.8.2 KNOWLEDGE BASE DESIGN

A Knowledge Base will be accessible under a related link that is presented on the top left corner of the Documents Repository Interface. The role of Knowledge Base is to store data in the form of articles/documents related with occupational safety guidelines, environmental policy regulations, and cost related issues. Guidelines issued by international organizations such as IMO and ILO can be easily uploaded and stored.

KNOWLEDGE BASE	
ID	UNIQUE IDENTIFIER ASSIGNED TO THE KNOWLEDGE BASE TABLE
TITLE	THE TITLE OF THE ARTICLE/DOCUMENT
EDITOR AUTHORITY	THE AUTHORITY RESPONSIBLE FOR EDITING THE ARTICLE/DOCUMENT
TYPE	THE CATEGORY TYPE THAT CHARACTERIZES THE ARTICLE/DOCUMENT
DATE	THE DATE THE ARTICLE/DOCUMENT WAS UPLOADED
KEYWORDS	AN IDENTIFIER WORD/SYMBOL/NUMBER THAT CAN BE TRACED IN THE ARTICLE/DOCUMENT
CITATION	THE TITLES OF PREVIOUS USERS THAT HAVE CITED THIS ARTICLE/DOCUMENT

Table 4.1: Knowledge Base

An article/document can be easily traced in the search field. The options of searching by title, date, editor, etc. make the query more complex. Under the same notion, the findings can be displayed by categories, date, etc.

Other than searching directly in the system's database to retrieve a specific document, selected documents will be displayed in the announcement table. Whenever a new document that fulfils some certain criteria (i.e. importance, relativity to previous queries, applicability to many users etc.) is uploaded, users will be able to view it in the announcements and get informed in that way for new updates, alerts and messages.

4.8.3 DATABASES DESIGN

The following ER (Entity-Relationship) diagram has been designed to show the tables and fields of the main databases and the relationships among them. The proposed ER sketches two basic databases: i) the vessel database that contains information about ships (builder, dimensions, weight, propulsion system, components and their location, vessel type, materials, etc.) and ii) the dismantling site database that contains information about the processes carried out in dismantling (e.g. paint removal, cutting, pulling cables, etc.) including specific information for the specific yard (e.g. technologies, technical estimation, equipment, disposal methods etc.). It also includes information about the regulations and directives issued by national and international organizations, institutions and governments.

