SPACE@SEA

Business Case Transport&Logistics@Sea

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Contents

List of abbreviations

Automated Guided Vehicle	AGV
Capital Expenditure	CAPEX
Capital Recovery Factor	CRF
Discounted Cash Flow	DCF
European Commission	EC
European Union	EU
Financial Net Present Value	FNPV
kilowatt hour	kWh
Member State	MS
Net Present Value	NPV
Operation and Maintenance	O&M
Operational Expenditure	OPEX
Port of Antwerp	PoA
Rail Mounted Gantry	RMG
Return on Investment	ROI
Ship-to-Shore	STS
Transport&Logistics@Sea	T&L@Sea
Twenty-foot Equivalent Unit	TEU

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Executive Summary

The business case of the Transport&Logistics@Sea (T&L@Sea) hub is a detailed comparison between the modular floating (T&L@Sea) hub that is being developed in the Space@Sea project, and respective container terminals situated onshore. Taking into account that the Port of Antwerp (PoA) is already considering expansion further along the river Scheldt the T&L@Sea hub is examined as a potential alternative to normal onshore expansion or via land reclamation. The question to be answered was whether the T&L@Sea hub is able to fulfill the purposes of a container terminal, and under which circumstances it can be more beneficial than the 2 major alternative solutions, an onshore terminal and a terminal situated on reclaimed land. Additionally, 2 other locations are examined as potential deployment sites with different characteristics. A smaller T&L@Sea hub outside the Port of Genoa which has limited inland expansion opportunities and is situated at deeper water depths compared to the North Sea, and a much smaller scale disaster relief effort off the coast of Africa that is operated for 1 month rather than years, and does not require a lengthy installation process like the long-term alternatives.

The T&L business case is explored from the point of view of the 2 main stakeholders related to the development and operation of a port terminal – the relevant port authority and the terminal operator. The port authority is the one that is shouldering the investment costs for all civil works related to a terminal, while the terminal operator will procure the equipment, is responsible for the operational and maintenance costs, and usually leases the land (where applicable) from the port authority.

Based on the results, the T&L@Sea hub cannot achieve lower costs than either of the 2 alternatives, resulting in 1,8 to 4,1 times higher Financial Net Present Values (FNPVs) in all cases. The main reason is the high construction costs of the modules that comprise the platform, and the constraints of the modules requiring an equipment unit present on each module, leading to significant equipment acquisition and maintenance costs. However, if the module related costs and the on-platform handling of containers can be improved via smarter design (leading to a reduction in equipment required), the T&L@Sea hub can potentially become an attractive alternative for land reclamation onshore terminals.

Looking at the T&L@Sea hub as an independent project, it is clear from the results throughout this business case that efforts need to be focused on reducing the cost of modules, try to secure high EU contributions and/or low public and private loans, and a low discount rate for the duration of the project, since these factors have the most significant impact on the FNPVs in all cases.

The results from 2 smaller cases examined, a smaller scale T&L@Sea hub off the coast of Genoa and as a temporary disaster relief effort, still not favor the T&L@Sea hub as a direct competitor of onshore ports. However, in cases of deep water and extremely limited possibilities for expansion, such as the Genoa port, or for short lived specialized operations, a T&L@Sea hub might be the best available choice, as currently there are no feasible alternatives.

However, the T&L@Sea hub offers numerous non-monetary benefits (or non-direct monetary benefits), which may make it a viable option for certain cases, either as an extension of the Antwerp port or as a standalone project. Reduced vessel turnaround times, flexibility in size/operations, low environmental impact and opportunities for temporary deployment may be deciding factors for the realization of such a project.

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1   Introduction

1.1   Motivation

Global trade is increasing continuously in all dimensions like tonnage, number of containers, number and size of vessels and port size. With the projected shipping – and specifically container – traffic expected to increase, ports will potentially require expanding their infrastructure. However, the expansion of container handling capacity is a major issue for many sea ports because of limited land space and water depths restrictions in adjacent river mouths or channels. Innovative solutions are required to overcome these problems. Rotterdam has solved this problem for now by expanding into the North Sea via land reclamation, ultimately adding approximately 2000 hectares, with a 1000 hectares of space dedicated to innovative, sustainable, deep sea-related port industry [1].

This solution cannot always be applicable for all harbours, and has a significant impact on local ecology, as it is a permanent solution. For city ports which have limited space or deep sea waters to grow into such as Constanta, Barcelona or Gibraltar, expansion via land reclamation is not an option. For ports like Hamburg and Antwerp extending the port activities means expanding in the adjacent river mouth or river channels, which further complicates the navigation of large vessels through the narrow waterways and increases vessel turnaround times in already congested ports. Additionally, expanding via land reclamation or in adjacent river mouths and channels can lead to serious environmental impacts on the surrounding area.

1.2   Subject

The modular floating T&L@Sea hub that is being developed in the Space@Sea project constitutes one possible solution for this problem. A logistics hub offshore can be an attractive opportunity for growth of container terminal business, and can have a positive effect on the strategic position of the relative stakeholders, on the competitive marketing and imaging, operations and functions, as well as the products and services business areas. Figure 1 presents the suggested layout for the T&L@Sea floating hub.

In greater detail, an offshore container terminal can have immediate quantifiable benefits to a wide variety of stakeholders: Avoiding significant costs for land reclamation or existing land expansion, increasing the market share and the repeat business of the serviced port(s), increasing the throughput capacity as well as providing improved customer satisfaction. Its use can reduce the total vessel sailing and turnaround times, since the container ships will not have to navigate through narrow waterways to get to the terminal. This will be especially beneficial for the largest container vessels.

Another one of the main benefits of the floating solution is the low ecological impact. Where land reclamation or expansion projects and gravity based artificial islands heavily interfere with the environment, floating solutions, apart from the anchoring of the floating platform, have no permanent impact on the environment.

Additional benefits and opportunities of the floating terminal solution can include disaster relief for coastal areas, creation of a temporary (or not) port in locations that have a need for it, recognition as a technology, innovation and performance leader in the sector. Additionally, the uses of a floating platform are not necessarily limited to use as a port terminal, but also as an offshore energy production hub, aquafarming and potentially as a living location in the future.
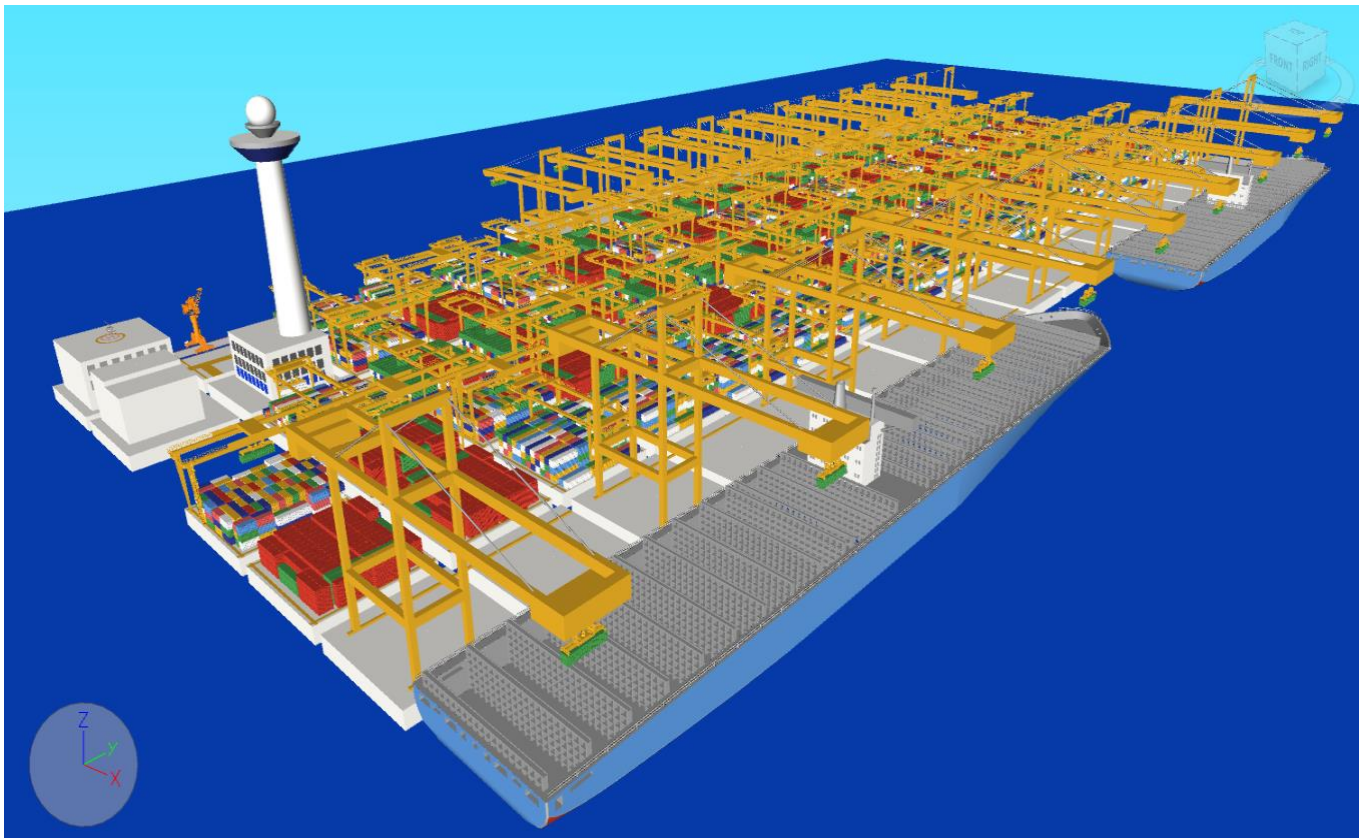
Figure 1: Floating T&L@Sea hub design concept [2]

1.3 Purpose

The objective of this document is to assess the business potential for various forms of transport and logistics solutions using an offshore transshipment hub. This includes the feeder and hinterland logistics as well as the possibility to use the hub as a base port for operation and maintenance (O&M) activities on renewable energies. The T&L@Sea hub is examined as a potential alternative to the Antwerp port expanding further along the river Scheldt, either via normal onshore expansion or via land reclamation (see Figure 2). The Port of Antwerp was selected as the most suitable candidate for such a research project after a consideration of several ports throughout Europe, due to a combination of cargo streams, added value to the location, logistical hotspots and navigation routes [3].The question to be answered is, whether the T&L@Sea hub is able to fulfill the purposes of a container terminal, and under which circumstances it can be more beneficial than the 2 major alternative solutions mentioned in section 1.1, an onshore terminal and a terminal situated on reclaimed land.

The results of this business case can be of use to a variety of stakeholders directly or indirectly related to the construction and operation of a container terminal. Internal, such as the port authority or shareholders; external – terminal operators, cargo owners, shipping and logistics companies, industrial companies; legislation and public policy – government or local municipalities/authorities; and community stakeholders – environmental agencies, community groups or the press.

Figure 2: Proposed location for the T&L@Sea hub [4]

2   Methods and assumptions

2.1   Scope

The business case for all the investigated cases (offshore, onshore and land-reclaimed terminal), takes into account the complete investments and operational and maintenance costs that are made for the establishment and the operation of each terminal for the selected time period. Projected gains/cash inflows are not taken into account, so the cost benefit analyses only take into account cash outflows, discounted cash flows (DCF) and net present value (NPV) is used. The analysis period of the case is set at 25 years, which is the reference period for investment projects as proposed by the Costs/Benefit Analysis Guide of the European Commission for the period 2014-2020 [5].

Investment costs in that sense comprise of civil works (floating module or quay construction, power substations, drainage etc.), equipment procurement and other terminal facilities (offices, gates etc.). Operational and maintenance costs consist of the electricity and fuel needed for the operation of the equipment and facilities of the terminal, the maintenance needs of the above, labor costs, as well as general periodical expenses (insurance, land lease, overhead etc.).

Financial data relating to the EU's contribution or public and private loans are taken either from the Costs/Benefit Analysis Guide of the European Commission for the period 2014-2020 or are assumptions made for the purposes of this task.

The T&L@Sea hub business case is explored from the point of view of the 2 main stakeholders related to the development and operation of a port terminal – the relevant port authority and the terminal operator. The port authority is the one that is shouldering the investment costs for all civil works related to a terminal, while the terminal operator will procure the equipment, is responsible for the operational and maintenance costs, and usually leases the land from the port authority.