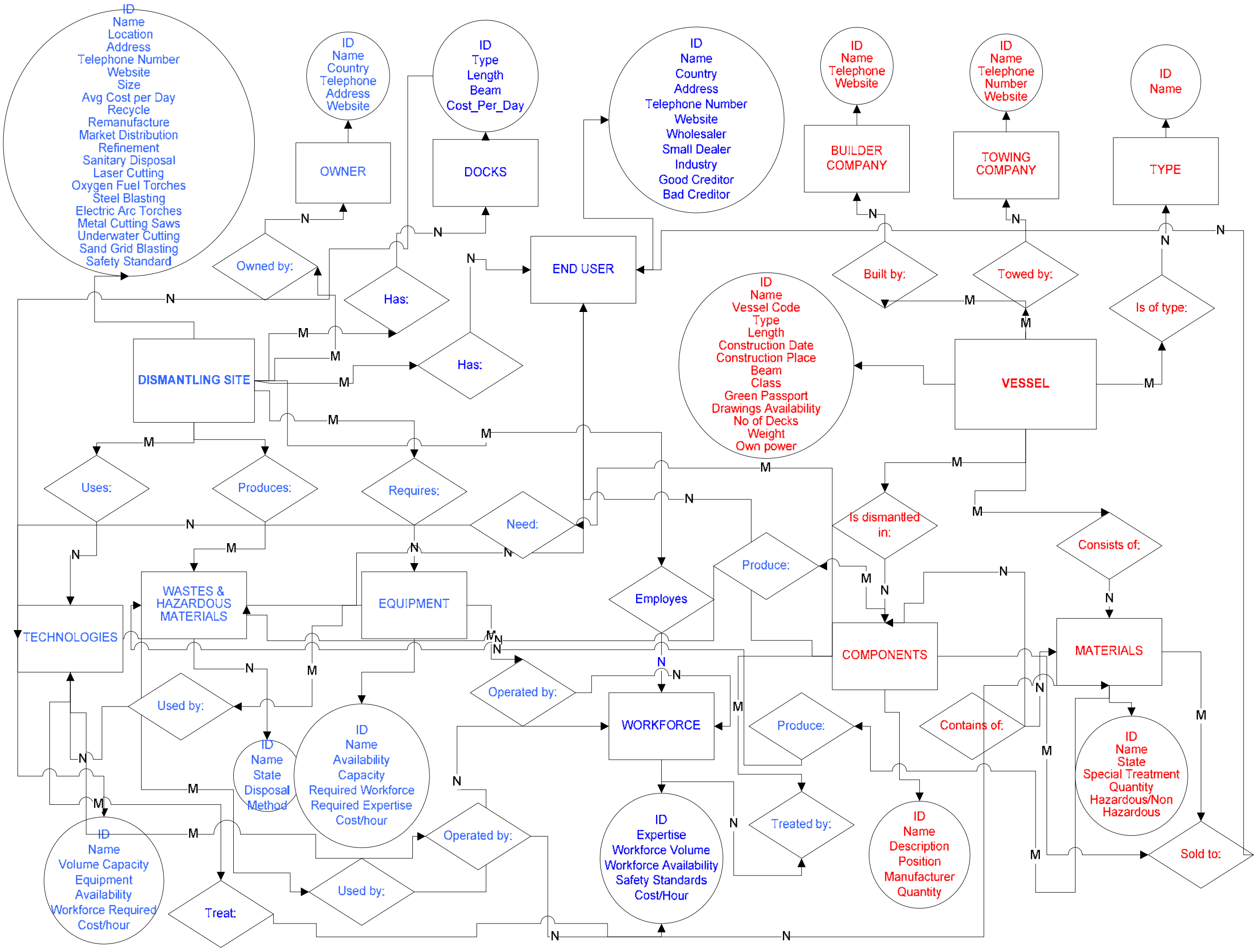


Figure 4.9: ER Diagram

4.9 SYSTEM IMPLEMENTATION

4.9.1 SYSTEM DESCRIPTION

The *ShipDismantl* Web site has been designed and implemented as part of the *Cost-Effective and Environmentally Sound Dismantling of Obsolete Vessels* project under the *SUSTDEV-2003-3.2.2.2.5* activity code. Decision Support System for Ship Breaking Processes (DSS-SBP) (for brevity reason ShipDismantl or just web site) has been transformed into a fully operational system through an appropriately selected development platform. The development of this system involves population of the system's knowledge and data bases, implementation of the interface and problem processing module, and appropriate integration of all the above. The population of the knowledge base is performed by taking into account the outcomes of WP4, as well as existing EU and international directives concerning environmental, waste treatment, and occupational hazards issues. The integration of the constituent modules, is evaluated by a series of testings against requirements.

The *ShipDismantl* platform consists of two distinctive parts:

- Public Web site accessible at: **http://www.shipdismanlt-project.org:8000/dss** with the main objective of dissemination of the information and activities related to obsolete vessels dismantling and recycling
- Collaborative Platform (password protected and members only), which is integrated and accessible via the web site.

The web site does not require any specific software requirements other than two basic prerequisites that a user needs to have:

- An internet connection. A connection above 512 Kbs, would be beneficial and productive and able to eliminate time lag.
- A modern web browser. Site has been tested with internet explorer 6.0 and above and Mozilla Firefox 1.7 and above.

4.9.2 SHIPDISMANTL USERS

Once a user is registered in the site, a distinct *User Menu* appears after the *log in* procedure. Regardless of the specific role of the user, i.e. Registered, Author, Editor, or Publisher, the same User Menu is presented on the screen. However, the available functions from the menu vary depending on the access permissions each user has been given. The users of the web site are separated into two broad categories:

- **Guests**
- **Registered Users**

All types of users have access to the following tools:

- Recovering a lost password. *ShipDismantl* site is based on CMS, like most systems today, and allows a user to automatically reset his password should a user forget it.

- Log In/Log Out. Once a user has been registered in the web site, he simply enters his username and password in the Login Form and click on the Login button to login to the ShipDismantl site. For security reasons, a registered user must logout right after he has completed his tasks.

- DSS Users. The users of the system are explained in detail in chapter 3. Depending on the log in details, the type of the user that entered the site (i.e. DSO) appears on the top right of the menu list. The type of the user determines the access rights of the user and the menu of the web page.

- Personal Details. To view the account details a user can click on the *Personal Details* menu link, which brings forward the desired information.

- Syndicate Tool. At the right bottom there is a module called *Syndicate*. This is RSS automatic service bringing news feeds from *ShipDismantl* web site directly to anyone's personal computer. At the bottom of the menu list and below the Syndicate, the ShipDismantle-Project page can be accessible through a web link. The user can view a screenshot of the web site and access it either by clicking on the image or the link itself.

4.9.2 ACCESSING FUNCTIONS FROM THE FRONT-END

Once a user is registered in the site, a distinct *User Menu* appears after the *log in* procedure. Regardless of the user's specific role, i.e. Registered, Author, Editor, or Publisher, the same User Menu is presented on the screen. However, the functions available from the menu vary depending on the access permissions each user has been given. There are simple guidelines provided in the manual, regarding the basic functions of the system. These are:

- Manage Content. In general, content management consists of the following three operations:
  - I. Submission of new content to the system (Content Item).
  - II. Proof reading and editing of that content if necessary.
  - III. Publication of the content.
- Submit News via the Fron-End. When an author clicks on the *Submit News* menu link, in the User Menu, the window *The News / Add Content* appears on the

screen. The top area contains input fields for the title of the new article and an appropriate Category for the Item. Toolbar Buttons: *Save, Apply,* and *Cancel* is available. Through *Images Tab,* images can be uploaded, from a user's hard disk directly to the web site. Once all News have been uploaded, any user (depending on access rights) can view all the *News* titles and select any file.

- Submit a Web Link. Web links are, simply, links to other web sites of interest and all *registered* users can submit those in the site interface. This function is accessed by clicking on the Submit Web Link menu item in the User Menu.
- Check-in my Items. When editing any of the windows, i.e. when an Author is creating a new content, he should always click on the *Cancel* or *Save* buttons to exit the page. The site locks the content when it is edited, preventing other users such as Editors and Publishers from accessing the content.

4.9.3 OTHER FEATURES

There are additional useful tools built in the system designed to promote communication, collaboration and knowledge acquisition. These are:

- Google Maps. **Google Maps** is a helpful component to assist vessel owners locate vessels and calculate the possible nearest places, and dismantling sites to the position of the vessel.
- Discussion Community. **Discussion Community** encourages and facilitates member discussion, opinion interchange, help requesting and so on. It is based on an open-source state of the art forum and has all common features that enable ease of use.
- Photo Gallery. **Photo Gallery** is a gallery system that can store: Images (photos), Video files, Audio files. A user can upload any kind of the above file types and share it among its partners
- Documents Repository. **Document Repository** is a knowledge based component that enables knowledge acquisition through a user friendly and simple menu. It integrates tightly with the ShipDismantl web site and promotes knowledge sharing.
- Search. Although a **search** tool exists in the data repository, a generic search tool is located on the top right corner of the main web page to let the user find any type

of file a user is interested in. The user can check any of the three options and enter a keyword, according to the data he has and the information he looks for.

- Contact. Any user, who simply wants to contact the administrator, can fill a form and notify the administrator.
- FAQ. *Frequently asked questions (FAQ)* include answers to questions a user could make. These clear and simple answers, are able to guide the user through his use in the web page.

4.10 DSS METRICS

As part of the literature on DSS evaluation models and methods, the following five approaches are extensively presented in the D.5.4:

- The IIR Evaluation Model
- Technology Acceptance Model (TAM)
- Heuristic Evaluation of UI
- Evaluation Research Method
- Multiple Criteria Method

The metrics proposed below concern the different types of users that the DSS system is expected to serve (but are not grouped according to user type). The objective is to check whether functional, interface and coordination requirements are fully satisfied. This is done in subsection 1. Subsection 2 contains metrics for the ship dismantling process itself (they can be used to estimate whether the DSS has made a difference in the production process itself).

4.10.1 THE PROPOSED METRICS FOR THE DSS

In developing metrics for the DSS, none of the five methods outlined above is strictly adopted. The five methods inform rather than prescribe the metrics listed below. Most of the measures by which a DSS can be judged concern intangible quantities. The metrics presented below are grouped into several categories. If an evaluation of the system is to be carried out, then the following list should be seen as a guide and not as a definite or final tool. It should be modified and extended to reflect the specific and unique objectives of each type of user.

Perceived Usefulness

1. Using the system in my job increases my productivity
2. Using the system enhances my effectiveness in my job
3. I find the system to be useful in my job
4. The system is able to keep track of operational changes sufficiently
5. The system is able to keep track of organizational changes sufficiently
6. The system is able to keep track of information changes sufficiently

Perceived Ease of Use

1. I find the system to be easy to use
2. I find it easy to retrieve data from the system
3. I find it easy to upload data to the system
4. I find it easy to use the simulation tools
5. I find the user interface intuitive to use

Job Relevance

1. In my job usage of the system is relevant
2. Was the DSS suitable for responding to the problem?
3. I use the system (every day/every week/every month)

Output Quality

1. The quality of the output I get from the system is low/medium/high
2. I find graphical output to contain the right amount of information for me
3. I think there are ways to improve the output of the system (please mention)
4. I think it would be better if the system allowed more customization (suggest)

Economic Effectiveness

1. What monetary value can you assign to the average annual production cost reduction due to DSS utilization in your firm?

2. What monetary value can you assign to the average increase in productivity due to DSS utilization in your firm?
3. What monetary value can you assign to the improvement in decision making due to DSS utilization in your firm?

4.10.2 METRICS FOR THE IMPROVEMENT OF THE DISMANTLING PROCESS

The dismantling process is in essence a manufacturing process and it is approached as such in proposing metrics of improvement. Measurement of such a process is in most cases done in accordance to the critical success factors of the organization. During ship scrapping, the activities of metal cutting and scrap metal management present environmental as well as worker health and safety concerns. There are many proposed frameworks for measuring the performance of a production process and the wider organizational performance (e.g. Balanced Scorecard Kaplan and Norton, 1992). In the case of the shipyard, most of the metrics proposed concern either physical quantities or are easily quantifiable. Tracing variation of each of these metrics after the adoption of the DSS may not be possible in every case due to the complexity of the operation and the absence of appropriate metrics prior to the adoption of the DSS system that could capture the effects of its use. In any case, we argue that the majority of these metrics could be applied in evaluating the extent to which the adoption of the DSS contributes to the overall dismantling process's performance improvement.