2.2   Metrics and Decision Criteria

2.2.1   Financial Metrics

The financial metrics used in this business case are the following:

Cash outflow

Cash flow is the most basic metric or measurement in a business case. This means either cash flowing in the business or cash flowing out of the business. In this particular case, the cash inflows are unknown, so cannot be taken into account, leading to the use of cash outflows (costs incurred) as the only metric [6].

Net Present Value (NPV)

Discounted Cash Flow (DCF) is a cash flow summary which has been adjusted to reflect the time value of money. When the discounted values of a cash flow stream extending across time are added together, the total sum is called Net Present Value (NPV). NPV for a cash flow stream is the financial metric used in this business case. DCF methods produce the NPV.

DCF method is based on the idea that money you have now should be valued more than an identical amount you would receive in the future. This adjustment is made to account for *inflation* and *capital cost of opportunity*, i.e. the loss of the opportunity to invest the future money today. What future money is worth today is called its Present Value and what it will be worth when it finally arrives in future is called its Future Value [6]. What determines the amount of discounted value between the Future and the Present Value is the amount of time in between and an interest rate. DCF is then by calculated by:

$$DCF = \frac{(Future\ Value)}{(1 + Interest\ Rate)^N}$$

Interest Rate may be considered as the return rate we would expect from an investment and *N* is the number of periods (usually every period corresponds to a year) between the Present and the Future Value. When the above formula is applied to Net Cash Flows, Discounted Cash Flows are derived. The sum of Discounted Cash Flows represents the Financial Net Present Value metric and the formula is expressed as:

$$FNPV = \sum_{N=1}^{N=max} \frac{(Future\ Value)}{(1 + Interest\ Rate)^N}$$

As mentioned above, financial benefits and revenues are not considered for this business case, so the FNPV is a FNPV of costs/investments only, and will be noted from here on as $FNPV_C$. The $FNPV_C$ is calculated considering only the investment and operating costs as outflows; thus, the cost of financing is not included in the calculation of the performance of the investment $FNPV_C$. For this reason, another financial metric is used, the financial net present value of capital, $FNPV_K$. The objective of the $FNPV_K$ calculation is to examine the project performance from the perspective of the assisted public, and possibly private, entities in the Member States (MS) ('after the EU grant'). The $FNPV_K$ is calculated considering as outflows: the operating costs; the national (public and private) capital contributions to the project; the financial resources from loans at the time in which they are reimbursed; the related interest on loans [5]. In short, all sources of financing are considered, except for the EU contribution.

Due to no profits being taken into account in this business case, additional metrics such as Payback Period and Return on Investment (ROI) are not used in this approach.

2.2.2   Other Decision Criteria

Although direct monetary benefits/revenue are not taken into account in this approach, it is not always possible to assign a straightforward financial value to all benefits of a business case. Non-financial benefits are usually linked to business objectives which are difficult to be financially evaluated but can nevertheless produce highly desirable outcomes for a business.

Benefits such as the decrease in vessel turnaround times, the use of a floating platform as a multi-purpose platform, e.g. as on operations and maintenance hub for other offshore operations as well or for disaster relief purposes, and the environmental benefits cannot easily be given in an explicit financial metric.

Measures of timeliness is a major port key performance indicator, for which the vessel turnaround times are the major parameter. Ports often compete over lowering turnaround times, and this indicator is a major decision criterion for shipping companies when selecting the ports to visit. An investigation on the decrease in vessel turnaround times and a multi-purpose use of the platform has been performed and can be found in section 4.3.1 and 4.3.2 respectively.

2.3   Scenario Design

The proposed offshore container terminal off the coast of Antwerp (location A1) is compared with the 2 most common alternative cases of container terminals:

- An onshore terminal where the terminal is developed on existing land at the coast/river mouth (location A2) and
- An onshore terminal where the development takes place in land reclaimed from the ocean (location A3), much like the Maasvlakte 2 port expansion in Rotterdam

The 2 alternative scenarios are similar to each other in terms of infrastructure and equipment, with the major difference being the investment for the land reclamation. However, there are significant qualitative differences from the offshore approach, in almost every aspect – equipment and storage area needs, maintenance etc. As such, they can be considered as competitive scenarios.

The main chosen location for the T&L@Sea hub is challenging. The Port of Antwerp boasts the best logistical services among European seaports and is considered one of the main gateways to the European continent [3]. For international freight shipping, the Port of Antwerp is the second busiest port in Europe and the tenth busiest in the in the world. A floating platform situated in shallow waters, such as the chosen location, and with increased competition from nearby established ports and from the extensively developed facilities of the Port of Antwerp itself might be a major financial hindrance in the T&L@Sea hub's realization.

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For this reason, an investigation is performed to whether a T&L@Sea hub might tilt the results in its favour, by checking the boundaries of its efficiency. The chosen cases are:

- A comparison to the smaller Port of Genoa (location B), which was one of the original candidates mentioned in section 1.3 is performed, in order to examine whether a T&L platform might be more suitable for a smaller, deep sea port in the Mediterranean. More information and the results of this approach can be found in section 2.4 and section 4.1.1 respectively

- Similarly a micro-case for a temporary (one month duration) port setup along the coast of Africa (location C), aimed to provide disaster relief during a crisis. More information and the results of this approach can be found in section 2.4 and section 4.1.1 respectively

These 2 cases are not as detailed as the main business case, but can still provide a basis for assessment of other beneficial operation types of the T&L@Sea hub through the evaluation of 2 key performance indicators.
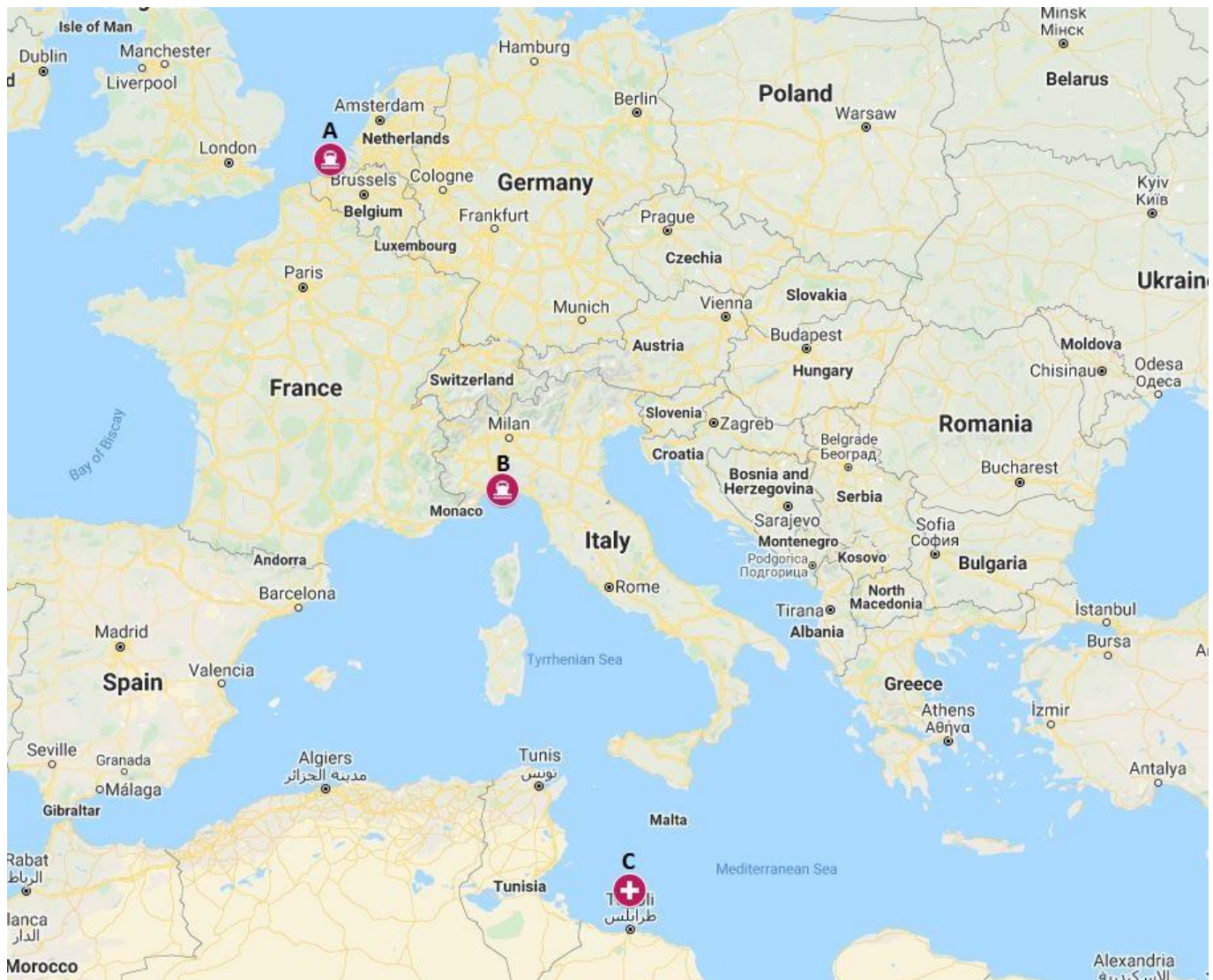

Figure 3: All examined locations for the T&L@Sea hub business case

2.4   Major Assumptions

The assumptions presented in this section apply to all 3 of the scenarios (offshore, onshore, land reclaimed) and all 3 locations equally.

2.4.1   General assumptions

As mentioned in section 2.1, the analysis period of the case is set at 25 years, which is the reference period for investment projects as proposed by the Costs/Benefit Analysis Guide of the European Commission for the period 2014-2020 [5].

The throughput of the 3 main terminals under consideration is the same, and is set at 4.690.000 TEU/year (2.931.250 container moves/year), as determined by scenario D during the development of Work Package 9 [7]. The throughput of the Genoa terminal is assumed to be 500.000 TEU/year, while the disaster relief case is assumed to handle 3.000 containers for the time span of one month.

All scenarios and cases considered assume that the terminals handle only 20 and 40 foot normal cargo containers, and no reefer or irregularly sized containers.

The term operational costs include the energy requirements of the infrastructure and equipment, as well as the fuel needs when Automated Guided Vehicles (AGVs) are used in the case of onshore terminals. The term maintenance costs include all the maintenance expenses necessary for the infrastructure and equipment. The labour costs are the annual salaries for the necessary personnel to operate the terminals, and the periodical expenses refer to costs such as insurance, land lease (where applicable), general overheads etc.

The operating hours between the offshore and onshore terminals differ. The offshore terminal is assumed to operate 6200 hours per year taking into account environmental conditions as presented in deliverable D9.3 [7], while the onshore terminals are assumed to operate more, namely 7040 hours per year, since they are more resistant to harsh environmental conditions.

The modules used for the main T&L@Sea hub case in Antwerp are 11m high since their frame can handle the necessary loads [8]. The modules considered for the Genoa and disaster relief comparison are assumed to be 6m high (thus cheaper) since lower loads are involved.

It is assumed that the modules, at the end of the 25 years that is initially considered as the lifetime of the port, have no residual value left and are fully decommissioned. Ideally however, an evaluation of the modules' status should be performed at the 20-year mark, just as with regular onshore infrastructure or vessel evaluation, in order to determine whether their lifetime could be extended beyond 25 years, or at least if the modules could have some residual value at the end of the project.

Table 1: General assumptions of the business case

Parameter	A1. T&L@Sea hub	A2. Onshore	A3. Reclaimed land	B. Genoa	C. Disaster relief
Analysis period [y]	25	25	25	25	1 [month]
Throughput [TEU/y]	4.690.000	4.690.000	4.690.000	500.000	3.000
Operating hours [h/y]	6200	7040	7040	6200	720 [h/month]
Module number [-]	100	-	-	14	5
Module height [m]	11	-	-	6	6

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Terminal size [m₂]	194.400	240.000	240.000	24.300	8.100
Ship-to-shore cranes Seaside	7	7	7	1	1
Ship-to-shore cranes Landside	11	-	-	2	-
Rail mounted gantry cranes	71	11	11	8	1
Automated guided vehicles	-	19	19	-	-

2.4.2 Financial assumptions

The main performance indicators used in this business case are the costs per container move. They are calculated on a yearly basis based on the respective periodical costs incurred – operational, maintenance, labor and other costs, as well as the investment costs spread over the lifetime of the project [9].