Performance

1. Cost of conformance to regulatory (EU) requirements
2. Cost of conformance to institutional requirements
3. Revenue per ship

Control

1. Number of vessels the yard has dismantled over total number of vessels the yard has bid for dismantling.
2. Number of breaches of safety, health, working guidelines as described by IMO (2004)

Effectiveness and Efficiency

1. Work completion rate (ships dismantled annually by vessel type and LWT)
2. Utilization of resources (human, manufacturing etc)

3. Resource availability (% of recourses available on demand)
4. Total man-hours per ship cut
5. Man hours per ton of recoverable material by type
6. Man hours per dollar value of recoverable materials excluding metal
7. % of total vessel mass reused, recycled or disposed.

Safety and Environment

1. Environmental impact of dismantling process per ship (this is a metric that should be disaggregated according to vessel type and environmental impact of various fluids contained in the vessels).
2. Mean time between accidents
3. Lost man hours per accident
4. Mean time between deaths
5. Worker exposure to air contaminants (metal fumes, particulates and smoke)
6. Lost man hours due to worker heavy exposure to contaminants
7. Number of breaches of international regulations concerning safe disposal of waste streams

CHAPTER 5: WP6 OVERVIEW

INTRODUCTION

This report is prepared in addition to the reports required to fulfil the SHIPDISMANTL consortium obligations to EC as per Project Proposal. This Technical Synopsis Report summarizes the work carried out in Work Package 6 of the SHIPDISMANTL project, as also presented in the required (as per project proposal) format in the deliverable reports for Work Package 6, namely D6.1 through D6.9. Each chapter of the present report makes a synopsis of the discussions, results, recommendations etc of the above deliverable reports, with the aim of providing the EC with a concise and manageable "summary" of the work carried by the SHIPDISMANTL consortium. For exactly this reason very few, if at all, any photos, sketches, graphs, tables etc are also presented here.

IMPLEMENTATION OF CONTAINMENT SYSTEM AND NEW EQUIPMENT FOR THE FULL DISMANTLING SITE (Deliverables D6.1/D6.2)

SUMMARY

This section describes the implementation of the improved infrastructure and technology equipment for the full dismantling site. Starting from the baseline scenario of WP2, the reports builds upon the work carried out in WP4 for the development of an scientifically rigorous framework for the evaluation of possible improvement options. Both the evaluation framework and the possible improvement options available for evaluation and implementation were developed in cooperation with a group of industry experts who provided the consortium with both objective and subjective inputs. The main improvement categories considered (from WP4) are docking (yard layout), cutting (primary and secondary zones), de-coating/paint removal and containment (land and sea, with the addition of air –for asbestos- from WP2 and WP3). The results analysis and the project scope led to the qualification of improvements for cutting and containment. Those improvements were successfully implemented at the LEYAL facility as a representative for the full dismantling yard, and are presented in this report.

LAYOUT AND CUTTING TECHNOLOGIES

The setup and operations of LEYAL's full dismantling site in Turkey, as presented in D2.1, was defined as the Baseline case on which the generic guidelines and further specific optimization of WP4 were based.

Turkey – and to that effect also LEYAL – employs the standard natural slipway docking method, were the ship is dismantled both afloat (initial stages) and on land (later stages) on a natural slipway and in the absence of tides (in contrast to for instance to the practices in the Indian sub-continent). This is defined as Zone A, with subsequent on land zone defined for further cutting, material separation, storage, waste management and other general support areas and structures. For the purpose of the problem definition in WP4, the Baseline was restricted to two zones: the docking zone where the main ship structure stands and where the initial ship dismantling takes place; and the cutting zone, where the further cutting and processing of ship's steel takes place. In this respect, operations, infrastructure, tools etc are analyzed separately for each of the two main identified zones.

No reception facilities are assumed under the Baseline scenario, as this is the case in most areas, where liquids emerging from the ship (mainly ship's fuels, lubes and other oils used during the operation and remaining at the time of dismantling) follow a rather questionable path to mostly 'free' disposal.

Actual ship dismantling is (under the presumed Baseline scenario) exclusively performed with torch cutting (oxygen –LPG hot cutting). Torch cutting is the prevailing cutting method for ships all around the world. Very little mechanical cutting is performed, mostly in relation to cable cutting.

The technology equipment investigated in WP2 (D2.1 and D2.3) involved alternate cutting methods and paint removal methods. As already described, the prevailing cutting method for ship dismantling world-wide is torch cutting. Main alternative cutting methods involved the use of water jet cutting and mobile mechanical shears. In relation to paint removal, currently there is virtually no such operation in place. However, it was identified in D2.1 that such an operation may have benefits and therefore abrasive blasting vs. hydroblasting vs. dry ice blasting vs. soda blasting was investigated within of D2.3.

GUIDELINES AND OPTIMIZATION

A systematic approach to planning of a generic ship dismantling facility is presented. The multi-dimensional and multi-objective nature of the problem is discussed for facility design at a detailed level. A hierarchic representation of layout objective criteria is developed. Layout modelling framework for layout variants also presented in the report. Based on the available docking, cutting and de-coating technologies, a template for development of technology-mix scenarios to be sued in the facility design and development is created. Finally, a "layout scorecard", a matrix form evaluation tool has been developed in order to guide the user to select most cost effective, environmentally friendly and safe technology mix for dismantling of the vessel.

Generic full ship dismantling yard layout development was split into two parts: layout variants and technology scenarios. The former deals with high level arrangement of yard zones, and in particular investigates the nature of the primary zone used for ship docking purposes, and the secondary zones where cutting and sorting of materials takes place

In relation to technology and equipment scenarios, the first step of development of the generic concept is to prepare a list of available technologies that can potentially be used during the analysis. For this purpose, a number of Best Available Environmental Technology (BAET) options that can be used for principal processes have been identified. In order to reduce the complexity of the model, the scope of the study is also limited to key zones within a facility.

Optimization aims to facilitate development of necessary infrastructure, redesign and re-organisation of the full ship dismantling yard by identifying the optimum mixture of technology alternatives by ranking currently available technologies in order to address complex set of decision criteria such as health and safety, environmental, financial and other internal and external factors. In order to reflect the complex, multi-criteria and multi-attributive nature of the ship dismantling problem, also expert opinions from a group of experts collected via survey forms which are based on the preceding generic principles and available information.

The framework for the evaluation of technology equipment alternatives is more complex and is based on various evaluation layers. The process flow for ranking and selection includes expert opinions, expert weights, application of cost/benefit factors, and aggregation of criteria weights based both on homogeneous and heterogeneous weightings.

For the case of LEYAL, a balanced to business model was assumed, leading to the following docking layout and technology equipments. Note that the scenario weights for each of the business models was aggregated again based on the collection of experts' opinion, hence the below ranking is not the ranking based on the views of LEYAL management, but rather the ranking for suitable LEYAL operations based on expert opinions:

- Docking alternative: Natural slipway
- Cutting primary zone: Torch cutting
- Cutting secondary zone: Mechanical shear
- De-coating/paint removal: Oxy-ice

Containment: Impermeable floor

UPGRADE IMPLEMENTATION

Based on the work carried out in WP4, infrastructural upgrades are categorized as Layout upgrades and Containment upgrades.

A number of containment alternatives were investigated, with impermeable floor topping the rankings in most scenarios. However, note that in the case of the containment category, options had a positive ranking in the ranking scale for almost all of the business scenarios, with containment options being complementary to each other. Therefore all were selected as appropriate to implement.

Among the various technology equipment investigated in WP2 and WP4, two were selected for the purpose of implementation during the full dismantling site optimization. It is noteworthy that no de-coating/paint removal technologies qualified for further real case applications. The primary reasons being their reduced mobility, high specialization for operation, and high cost.

The leading hazardous material existing on ships destined for dismantling that is endangering workers' health is asbestos. Asbestos is used a thermal insulation on most pre-1985 and if inhaled can lead to cancer. Asbestos fibres are microscopic and can be highly friable, leading to challenging control mechanisms. Hence, in addition to land emission control (impermeable floor etc) and sea water spill control (booms etc), we also consider and implement air emission control particularly for the case of asbestos.

TRAINING OF PERSONNEL

The aim of this activity was the preparation of training material for the key personnel at the full and the partial dismantling sites. The presentation was prepared in PowerPoint to assist the receivers of the training with visual/schematic oriented information, especially given the sometimes lower level of literacy usually encountered among the ship dismantling workforce.

The presentation on three aspects of the work, namely Health, Safety and Environment. The presentation outlines the various risks and hazards of the ship dismantling operations, also associated with occupational risks and hazards.

The presentation looks separately at the ship and at the yard, as there are different modes that need to be identified, explained and addressed. Risks are evaluated on technical, human and organizational level, with the identification of equipment, procedures, and locations where they may arise.

Specific risks are examined in greater detail in order to give the audience some basic understanding of how they should go about identified and evaluating other risks at the yard. Also hazardous material specific risks are outlined, with focus (as example to asbestos identification, removal and disposal).

More advanced tools for the analysis of risks are identified, which mainly speak to the yard managers and directors, as they require additional expertise and equipment to be employed (eg PIMEX method).

5.4 OPERATION OF DSS

This activity concerned the installation and real case operation of the DSS platform that has been developed in the context of the project. In previous tasks (WP5), the analysis, design and implementation of the Decision Support System for Ship Breaking Processes (DSS-SBP) had been fully described. The system's prototype and its components were initially presented in deliverable D5.2. This prototype has been transformed into a fully operational system through an appropriately selected development platform. The integration of the constituent modules has been evaluated by a series of testings against requirements. The final Decision Support System has been verified against existing data, modified accordingly and installed appropriately.

The overall platform consists of two parts:

- The public website, accessible at: **http://www.shipdismanlt-project.org:8000/dss**, having as main objective the dissemination of information and activities related to obsolete vessels dismantling and recycling
- The Collaborative Platform (password protected and members only), which is integrated and accessible via the abovementioned web site.