The yearly increase in labor, energy and maintenance costs is assumed to be fixed throughout the whole time period under consideration, and are equal to 1,94%, 0,08% and 0,5% increase per year for labor, electricity and fuel and maintenance costs respectively.

The value of 4% for the long-term opportunity cost of capital (discount rate), adopted by European Commission (EC) as benchmark is used [5].

The project is assumed to receive a 50% EU assistance on initial costs, with the rest of the investments costs split between public contribution, private equity and private loan (detailed breakdown in Table 9).

2.5 Data Sources

All cost data used in this business case have been procured via extensive literature review, personal interview/requests with related stakeholders, (annual) reports of port authorities and online sources. Individual sources for each case can be found in the detailed cost data Table 3 to Table 9 in section 3.2.

2.6 Data Structure

Since no monetary benefits/revenues are considered in this work, the full value (cost) approach instead of the incremental approach is used for all scenarios.

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3 Cost Analysis

3.1 Cost Model

The cost model is an organized list, grouping together *cost items* and groups them in *cost item categories*. More importantly, the cost model adds the dimension of time by analysing costs for all the life-cycles of the case which corresponds to the chosen analysis period. Cost items will constitute the lines of costs in the cash flow statement. The development of the cost model for the T&L@Sea hub business case followed the Resource-Based approach presented in Table 2, where the cost item categories are activities – investment, operational and maintenance costs.

In the vertical dimension, the cost item categories represent resources such as civil works, equipment costs etc. The horizontal dimension of the cost model represents the stage of the business case. The bullet items represent the cost items which will appear also in the cash flow statement.

Table 2: Resource-Based Cost Model for the T&L business case

Cost Model	Acquisition & Implementation Costs	Operational Costs	Growth Costs
Construction & civil works	Module construction Module foundation & mooring Module towing & installation Quay construction Yard construction Land reclamation	Maintenance expenses	Additional maintenance
Equipment	Quay cranes Rail mounted gantry cranes Automated Guide Vehicles	Maintenance expenses Electricity consumption Fuel consumption	Additional maintenance Increasing electricity costs Increasing fuel costs
Personnel	Offices Food & general storage Kitchen area Medical area Social areas	Maintenance expenses Labor expenses	Additional maintenance Increasing labor costs
Other infrastructure	Electric infrastructure Lighting towers Gate Pump stations Power substations Drainage system Security & paving	Maintenance expenses Electricity consumption	Additional maintenance Increasing electricity costs
Other costs		Land lease Insurance General overheads	Increasing periodical costs

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3.2 Cost and financial data

According the cost model in section 3.1, the detailed cost item categories can be found in Table 3 to Table 8 below.

Table 8 presents the financial data related to this business case.

Table 3: Civil works & other infrastructure costs for the onshore and reclaimed terminals [10,11]

Civil works & other infrastructure	CAPEX	Unit	Maintenance [% CAPEX/year]
Land reclamation	2.100	[€/m2]	2
Quay construction	55.000	[€/m]	0,2
Yard construction	115	[€/m2]	0,5
Gate	900.000	[€/unit]	2
Electric infrastructure	5.000.000		3
Lighting tower	30.000-100.000		3
Pump station	500.000		3
Power substation quay	270.000		3
Power substation yard	90.000		3
Power substation general	90.000		3
Sewer system	115.000	[€/ha]	2
Paving of terrain	30	[€/m2]	2
Security fence	50.000	[€/ha]	2
Decommissioning costs	8	[%] of CAPEX	-

Table 4: Floating module construction & installation costs and other infrastructure costs for the T&L terminal [8,10,11]

Floating modules	CAPEX	Unit	Maintenance [% CAPEX/year]
Module construction (11m)	5.487.000	[€/module]	4
Foundation & mooring	862.070		4
Towing & installation	125.000		4
Electric infrastructure	5.000.000	[€/unit]	4
Lighting tower	30.000		4
Pump station	500.000		4
Power substation quay	270.000		4
Power substation yard	90.000		4
Power substation general	90.000		4
Decommissioning costs	8	[%] of CAPEX	-

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Table 5: Container terminal equipment costs [11–16]

Equipment	CAPEX [€]	OPEX [kWh/move]	Maintenance [% CAPEX/year]
Large ship-to-shore (STS) crane, single spreader	9.000.000	8	3-5
Large ship-to-shore (STS) crane, double spreader	10.000.000	8,2	3-5
Rail mounted gantry (RMG) crane, single spreader	5.400.000	6	3-5
Rail mounted gantry (RMG) crane, double spreader	6.000.000	6,3	3-5
Automated guided vehicle (AGV)	600.000	3,34	4

Table 6: Personnel buildings costs [17,18]

Personnel buildings	CAPEX	Unit	Maintenance [% CAPEX/year]
Office areas	2.250 – 2.700	[€/m2]	2
Corridors/stairs	1.300 – 1.450		
Kitchen area	2.300 – 2.600		
Food storage	3.200 – 3.200		
Medical area	3.200		
Social areas	2.250 – 2.700		
General storage	1.100 – 1.450		

Table 7: Labor costs [19,20]

Labor type	Salary	Unit
Engineering & maintenance	46.000 – 54.000	[€/y]
Crew transport vessel (CTV) crew	31.000	
Office & administration staff	54.000 – 60.000	
Board & lodging staff	36.500	
Management	89.000	

Table 8: Other costs [10,11]

Other periodical expenses	Value	Unit
Land lease	10	[€/m$_2$/y]
Computer system	2.000.000	[€/y]
Insurance	0,8	[% of infrastructure CAPEX]
	1	[% of equipment CAPEX]
General overheads	1	[€/TEU]

Table 9: Financial data for all 3 scenarios [5]

Financial data	Value	Unit
Discount rate	4	[%]
Tax rate	0	[%]
EU assistance on initial costs	50	[%]
Public contribution	20	[%]
Private equity	15	[%]
Private loan	15	[%]
Equity capital costs	0	[%]
Loan interest rate	4	[%]
Loan duration	15	[y]
Payback start period	3rd	[y]

4   Business Case Results

In this chapter, the Cost Model developed in chapter 3, along with the Methods & Assumptions presented in chapter 2, set the base for deriving Cash Flow Projections, Financial Metrics and Non-Financial Results, as they are used to predict the costs for running each of the three alternatives. The results presented in this section will be used for drawing conclusions and making recommendations in chapter 6.

4.1   Predicted cash flows & cost comparison

As mentioned in section 2.2.1, in this business case, the cash inflows are unknown, so cannot be taken into account, leading to the use of cash outflows (costs incurred) as the only metric.

In Table 10 the investment costs for all the 3 examined scenarios are presented. The modular floating T&L@Sea hub has higher civil works costs than the other 2 scenarios, as the construction, foundation and mooring, and towing and installation of the modules exacts a higher initial price than an onshore or a reclaimed terminal [8]. The reclaimed terminal also requires significant investments in civil works for land reclamation. The equipment costs are disproportionately higher for the offshore terminal scenario. This is due to the hard constraints set for the stability of the modules, that require no rigid interconnections between them, which in turns leads to the need for the presence of equipment in each individual module (out of the 96 total modules) [7]. Moreover, the module and equipment require more frequent and detailed maintenance (4 and 5% respectively) than the infrastructure and equipment on an onshore terminal due to their exposure in more severe weather and environmental conditions throughout the year.

On the other hand, onshore terminals have a need for infrastructure like paving of terrains, sewer systems, gates etc. that the offshore terminal does not require. The scale of the costs in this category however is 10 times smaller than the 2 major cost categories which does not influence the overall results significantly.

Table 10: Investment cost comparison for all scenarios

Cost category	A1. T&L@Sea hub	A2. Onshore	A3. Reclaimed land
Civil works	647.407.000 (modules)	66.100.000	570.100.000
Equipment	513.400.000	140.800.000	140.800.000
Other infrastructure	19.288.500	27.013.500	29.648.500
Investment costs [€]	1.180.095.500	233.913.500	740.548.500
Contingency [%]	15	15	15
Total investment costs [€]	**1.357.109.825**	**269.000.525**	**851.630.775**

The cash outflows for all 3 cases and for 3 selected years are presented in Table 11; year 2, right after the original investments have been made, year 12 in the middle of the examined timeframe of 25 years, and year 24, right before the decommissioning costs occur at the last time period. As expected, based also on the results of the investment costs from Table 10, the maintenance costs for the significantly higher number of equipment used in the offshore terminal is the main component of the terminal's cash outflows, ranging from 52 -70,5% of the total yearly costs. Maintenance costs are similarly substantial for the land reclaimed terminal but due to the maintenance needed for the area that is reclaimed from the sea, rather than the equipment costs.

The periodical costs also claim a high percentage of the yearly costs among all terminals, ranging from 22% of the total costs for the offshore terminal to 50% for the onshore terminal. This is due to the contribution of insurance, land lease (for the 2 onshore terminals) and the general overhead costs.

The highest relative increase for all 3 scenarios is observed for the labor costs, with an almost 35% increase from year 2 to year 24, since the working assumption is that salaries increase by 1,94% per year in order to keep up with inflation. These costs might actually be even higher if we assume a higher inflation rate, thus a higher annual increase in salaries, promotions or other type of salary adjustments etc.

Table 11: Terminal cash outflows (all scenarios)

Cost category	Year 2	Year 12	Year 24
A1. T&L@Sea hub cash outflows			
Operational	2.491.992	2.512.000	2.536.221
Maintenance	52.061.950	54.724.405	58.099.686
Labor	2.929.902	3.550.581	4.471.312
Periodical cash outflows	16.365.621	17.202.561	18.263.577
Loan	0	13.571.098	0
Total cash outflow [€]	**73.849.465**	**91.560.645**	**83.370.797**
A2. Onshore terminal cash outflows			
Operational	2.235.199	2.253.145	2.274.870
Maintenance	5.237.576	5.272.585	5.316.968
Labor	3,408,600	4,130,688	5,201,851
Periodical cash outflows	10.931.787	11.490.840	12.199.570
Loan	0	2.690.005	0
Total cash outflow [€]	**21.813.162**	**25.837.263**	**24.993.259**
A3. Reclaimed land terminal cash outflows			
Operational	2.235.199	2.253.145	2.274.870
Maintenance	15.398.679	15.437.836	15.487.477
Labor	3.408.600	4.130.688	5.201.851
Periodical cash outflows	10.931.787	15.908.054	16.889.228
Loan	0	8.516.308	0
Total cash outflow [€]	**36.176.572**	**46.246.030**	**39.853.426**

Table 12 presents the total life cycle costs of the project, which is the sum of all recurring and one-time (non-recurring) costs over the full life span of the terminals. It includes initial investments, installation costs, operating costs, maintenance costs, and remaining (residual or salvage) value at the end of ownership or its useful life. In this business case, the assumption is that there is no residual value at the end of the lifetime of the terminals (25 years), so the only costs incurred at the final period are the decommissioning costs. All these costs are discounted to a present-day value. The T&L@Sea hub has life cycle costs 3,9 times higher than the onshore terminal and 1,9 times higher than the reclaimed land terminal, a result that was expected based on the outcomes of the investment cost and terminal cash outflows comparisons performed above.

Table 12: Costs over the total lifetime of the project (all scenarios)

Cost category	A1. T&L@Sea hub	A2. Onshore	A3. Reclaimed land
Initial investments	1.357.109.825	269.000.525	851.630.775
Operational costs	1.960.667.884	587.436.907	948.666.580
Decommissioning	40.725.976	21.520.042	21.762.462
Total life cycle costs [€]	**3.358.503.685**	**864.509.962**	**1.808.460.820**

The costs per container move of all 3 scenarios are presented in Table 13. As mentioned in section 2.4.2, costs per move is one of the most useful indicators for comparison of total port activities [9]. The capital costs are incorporated in the total costs/move value, by using a capital recovery factor (CRF), which represents the annual equivalent of the capital cost of equipment for the whole lifetime of the project. The CRF can be calculated via the following formula:

$$CRF = \frac{i * (1 + i)^n}{(1 + i)^n - 1}$$

where: i is the annual interest rate (in this business case 4%), and n the is the lifetime of the project, 25 years.

Costs per move for the offshore terminal is 1,9 - 4,2 times as expensive compared to the onshore and reclaimed one. The disproportionally high construction and maintenance costs for the modules and equipment of the offshore terminal as defined in the cost model in Table 2, have the greatest effect on the value of the indicator, as can be seen in the detailed breakdown in Table 13. Similarly, the civil works required for reclaiming land and its subsequent maintenance costs result in a 2,25 times higher €/move value between the reclaimed land and the conventional onshore terminal.

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Table 13: Costs per move (all scenarios)

	A1. T&L@Sea hub	A2. Onshore	A3. Reclaimed land
Capital			
Civil works/construction	14,14	1,44	12,45
Equipment	11,21	3,07	3,07
Other	0,42	0,59	0,65
Subtotal (incl. contingency)	29,64	5,87	18,6
Operational			
O&M	18,52	2,13	5,6
Labor	0,98	1,14	1,14
Other	5,53	3,76	3,76
Subtotal	25,03	7,03	10,5
€/move	**54,67**	**12,91**	**29,10**

In conventional onshore container terminals, the costs per container move usually variates between 35 -100 €/move [21–23], depending on literature source, size and location of the terminal, level of automation etc. The costs per move based on the results of the business case is approximately 36% lower than the lower end of that range. However, there are multiple reasons that contribute to this outcome:

- The range mentioned above takes into account all the infrastructure present in a conventional terminal, such as equipment and infrastructure for reefer containers, irregular sized containers (45 foot units), tank or half height containers etc. The reefer container handling costs are approximately double the ones of the standard containers [24], due to the need for specialized infrastructure for transport and storage, as well as associated operation and maintenance costs. The same is valid for all other types of containers outside the 20 and 40 foot standard units. This business case operates under the assumption that the terminals under consideration handle only standard size dry cargo containers, as mentioned in section 2.4, which avoids all these added costs.
- All the examined terminals are assumed to be fully automated, which significantly reduces labor costs. Labor costs have a major impact on costs per move, as they can constitute more than 50% of the operational costs of container terminals [23,25]. The importance of labor costs even under this assumption can be seen in this business case as well, throughout the results presented in this section.
- Additional costs such as inspection of cargo, seals and wiring, customs charges or damage from accidents [24,26], are not taken into account.
- Finally, one of the more important reasons for this difference in values is the approach used. Optimization instead of simulation approaches were used for the dimensioning of the terminals, the investments in infrastructure and equipment, the operation of the terminals and the personnel number necessary for the terminals' functions. Generally, simulation tries to measure the performance of the researched objective under different assumptions or parameters, but does not optimize the solutions it provides. Optimization, by its nature, tries to provide a single optimum solution for the problem being examined. Subsequently, parameters like the

efficiency of container transfer of the quay cranes and the rail mounted gantry cranes, breakdown of equipment, delays in operations or other stochastic events have little to no effect on the numerical results.

Taking into account all of the above, the resulting values for the €/move indicator are acceptable, even though in reality they would in all probability be higher. The most important observation to make here, is that the above assumptions were taken for all scenarios and purposes under examination in this business case. Thus, while the indicator values themselves might realistically be higher, the comparative results between the examined terminals are valid.

4.1.1   T&L@Sea hub use in deep sea ports and as a disaster relief hub

Table 14 presents the costs per container move of all 3 purposes under consideration; a main T&L@Sea hub for Antwerp, a small extension of the Genoa port in deeper waters and a short term relief effort off the coast of Africa. Costs per move between the Antwerp and Genoa cases are almost identical. As mentioned in section 2.4.1, it is assumed that in the Genoa and relief cases we use the smaller available modules (6m high vs 11m high in the Antwerp case) since the loads on the modules are lower, which corresponds to a €2.500.000 cost difference per module (€5.487.000 vs €2.993.050) [8]. Thus, while actually scaling down the terminal size and operations which normally would correlate to increased total and individual costs, the key indicator (€/move) are similar.

The disaster relief effort, as expected, has higher costs per move, since we need to mobilize modules, equipment and personnel at a significant cost for an urgent, short lived and small scale undertaking.

The results still not favor the T&L@Sea hub as a direct competitor of onshore ports, however in cases of deep water and extremely limited possibilities for expansion, such as the Genoa port, or for short lived specialized operations, might be the best available choice. Certain measures that can be taken to ensure that the financial performance increases, are discussed in detail in chapters 5 and 6.

Table 14: Costs per move (all purposes)

	A1. T&L@Sea hub	**B. Genoa**	**C. Disaster relief**
€/move	54,67	54,45	75,28

4.2   Financial net present value

As mentioned above, financial benefits and revenues are not considered for this business case, so the FNPV is a FNPV of costs/investments only, and will be noted from here on as FNPVc. The FNPVc is calculated considering only the investment and operating costs as outflows; thus, the cost of financing is not included in the calculation of the performance of the investment FNPVc. For this reason, another financial metric is used, the financial net present value of capital, FNPVk. The objective of the FNPVk calculation is to examine the project performance from the perspective of the assisted public, and possibly private, entities in the MS ('after the EU grant'). The FNPVk is calculated considering as outflows: the operating costs; the national (public and private) capital contributions to the project; the financial resources from loans at the time in which they are reimbursed; the related interest on loans [5]. In short, all sources of financing are taken into account, except for the EU contribution. The full FNPV results can be found in Table 27 to Table 29 in Annex 2.

4.2.1   Net present value of investment

As explained in section 2.2.1, the FNPVc of the investment is defined as the sum that results when the expected investment and operating costs of the project (discounted) are deducted from the discounted value of the expected revenues:

$$FNPV_C = \sum_{t=0}^{n} a_t S_t = \frac{S_0}{(1+i)^0} + \frac{S_1}{(1+i)^1} + \cdots + \frac{S_n}{(1+i)^n}$$

where: S_t is the balance of cash outflow at time t, a_t is the financial discount factor chosen for discounting at time t and i is the financial discount rate. Under normal circumstances, a positive FNPVc indicates that the projected earnings generated by a project or investment - in present monetary value - exceed the anticipated costs, also in present monetary value. It is assumed that an investment with a positive FNPVc will be profitable, and an investment with a negative FNPVc will result in a net loss. In this business case, since no revenues are taken into account, all FNPVc will be negative, and the scenario with the highest FNPVc among them will be the most financially sustainable. The initial investment costs are fully taken into account in the first period, $t = 0$.

Table 15 shows the FNPVc values for each scenario. The T&L@Sea hub's FNPVc is approximately 4,1 times higher than the onshore and 1,8 times higher than the reclaimed land terminal. This means that, from a purely financial point of view, the T&L@Sea hub is not an attractive alternative to current onshore terminals. Performing a full net present value analysis, where the projected revenues are taken into account as well might alter the results to an extent, but it is still highly unlikely that a modular, floating terminal will become a more financially attractive option. As mentioned in section 2.2.2 though, it is not always possible to assign a financial value to all benefits produced by the subject of a business case. Non-financial benefits linked to a terminal's business objectives which can produce highly desirable outcomes but are difficult to be financially evaluated will be presented in the next section.

The comparison of FNPVc between the onshore and the reclaimed land terminal favors the onshore terminal, since the initial costs for the reclaimed land terminal were much higher due to the substantial civil works required.

Table 15: Financial net present values of investment for all 3 scenarios in the Antwerp case

Scenario	FNPVc [€]
A1. T&L@Sea hub terminal	-2.569.941.961
A2. Onshore terminal	-629.095.349
A3. Reclaimed land terminal	-1.439.224.824

4.2.2   Net present value of capital

The cost of financing is not included in the calculation of the FNPVc. For this reason, another financial metric is used, the financial net present value of capital, FNPVk. The objective of the FNPVk calculation is to examine the project performance from the perspective of the assisted public, and possibly private, entities. The FNPVk is calculated considering as outflows: the operating costs; the national (public and private) capital contributions to the project; the financial resources from loans at the time in which they are reimbursed; the related interest on loans. In short, all sources of financing are taken into account, except for the EU contribution [5].

Based on the business case's assumptions and the financial data presented in sections 2.4.2 and 3.2 respectively, the FNPVk of all 3 scenarios can be calculated, and is presented in Table 16. The difference between the FNPVc and the FNPVk for all terminals is quite significant, ranging from 28 to 34% lower FNPVk, since the substantial investment costs are not taken into account for any case.

An interesting observation is that considering the financing of the project decreases the gap between the T&L@Sea hub and the onshore terminals, making it a more attractive option, although still not favourable. Even though the initial investment costs are not taken into account, the FNPVk of the offshore terminal is 3,6 times higher than the onshore and 1,8 times higher than the reclaimed land terminal. The maintenance costs of all the additional equipment, as well as the higher loan payback amounts (due to the initial loans based on higher initial investment costs) are still the main deciding factor in the final value of the FNPVk. As is mentioned in section 4.2.1, performing a full net present value analysis, where the projected revenues are taken into account as well might alter the results to an extent, but it is still unlikely that an offshore terminal will become a more financially attractive option from a FNPVk perspective as well.

Similar to the case for the FNPV$_C$, the reclaimed land terminal is not favorable against the onshore terminal from an FNPV$_K$ aspect as well, since the maintenance costs for the reclaimed area are much higher this approach.

A sensitivity analysis on different values of the financial data of the business case is performed in section 5.1.1.

As is noted the Costs/Benefit Analysis Guide of the European Commission for the period 2014-2020, for public infrastructure (although in this case an offshore terminal cannot be considered a purely public infrastructure), a negative FNPV$_K$ after EU assistance does not mean that the project is not desirable from the operator's or the public's perspective and should be cancelled. It just means that it does not provide an adequate financial return on national capital employed, based on the benchmark applied (i.e. 4 % in real terms). This is actually a quite common result, even for revenue generating projects receiving EU assistance. In such cases it is particularly important to ensure the financial sustainability of the project [5].

Table 16: Financial net present value of capital for all 3 scenarios in the Antwerp case

Scenario	FNPV$_K$ [€]
A1. T&L@Sea hub terminal	-1,687,820,575
A2. Onshore terminal	-454,245,008
A3. Reclaimed land terminal	-885.664.820

4.3   Opportunities and non-financial benefits

Besides the financial benefits (if those are realized), a floating offshore platform can offer several other types of benefits. One of the main ones is the low ecological impact of the platform. Where land reclamation or expansion projects and gravity based artificial islands heavily interfere with the environment, floating solutions, apart from potentially the anchoring, have no permanent impact on the environment.

Apart from the above, the floating terminal solution can offer qualitative benefits as well:

- Providing business flexibility with an easy to expand/resize/relocate platform for operations
- Disaster relief for coastal areas where the need for evacuation, care and operations cannot take place onshore
- Creation of a temporary port in locations that have a need for it
- Recognition as a technology, innovation and performance leader in the sector
- Use of a floating platform are not necessarily limited to a port terminal, but also as an offshore energy production hub, aquafarming and potentially as a living location in the future.

Figure 4 presents the business benefits of a generic container terminal, and the degree to which the 3 different concepts are fulfilling them. The three scenarios are presented on the left and the business benefits for the port authority and terminal operators on the right. A dashed line represents contribution of the concept to the business benefit, but only partially or under specific circumstances. Based on the results presented above, lower costs can only be achieved on onshore terminals. However, the offshore floating solution is unique in achieving business flexibility (unlimited expansion as needed, resizing etc.), low environmental impacts, temporary deployment opportunities and disaster relief operations. All the concepts can offer innovation in business, but the onshore terminals can only do that to a limited degree, mainly through automation of operations, while an offshore automated terminal can improve the image of the related stakeholders as technology and performance leaders, as well as provide strategic positioning and competitive marketing advantages. All three concepts can also provide a maintenance hub for any type of offshore operations, but a hub based on an offshore location where all the equipment, parts etc. are in storage makes the transport of maintenance personnel easier, faster and less costly. The working and living conditions for the personnel are better fulfilled by the onshore terminals from all aspects – exposure to harsh environmental conditions,

safety and expert help in case of emergency, commuting etc. Finally, a reclaimed land terminal can be a partial solution to reducing vessel traffic and lower vessel turnaround times, but the offshore T&L@Sea hub is preferable in that regard, since it allows vessels to avoid going through waterways or river mouths altogether. An examination of this benefit that the T&L@Sea hub can offer is performed in section 4.3.1.