The system's prototype has been running since the beginning of the 2nd reporting period of the project, while the final version of the system was finalised and became fully operational at the beginning of the 4th reporting period. Since this is web-based software, no installation is required at the client side. Users only need to have:

- An internet connection (a connection above 512 Kbs is recommended)
- A contemporary web browser (the site has been tested with Internet Explorer 6.0 and above, and Mozilla Firefox 1.7 and above).

All operations are executed on the server's site, where a user is logged in. No additional installation is required even in the case of the simulation software, which is integrated in the system. Each user, depending on the type he/she belongs to is provided with a unique username and password and has access to certain functions (their access rights vary). Any user who wishes to use the system can contact the administrator and be assigned with a unique username and password.

5.5 SHE-MIS TRAINING PLATFORM APPLIED TO THE SUB-CONTINENT/INDIA

Partner IIT Bombay was committed on conducting the capacity building brainstorming workshops as part of SHE-MIS – training. In this subtask, efforts were being made to organize a skill-building and training workshop for all the stakeholders of the ship-breaking industry including owners of ship-recycling yards, Safety Managers and Supervisors, local TSDF operator, officials of State Maritime Boards as well as officials of State Pollution Control Boards.

Under the Green Alang Initiative started by IIT Bombay two workshops were organized to disseminate the works and findings of IIT Bombay related to laws, waste management, and health and safety.

First workshop was organized as brain storming session and stakeholders consultation meeting (Plate 1 and 2). Representatives from Gujarat Pollution Control Board, Gujarat Maritime Board, Ship Recycles, and Safety Managers and Supervisors from ship breaking industry attended this workshop. This brainstorming session was conducted in order to gather ideas towards making Alang as an ultimate green ship-recycling destination.

Second workshop was conducted on the topics related to maritime environmental laws related to ship recycling activity (Plate 3 and 4). This workshop was attended by 60 Safety Managers and Supervisors from various ship breaking yards and also representatives from different stakeholders. Participants were entrusted with various international and national laws and initiatives taken up by various governmental and non-governmental organizations including; IMO, ILO, Government of India, Supreme Court of India, Gujarat Maritime Board, Gujarat Pollution Control Board, Central Pollution Control Board, and Ship Recyclers Association.

The main purpose of conducting such as workshop was to enlighten the participants with the current regulatory framework governing ship-recycling activities. This will be helpful in reducing the accidents as well as minimization of pollution.

5.6 REAL CASE APPLICATION, ASSESSMENT FOR FULL DISMANTLING

5.6.1 INTRODUCTION

Development of DSS for ship breaking industry includes treatment and disposal of wastes. All these studies carried out at IIT Bombay are helpful to ship breakers while deciding the treatment and disposal of waste generated form ship breaking. As regards to the inputs borrowed from SHE-MIS related activities (as described in segment 1 in Figure 1), the important questions regarding the fraction of ships which can be deemed "wastes" through study of practices in India and Turkey of collection and interpretation of past data and present practices.

It is envisaged that the seven-odd-steps approach outlined in the schematic diagram Figure 1 of D6.7 can be broadly divided into three categories of inputs *namely*:

Segment I: The inputs from SHE-MIS (WP-5 as discussed in deliverable 5.5 in period three concluded by January, 2008 *i.e.* end of 36th month) and The inputs from SHE-MIS (WP-6 as discussed in deliverable 6.3.3 in period three concluded by January, 2009 *i.e.* end of 48th month). This segment of SHE-MIS related activities has helped us in articulating the first two steps of Figure 1.

Segment II: The inputs from segment I (from SHE-MIS related activities) have been utilized to get inputs for development of further steps in the direction of installation of DSS (Steps 3 through 6 in Figure1).

Segment III: This segment is primarily the suggestion for future work (as shown in step 7 related activities in Figure 1). the development and implementation of SHE-MIS as well as DSS is typically a very long drawn multi step process involving multiple stakeholders and multiple layers of research and technological development (RTD) and implementation in real-life situations. The work is in progress in the project under FP-7.

Experiments were carried out in IIT Bombay laboratories (as envisaged in step 5 of Figure 1) to develop the technologies for reducing the environmental pollution & damages as well as to minimized health risks posed by hazardous wastes generated from ship breaking industry if disposed in unlawful & unscientific manner. Experiments were also carried out for treatment and disposal of asbestos contaminated with PCBs and clean-up of soils contaminated with paint chips with special emphasis on removal of heavy metals from ship breaking yard sediments.

5.6.2 ASSESSMENT OF IMPROVEMENTS

For obtaining the real case results, actual decontamination and dismantling operations had to take place in accordance with the outputs obtained from the DSS. The DSS system was loaded with information about the recycling yard (LEYAL in this case), including the site improvements developed in WP4 and implemented in WP6, also in relation to equipment and infrastructure, such as containment.

For the purpose of the real case assessment of the DSS, the user LEYAL had the privileges assigned to the *Yard Owner* with access to providing date for the SD databases, defining processes and ordering the running of the DSS in Extent

Both the cost and resources results indicate an improvement after the simulated execution of the dismantling process for full dismantling sites. The results are represented in the internal statistics of the simulation software Extend, and the output page of the DSS.