Overall, the T&L@Sea hub shows the most connections to the benefits (seven) followed by the reclaimed land terminal (five) and the onshore terminal (four). However, the T&L@Sea concept fails to address one of the main business objectives, improving the financial performance of the concept. However, the importance of each unique individual benefit that it provides, may be an additional indicator for deciding towards this solution.
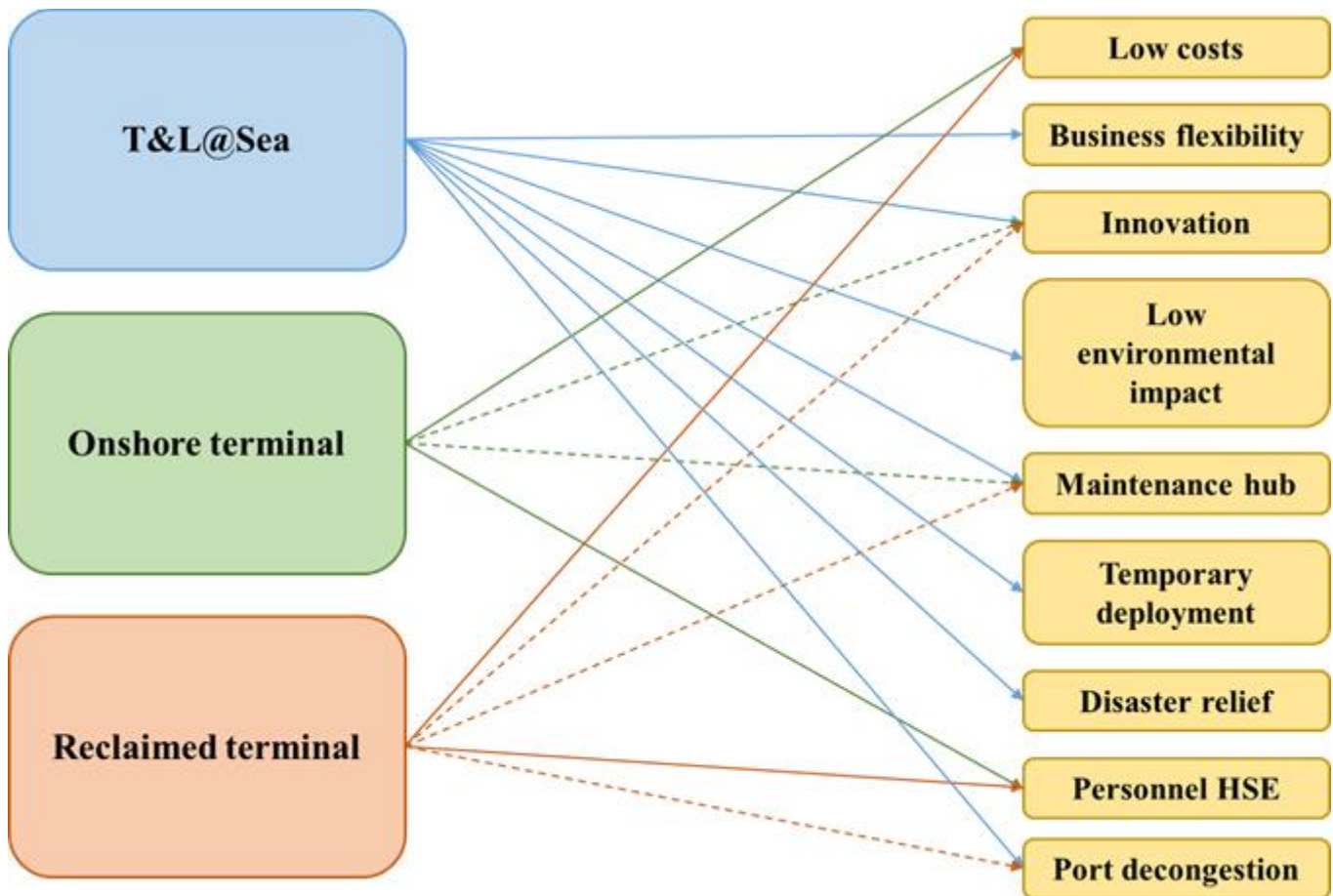

Figure 4: Contribution to business benefits by all 3 scenarios

4.3.1 Vessel turnaround times

Measures of timeliness is another major port key performance indicator, along with costs per TEU [9]. Port productivity measures are often best viewed by examining stevedoring performance, for which the vessel turnaround times are the major parameter. Ports often compete over lowering turnaround times, and this indicator is a major decision criterion for shipping companies when selecting the ports to visit [9]. In this section, an exploration in the effect of the T&L@Sea hub on the vessel turnaround times between the existing Port of Antwerp and the proposed offshore terminal situated in the mouth of river Scheldt is performed. Factors that are taken into account include: variations in sailing times, waiting for sea and river pilots, tugboats, mooring and (un)loading times between the two types of terminals. This investigation is performed from the point of view of a different stakeholder than the ones in the previous parts of this business case. Namely, the stakeholders most interested in this case are the shipping lines, since they are the ones with direct benefits and/or losses from decreasing/increasing the vessel turnaround times.

In order to compare the ship turnaround time between the two terminals, the vessel turnaround time when visiting the terminal in the Port of Antwerp, and when visiting the proposed T&L@Sea hub are calculated. Both cases have the same assumed starting point, located within 20 nautical miles of river mouth Scheldt [27] and 5 nautical miles away from the T&L@Sea hub (Figure 5).
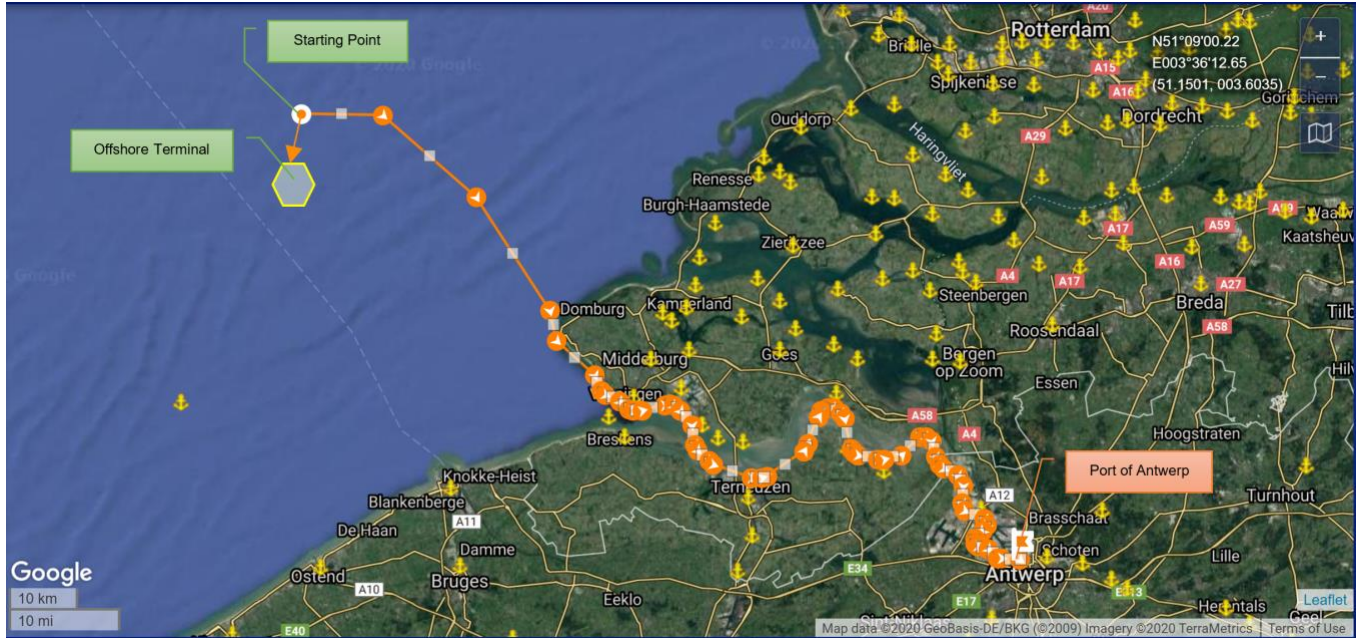

Figure 5: Vessel routes to T&L@Sea hub and the Port of Antwerp

Vessel turnaround time is defined as the total time spent by a vessel during a corresponding port call, which sums up all the waiting time, berthing time, service time, and sailing delay [28]. The corresponding data used in this time calculation is acquired from different available sources [29–31].

The type of vessel used for this example is an Ultra Large Container Vessel (ULCV) with particulars as shown in

Table 17. The T&L@Sea hub and the onshore terminals related data are shown in Table 18 and are the same that are used for all the calculation performed in this business case.

Table 17: ULCV particular data [30]

Parameter	Units	Value
Service speed	knots	14
Manoeuvring speed	knots	6
Load capacity	TEU	20,000

Table 18: Terminal specifications [7]

Parameter	Units	A1. T&L@Sea hub	A2. Onshore
Cargo un(loaded) [32]	TEU	7,000	7,000
No. of box moves	moves/h	30	30
No. of quay cranes	unit	7	7
Total capacity	TEU/h	100	108

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Sailing time is calculated by dividing the distance between starting point and pilot's gate of Port of Antwerp (60 nm away from the port), over the vessel's service speed. Pilot's gate is the designated area for pilots to board ships, before guiding the ships to enter the port. Manoeuvring times, waiting times for sea, river pilots, and tugboats all combined is approximately 6 hours [29]. Mooring operations time is estimated to be around 0.5 hours [31]. Cargo operations time is calculated by dividing the amount of cargo loaded and unloaded [32] with the quay crane total capacity per hour shown in Table 2.

Similar to the onshore terminal case, the sailing time to the offshore terminal is calculated by dividing the distance between starting point and pilot's gate of the offshore terminal (5 nm away from the terminal), over the ship service speed. Manoeuvring times is estimated to be 0.75 hours, where waiting times for sea pilots and tugboats is 0.5 hours each. Mooring operations time is estimated to be around 0.5 hours [31]. Cargo operations time is calculated by dividing the amount of cargo loaded and unloaded [32] with the quay crane total capacity per hour in Table 18. The assumption is that the ULCV takes over the whole berth, and all the cranes on that berth are dedicated to its (un)loading.

Moreover, we need to take into account that further transportation will be needed from the T&L@Sea hub to the Port of Antwerp, either to one of the onshore terminals there or for direct further inland transportation. This problem was addressed in Deliverable 9.4, and the results suggested 2 different barge looping strategies, which would add an extra 3-4 hours of travel time to the whole procedure [33].

Given the data and assumptions made above, the comparison of vessel turnaround times between Port of Antwerp and the T&L@Sea hub is shown in Table 19. It can be seen that the T&L@Sea hub can provide time-savings as much as 5.8 hours, or equal to 24% per port call. The calculation excludes the waiting time for berth space, where in most of the cases, this unexpected waiting time makes a port call less attractive. The analysis performed in the section is not an in depth analysis and other factors beyond waiting times may in the end influence the results, such as weather conditions, equipment malfunctions etc. Especially the (un)loading times that constitute the biggest part of cargo operations are assumed to be performed quite efficiently. If that time segment increases, the total turnaround time will increase accordingly and the relative time savings will decrease. For example, if we assume that only 3 of the 7 cranes are (un)loading the vessel, the total time savings will drop down to 16%, since the relative importance of the time saved during arriving and departing is diminished. It is however a reasonable approach that shows how the use of the T&L@Sea hub can influence the vessel turnaround times significantly, which in turn can be a major decision parameter for shipping lines when choosing which terminal to visit.

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Table 19: Comparison of vessel turnaround times

No	Description	Unit	A2. Onshore	A1. T&L@Sea
1	Arriving			
1.1	Sailing times to Pilot's Gate	h	1.4	0.4
1.2	Waiting for berth space			
1.3	Manoeuvring Times	h		0.75
1.4	Waiting for sea pilot	h		0.75
1.5	Waiting for river pilot	h	6.0	-
1.6	Waiting for tugboats	h		0.75
1.7	Mooring operations	h	0.5	0.5
	Subtotal	h	*7.9*	*3.15*
2	Cargo operation			
2.1	(Un)loading time	h	9.26	10.0
	Subtotal	h	*9.26*	*10.0*
3	Departing			
3.1	Unmooring	h	0.5	0.5
3.2	Waiting for sea pilot	h		0.75
3.3	Waiting for river pilot	h		-
3.4	Waiting for tugboats	h	6.0	0.75
3.5	Manoeuvring times	h		0.75
3.6	Sailing time to Pilot's gate	h	1.4	0.4
	Subtotal	h	*7.9*	*3.15*
4.	Transport between T&L@Sea hub and PoA	h		3
	Total turnaround time	**h**	**25.1**	**19.3**
	Time-savings	**h**		**5.8**
	Time-savings	**%**		**24**

4.3.2   Multi-use platform potential

Currently, the maintenance hubs for offshore platforms, irrespective of their function (aquafarming, wind energy, oil and gas) are situated in locations on the shore, as close as possible to the offshore platform locations. They still need to have access to port facilities, inland transportation etc. An efficient use of the offshore T&L@Sea hub would be its parallel utilization as an O&M hub for all nearby offshore locations. The T&L@Sea hub is already assumed to house on-platform storage areas for smaller, interchangeable parts that are used in the more frequent maintenance performed on quay and RMG cranes; electrical and steel cables, hatch covers, engine parts, bearings, lubricants etc. [20].

The idea of an offshore platform has been examined already, either as a standalone O&M hub for offshore platforms [34,35], or as potential multi-use platforms [36,37], showcasing the cost reduction potentials of such an approach.

The addition of several extra modules that can house maintenance equipment and parts for other offshore operations can be a valuable benefit for the T&L@Sea hub business case. O&M costs on, e.g. wind farms can reach up to 55% of the total periodical costs [38]. The onshore O&M hubs are also costly undertakings [39,40], and are generally used for their specific purpose only. Presuming that the T&L@Sea hub will materialize at some point in the future, utilizing it as an O&M hub will provide additional financial and non-financial benefits, in the form of needs for equipment and spare parts transport, storage etc. and will only require the transportation of personnel to and from the T&L@Sea hub. With detailed planning, O&M or other service type crews can even share transportation to the T&L@Sea hub, further increasing its efficiency.

5   Risk Analysis

After the costs have been financially estimated for the whole range of time segments and financial results have been presented, the next step is to produce a risk assessment for the business results derived. First, a sensitivity analysis will challenge the important assumptions made for the financial results presented in the cash outflow statement. Finally, financial and non-financial risks will be organized in a risk register and an initial management plan for those risks is determined.

5.1   Sensitivity analysis

The sensitivity analysis is a quantitative method to assess threats to the project. It "is used to determine the effect on the whole project of changing one of its risk variables" [41]. Usually it is presented in terms of the $FNPV_C$ or $FNPV_K$ of the project, depending on whether the variable under consideration is related to financing or not. A range is defined for each selected parameter to be varied. Then the influence on the outcome is calculated. This shows the robustness of investment alternatives to variability within the key assumptions. The results are usually presented in a table chart or a diagram.

In the following sections, a sensitivity analysis on 7 different parameters is presented.

5.1.1   Financial data

The effects of EU and public contributions and private loans, as well as the effects of the discount rate are presented in Figure 6 to Figure 8 below. The total contributions and loans are a major parameter affecting the $FNPV_K$ of all terminals. An increased EU contribution means less amounts need to be secured by public efforts and private loans, and in addition, the EU contributions are not taken into account when calculating the $FNPV_K$ of a project. A breakdown of funding that has the EU contributing up to 70%, the public contributing up to 10% and a private loan of only 5% of the investment can improve the $FNPV_K$ of the offshore terminal by 16,1%. The amounts of contributions and loans do not have any effect on the $FNPV_C$ of the terminals since financing is not taken into account at all in the calculations.
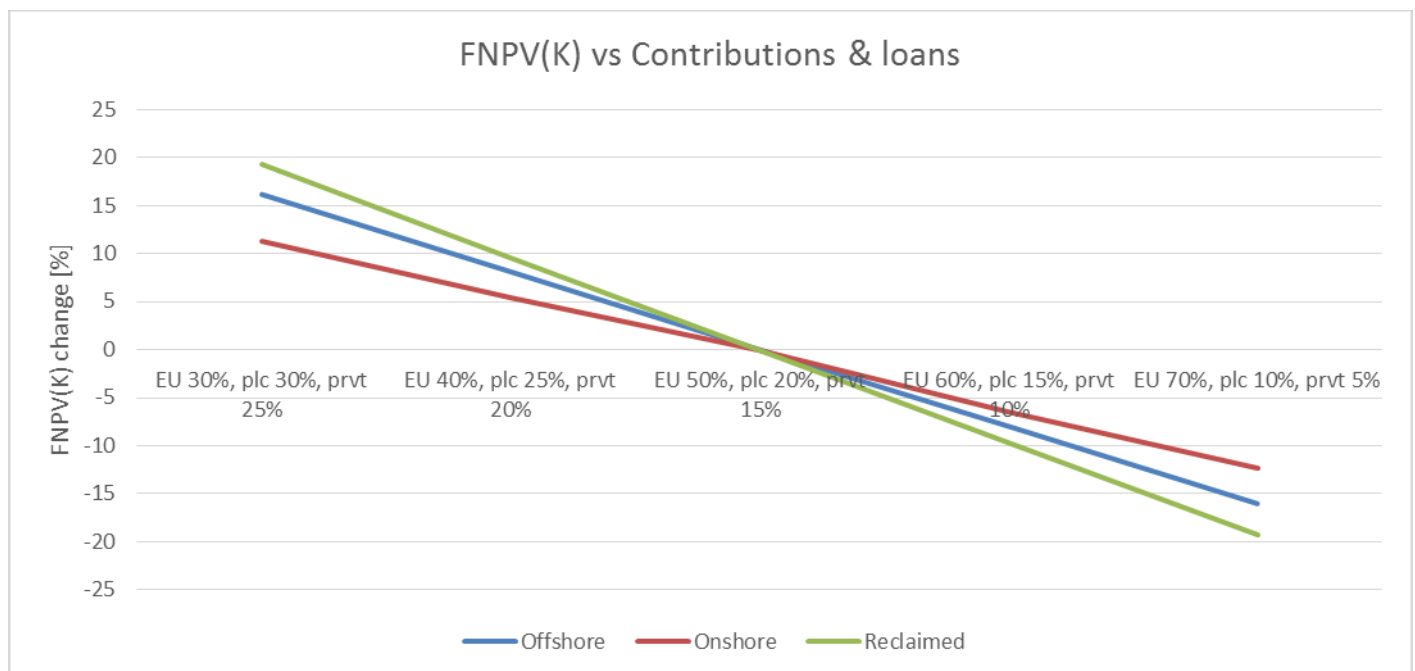

Figure 6: $FNPV_K$ change relative to EU and public contributions and private loans

The effect of discount rate on the FNPVs is even greater. Even a 2% increase in discount rates can improve the offshore terminal's $FNPV_C$ by 9% and $FNPV_K$ by 13,4%, while a 6% increase in the discount rate leads to improvements of 20,1% and 30,7% respectively. However, since the calculations of the FNPVs are the same for all 3 terminals, the relative impact on all of them is similar as well.
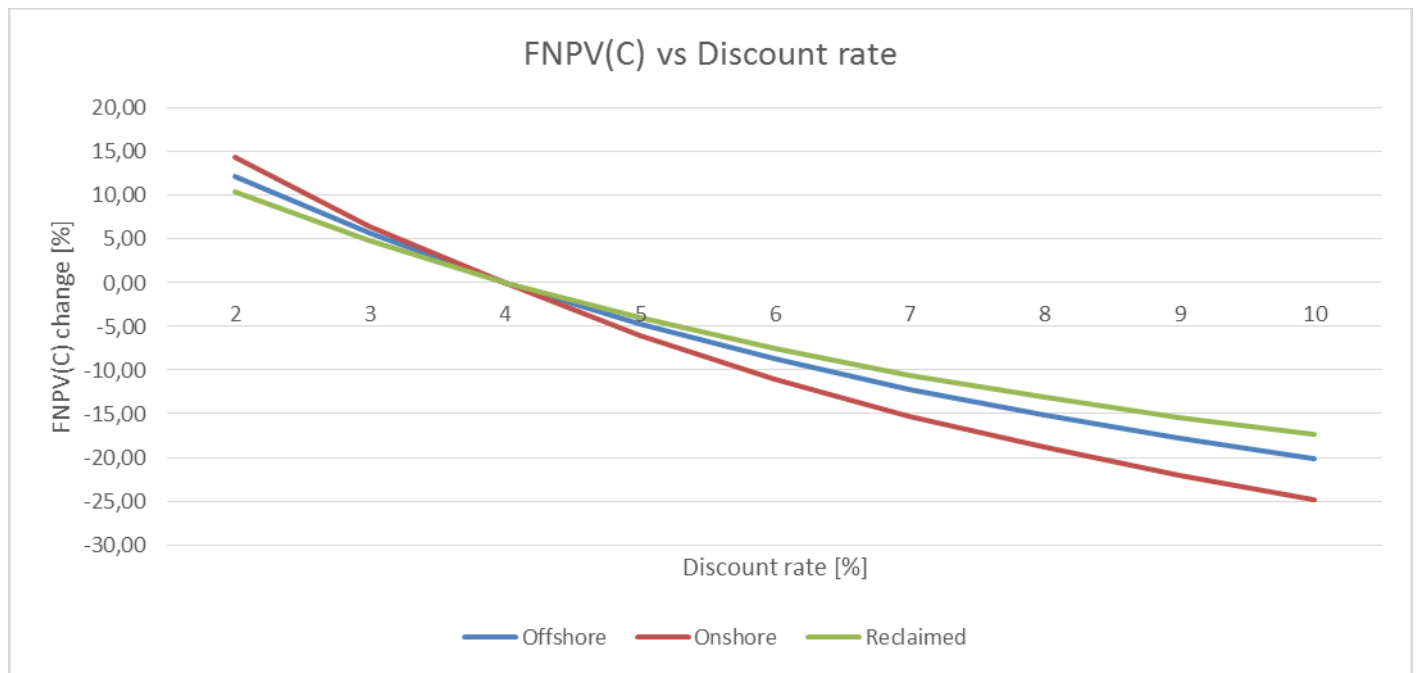
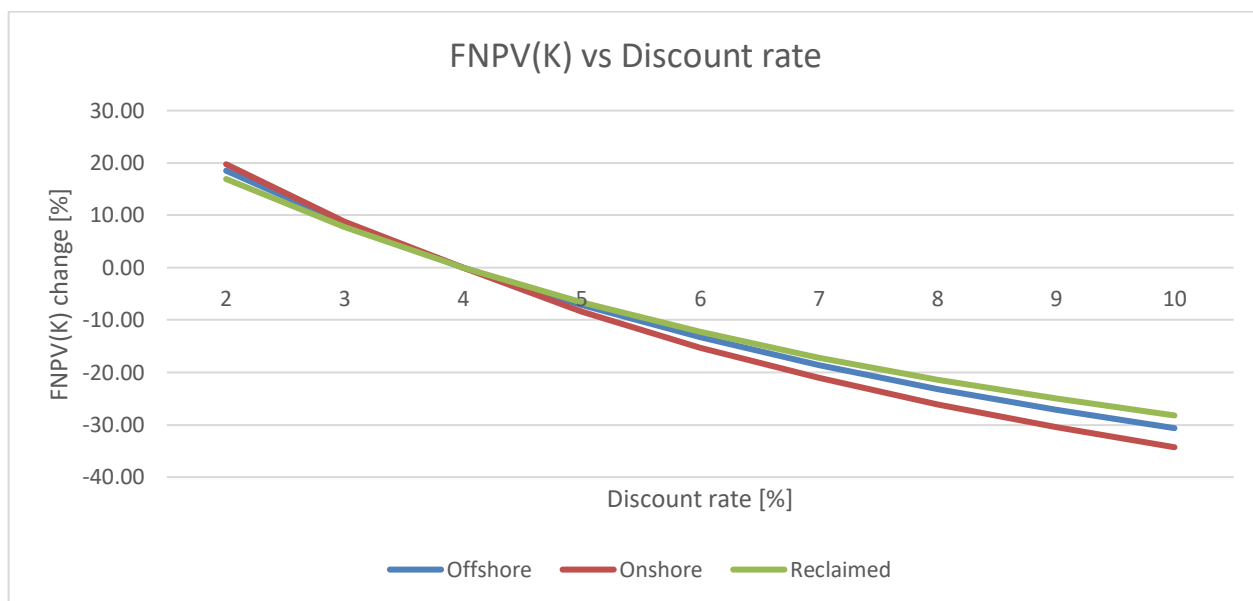**Figure 7:** FNPV$_C$ change relative to discount rate