The results of the simulated model showed reduced cost in total (Run 1: 5839 cost units vs. Run 2: 5506 cost units). This was achieved by increasing the resources (workforce) in certain steps which of course increased the cost in these steps, but the overall time was decreased, therefore also affecting the overall costs. The increase in workforce, resulted in the decrease in buffers (activities causing delays in the process) and the overall costs. The snapshots show the statistics, for the selected activity of section cutting.

In this case it is the Items Removal Activity that is depicted for its performance and the changes in utilisation and cost figures. The utilisation is considerably high prior to any tests, because the SD yard counts mostly on workforce and not equipment/automation. Further increase in workforce consequently increases the utilisation of both workforce and tools due to the decrease in time. Similarly the final model appears to have reduced costs because of the increase of workforce and tools that results in less days to complete. The sum of the cost before and after the simulation indicate the best performance.

5.6.3 ASSESSMENT OF DSS

Although there exist specific methodologies in relation to the evaluation of the application of DSSs, the unique nature of ship dismantling called for a purpose-designed approach with metrics specifically addressing the DSS in ship dismantling. The metrics upon which the DSS was evaluated where the usefulness in relation to doing the job at hand, the ease of use from the viewpoint of user, the relevance to the job at hand, the quality of the results, and the economic effectiveness of the application of the results to the real life situations

The DSS is *useful* but more attention should be placed on tracking operational changes. The DSS was also deemed *easy to use*, with some people indicating that the interface is not always intuitive. Not all users found the DSS to be *relevant* to the job usage, however the modularity of the DSS ensures futher expansion. The *quality of the results* is adequate from a technical perspective, however users indicated that the output should be improved in relation to the graphical representation and the volume of output data provided, specifically in relation to ability to customize the results' screens.

All users indicated the need for the system to run in an automatic fashion without the need for a moderator. More advanced users noted that certain statistics charts from Extent are not displayed on the DSS, hence keeping from the more advanced users statistical information which is however calculated by the system.

5.6.4 DECONTAMINATION OF POLLUTED SEDIMENTS

Ship breaking and its harmful consequences have increased rapidly in past few years, creating a big challenge to the environment. The haphazard way of breaking ships leaves disproportionately large environmental footprint behind. Mass environmental pollution, disposal of toxic materials in the sea or on nearby land are some of the incidents observed in ship breaking yard and in its vicinity.

Paint chip waste is one of the major hazardous waste generating from ship breaking industry, which contains various toxic compounds. Paints are found in every part of ship for anti-corrosion and anti-fouling purpose and are mostly made up of lead and other toxic heavy metals. Disposal of such paint wastes leads to contamination of water and land. The soil in and around the ship breaking yards are highly polluted with heavy metals. It is known that paint chips are the main polluting agents, which contaminate soil in and around the ship breaking yards.

Laboratory study conducted for decontamination of the polluted sediments from ship dismantling yard. Soil washing, a physico-chemical treatment method was employed to decontaminate soils contaminated with heavy metals. Screening protocol was developed to assess the effectiveness of various soil washing operating parameters such as soil to water ratio, type of extractants, and number of washing cycle. Soil washing exercise revealed that, 0.1M EDTA at S/L ratio of 1:5 w/v was a better alternative as compared to 0.01, 0.05, 0.2M concentration of EDTA and 1:2 and 1:10 w/v of S/L ratio for cleanup of soils from ship breaking sites.

5.6.5 STABILIZATION OF HAZARDOUS MATERIALS

Population growth, urbanization, and rising standard of living due to technological innovations have contributed to increase in the quantity as well as variety of solid and hazardous wastes generated. Presently, about 960 million metric tons of solid waste is being generated annually in India. In order to safeguard the environment, efforts are being made for recycling different wastes and utilize them as building materials. In this paper, an attempt has been made to identify the issues related to utilization of hazardous waste in building materials. Further, an attempt has been made to immobilize and recycle the hazardous wastes including paint chip wastes, asbestos and glass wool generated by the ship breaking industry adopting solidification/stabilization method. The results of these studies revealed that solidification/stabilization of low toxic and high volume hazardous wastes can be easily recycled and reused as building materials, which in turn reduces Green House Gas emissions as well as loss of top soil in agricultural land and river basins while manufacturing the conventional bricks and tiles.

5.6.6 FOOTPRINT OF STEEL RECYCLING DURING SHIP DISMANTLING

Iron and steel production consumes enormous quantities of energy, especially in developing countries where, outdated and inefficient technologies are still used. Carbon dioxide emission from steel production in India ranges between 5 to 15% of total emissions of the country. The carbon dioxide emissions will continue to grow as the development proceeds and demand for steel products such as construction materials, automobiles, and appliances increases.

Reduction of carbon footprint is achievable by increased use of recycled steel. Since 1990 steel recycling industry has made significant reductions in its carbon dioxide emissions. The industry can achieve further reduction in its own carbon dioxide emissions by adopting modern technologies. Through the use of its products and by products, the steel industry also helps other sectors to tackle the problem of rising greenhouse gas emissions and climate change.