Figure 8: FNPV$_K$ change relative to discount rate

5.1.2   Module construction costs

Module construction costs represent 46,5% of the total initial investment costs and their annual maintenance comprises of 30% of the total annual operating costs of the T&L@Sea hub. A reduction in construction costs can reduce their relative importance and achieve up to 8,5% reduction in the FNPV$_C$ and 8% reduction in the FNPV$_K$ of the T&L@Sea hub. The reduction in FNPV$_K$ is lower since FNPV$_K$ does not take into account the initial investment costs, but only the operational costs. A potential use of different type of modules (e.g. use of the 6m high modules for the (un)loading berths could further improve the results, although the decrease in FNPVs would be minimal, since

the majority of the modules used in the T&L@Sea hub are storage modules and need to be 11m high due to load considerations [8].
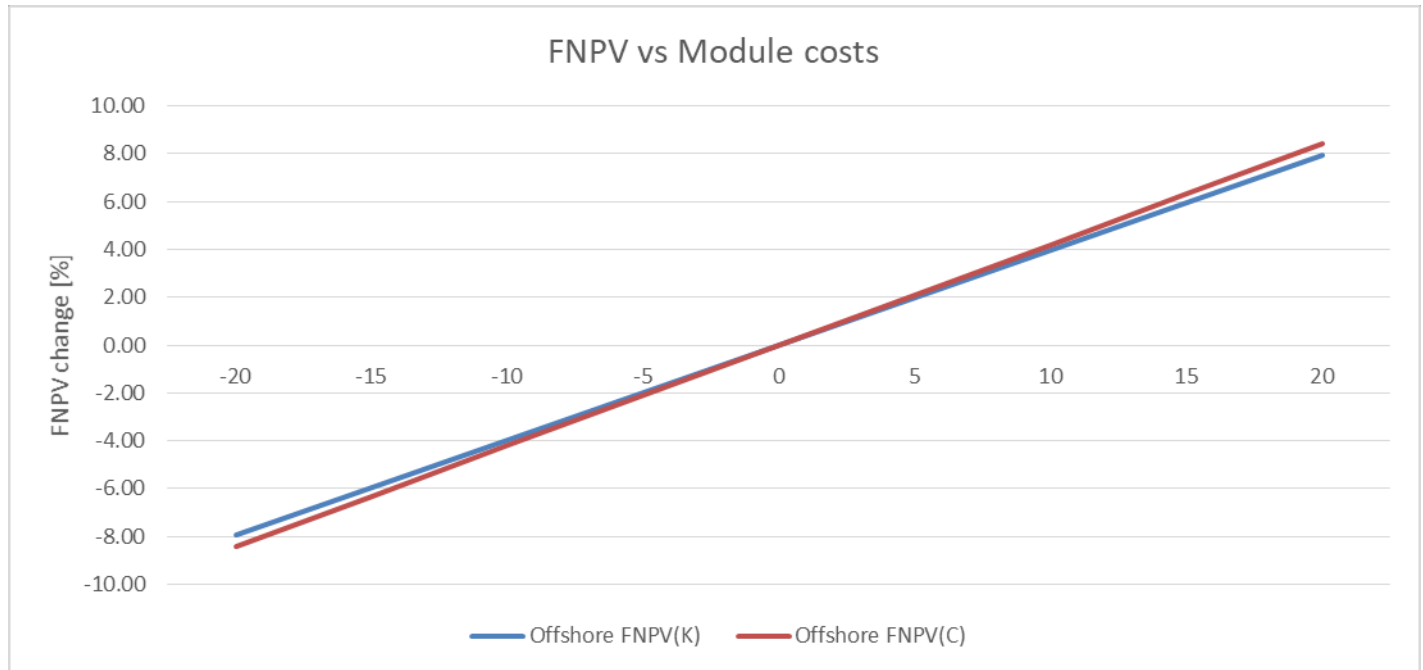

Figure 9: FNPV change relative to module construction costs

5.1.3   Operating hours

As mentioned in section 2.4.1, the operating hours between the T&L@Sea hub and onshore terminals differ. The T&L@Sea hub is assumed to operate 6200 hours per year taking into account environmental conditions as presented in deliverable D9.3 [7], while the onshore terminals are assumed to operate more, namely 7040 hours per year, since they are more resistant to harsh environmental conditions.

If the same operating hours for the T&L@Sea hub can be achieved, either through more favourable environmental conditions, or advanced control of the relative movements of vessels and platform [42], the FNPVs of the offshore terminal can be increased by approximately 8% (Figure 10).
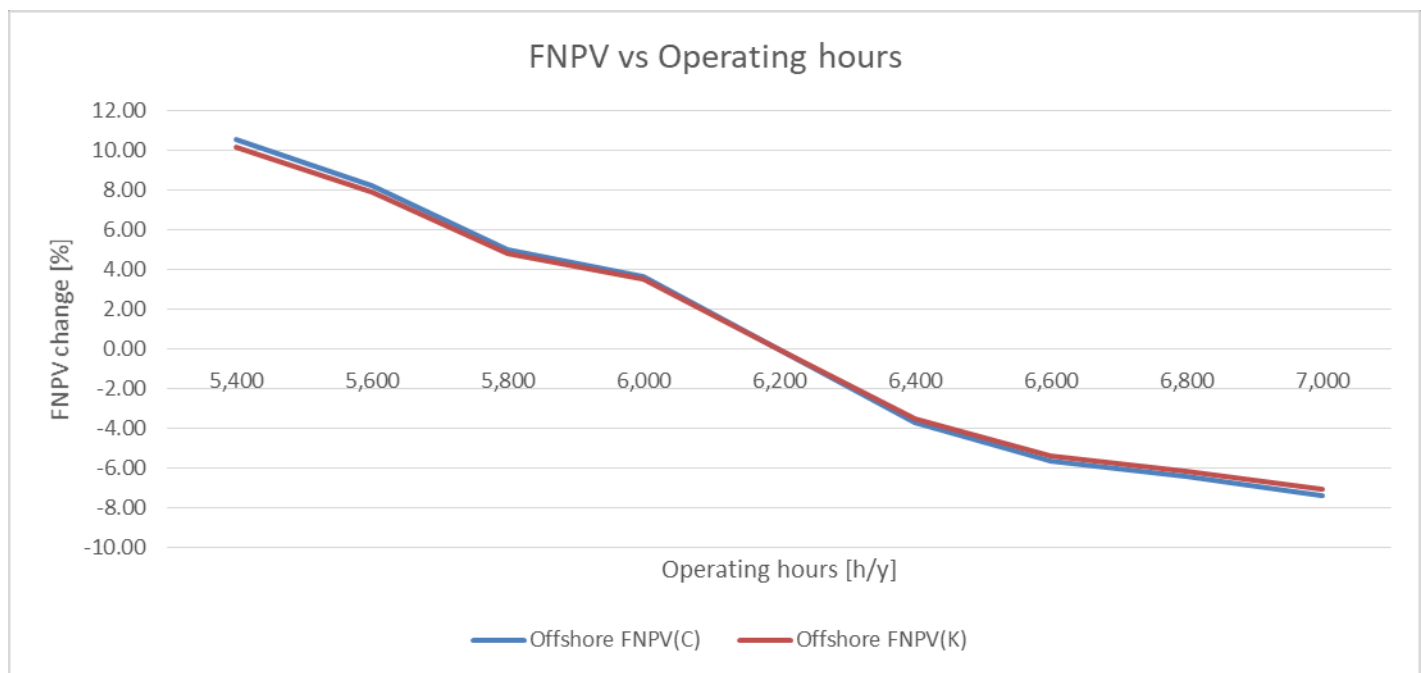
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Figure 10: FNPV change relative to operating hours

5.1.4   Labor and salary

The effects of the yearly labor costs increase are shown in Figure 11 and Figure 12. The effects on both FNPV$_C$ and FNPV$_K$ are relatively low, unless a significant yearly increase of more than 3% is in place. Even then, the effects are significant for the onshore and reclaimed land terminals only, as labor costs constitute a large part of their operational expenses, while in the T&L@Sea hub their relative importance is far lower, with maintenance and periodical costs having a more significant effect.
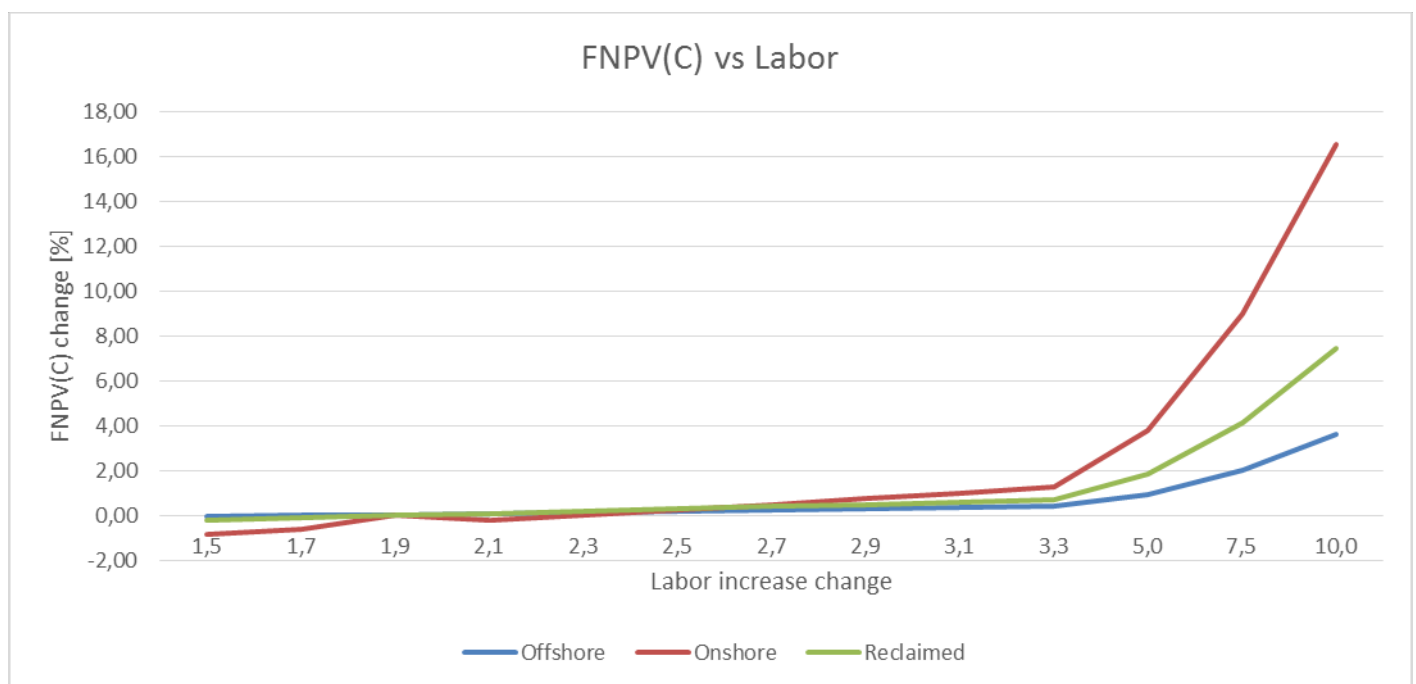
Figure 11: FNPV$_C$ change relative to yearly labor increase
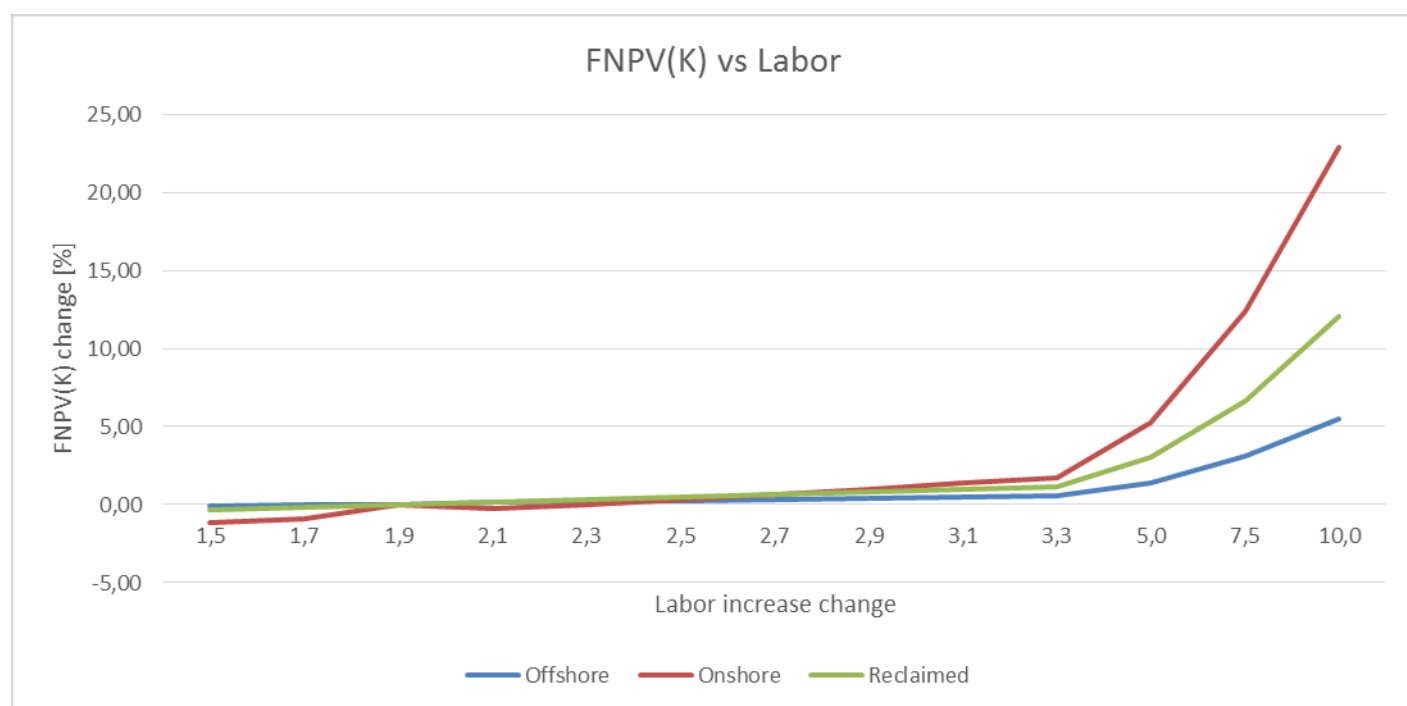
Figure 12: FNPV_K change relative to yearly labor increase