India accounts for 47 % of the ships dismantled in the World. Around 3,600 empty discarded ships cumulatively weighing approximately 28 million tonnes have been broken in India since 1982. This sector generates large quantities of materials that are directly reused or recycled (around 95 % of the cumulative weight of vessels *i.e.* approximately 26 million tonnes) and helps in minimizing and eliminating potential waste from going into environment and also contributes in conservation of resources. Ship breaking industry contributes about 10 – 15 % of India's steel demand. An attempt has been made to compare the global warming potentials in manufacturing of steel from virgin iron as well as re-rolled steel *i.e.* recycled from ship breaking industry using Economic Input Output Life Cycle Assessment model.

5.7 RESULTS ANALYSIS

5.7.1 INTRODUCTION

The objective of this activity was the analysis of the results derived from both the improved ship breaking sites and DSS platform, as well as the incremental modification of IS tools using dynamic simulation and comparison against the results obtained.

D6.9, being the last deliverable of WP6, has considered many results from previous deliverables of WP6, such as the implementation of the containment system for the full dismantling site, the evaluation and assessment of real case results, the installation and operation of DSS and finally, the incremental modifications of the DSS platform. Similarly, input from the first four deliverables of WP5 (all related to the Decision Support System) have been used for the completion of the analysis of the dismantling sites and the DSS platform.

5.7.2 EVALUATION OF DISMANTLING SITES

Our approach has attempted to achieve an easier mapping of the business processes, while ensuring a rapid, reliable and low cost information supply and model the existing organizational processes with as much accuracy as possible.

process before and after the execution of the simulated model verifies the efficiency and importance of the simulation tool that is conveyed by the installed system. A thorough evaluation and assessment of the improved infrastructure takes place in the sequel, according to carefully defined measures (these are mentioned in detail in D5.4).

The values of the qualitative metrics that cannot be easily quantified are displayed on the system's interfaces, enabling users to trace variations of each of these metrics after the adoption of the DSS and proceed to a decision making. The evaluation of quantitative metrics makes the assessment even easier, since all results are clearly indicated in easy-to-read tables.

5.7.3 FULL SD

Prior to ship breaking process planning by the simulation integrated tool in the DSS platform, an analysis of the existing process planning took place, so as to obtain a reference. This process planning analysis was performed using the DSO input interface. All activities that constitute the process of the partial vessel dismantling were stated and the numerical values were completed (Fig. 2). These data were provided by LEYAL, the full dismantling site partner of the project. Following the procedure that has been extensively described in previous deliverables (D5.2 & D5.3), the input parameters were processed by the simulation facilitator and the results were presented back on the output interface.

A thorough analysis was achieved by means of statistics charts in the simulation software. Statistics tables of resources, time and cost were obtained for every single activity of the process. As expected, after completing a series of simulation runs, the factors (buffers, operations, resources, etc.) that are responsible for high costs were identified and altered.

After this brief description of the existing and the simulated dismantling process, it becomes clear that a user is facilitated with a tool that helps him/her identify critical parameters, adjust their values and increase the partial and total cost, resources consumption and utilization of resources or activities. The increased utilization of the activities and the reduction in cost, after the full dismantling process model reconfiguration, validates the DSS platform as an effective tool to improve the performance of the process of a full ship dismantling site, like LEYAL.

5.7.4 PARTIAL SD

The evaluation of the partial dismantling site is performed in a similar way. The data for the partial dismantling site are provided by NAFTOSOL. Using exactly the same input interface, the user indicates the activities involved and the requested values. In this case, where the activities are less, the model utilises only the completed activities and the rest blocks remain idle.

5.7.5 EVALUATION OF DSS

Most of the measures by which a DSS can be judged concern intangible quantities. Therefore, most of the metrics have been developed in a question format for users to respond to using a Likert scale. DSS metrics were distributed to the partners, as part of D5.4, to prepare an evaluation and assessment of the improved infrastructure

Consecutive trials of the DSS platform have raised various concerns that needed modifications. The web site has been tested over a Microsoft Windows operating system. It has not met any problems using other operating systems. Within the 4th reporting period, informal evaluations have led to several changes/updates. Some of these changes were the result of suggestions made by partners and some others the outcomes of several real case applications. Most of the changes concerned name descriptions and results presentation.

A necessary upgrade of the system that needs to occur soon is the automatic simulation execution of the model. The notification of the simulation facilitator is time consuming, and sometimes it might take up to some hours, if the facilitator is not online. The automatic simulation execution will allow users to have immediate and direct access to results. Finally, the statistics charts that are provided by the Extend software are not displayed on the DSS interfaces, in their original form (tables). In such a way, much useful information remains hidden from the users.

The analysis for both sites indicated that noteworthy improvements occurred when the dismantling process models were processed by the DSS. The average savings in cost were increased by 15%, and similar improvements appeared in the resources utilization and the time consumption. Trials with several real case applications have revealed various improvements on the system's features and functionalities.