In Figure 13 and Figure 14 the consequences of salary change can be seen. As with yearly labor increase, the effects on the offshore terminal are insignificant, while they have a more pronounced effect on the onshore terminals.
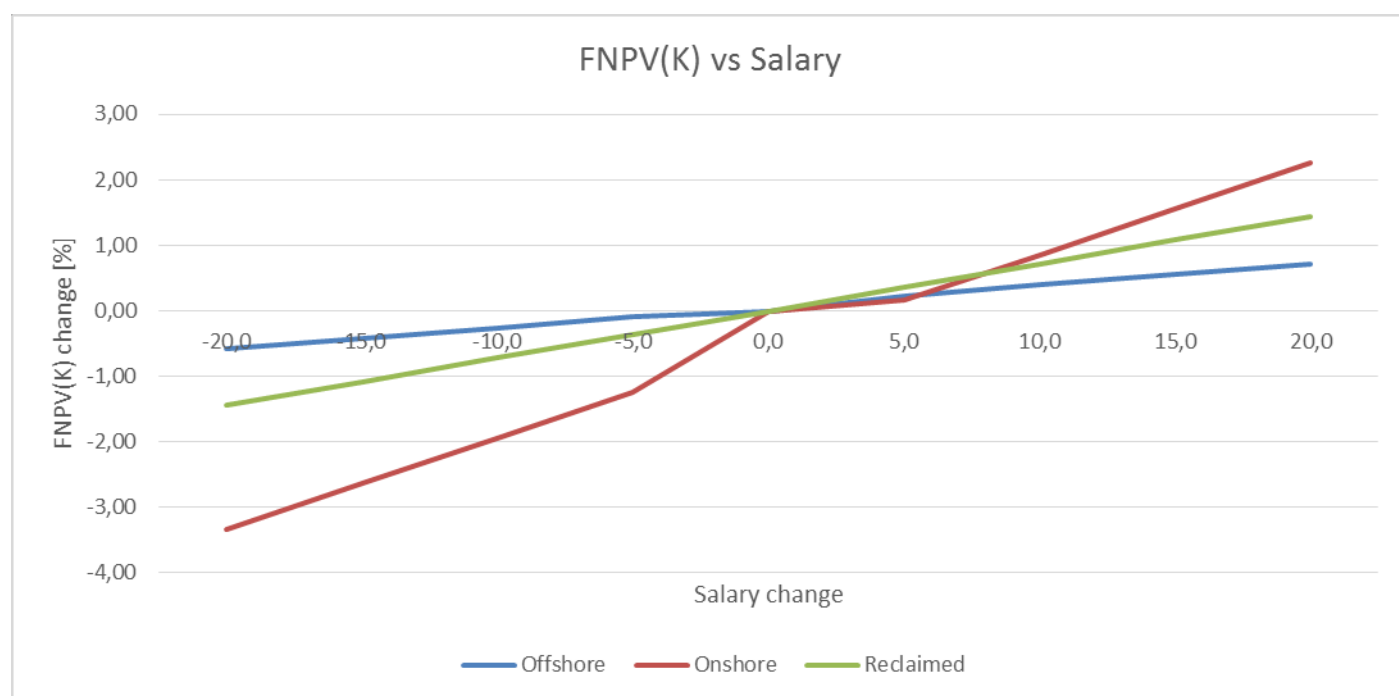
Figure 13: FNPV_C change relative to salary change

FNPV(C) vs Salary
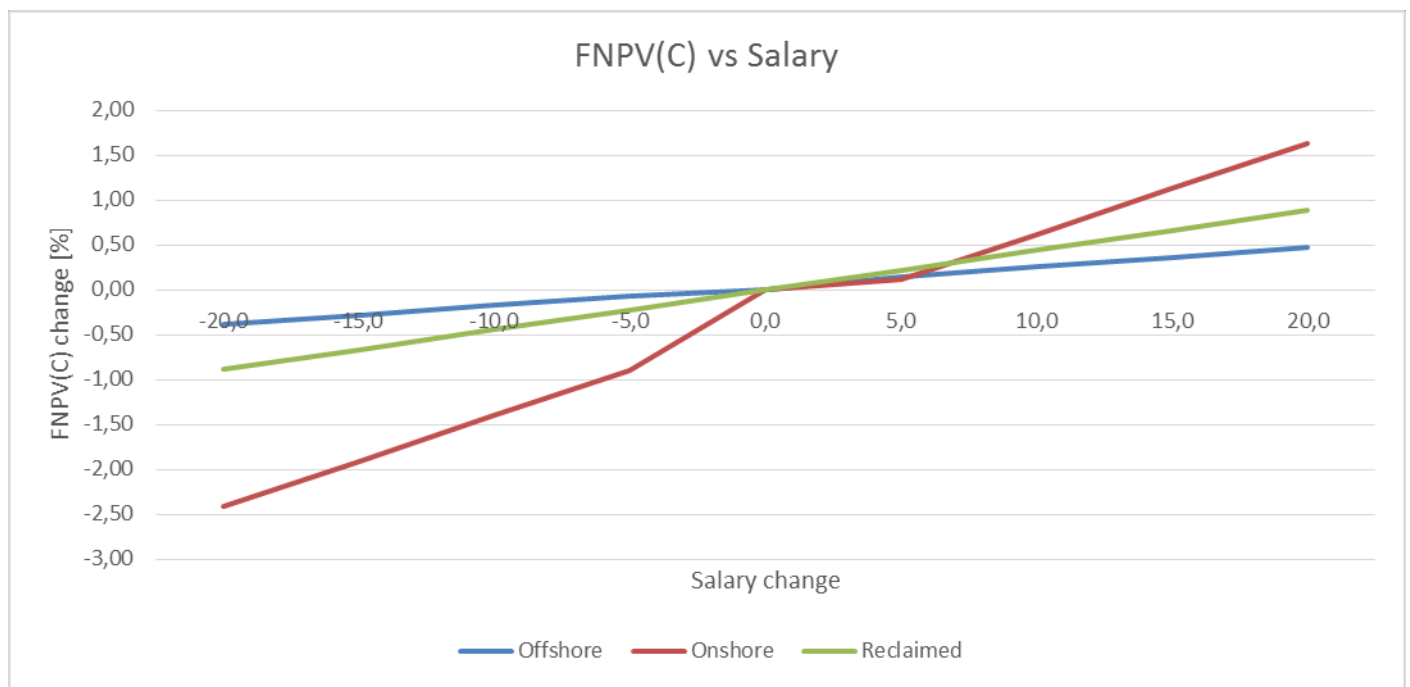
Figure 14: FNPVₖ change relative to salary change

5.1.5 Periodical expenses

Periodical expense change has a more significant impact on the FNPVs, especially on the FNPVs of the onshore and reclaimed terminals, with a 20% decrease resulting in a 6% decrease of the $FNPV_C$ and an 8% decrease of the $FNPV_K$. Once again, the offshore terminals FNPVs are dominated by the total maintenance costs, with periodical costs only comprising a small amount of the total, thus their small effect, even for a large increase or decrease.

FNPV(C) vs Periodical expenses

Figure 15: FNPVᴄ change relative to periodical costs change

Figure 16: FNPVₖ change relative to periodical costs change

5.2   Business risk register

Sensitivity analysis provided information regarding which assumptions are important for the business case outlook. Next step is the qualitative analysis of risks which might lead to significant deviations in variables connected to the adopted assumptions. For this pu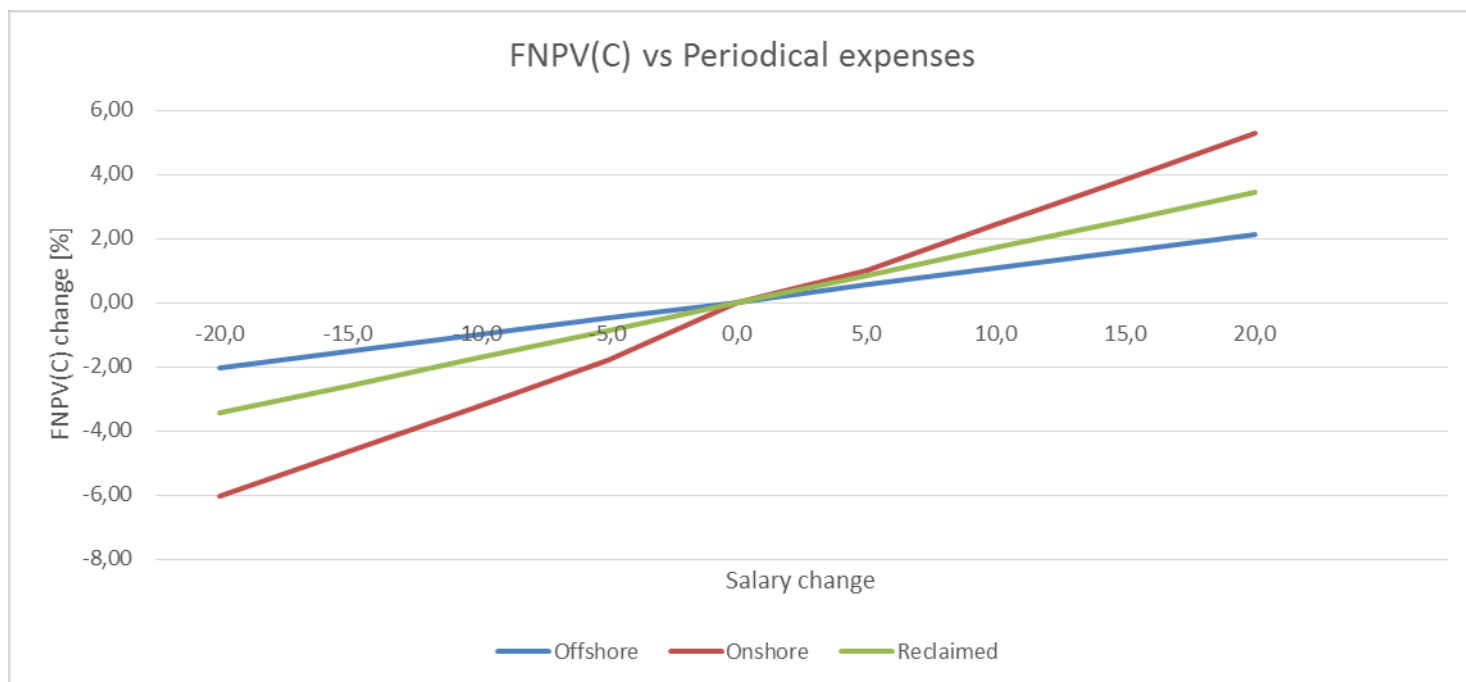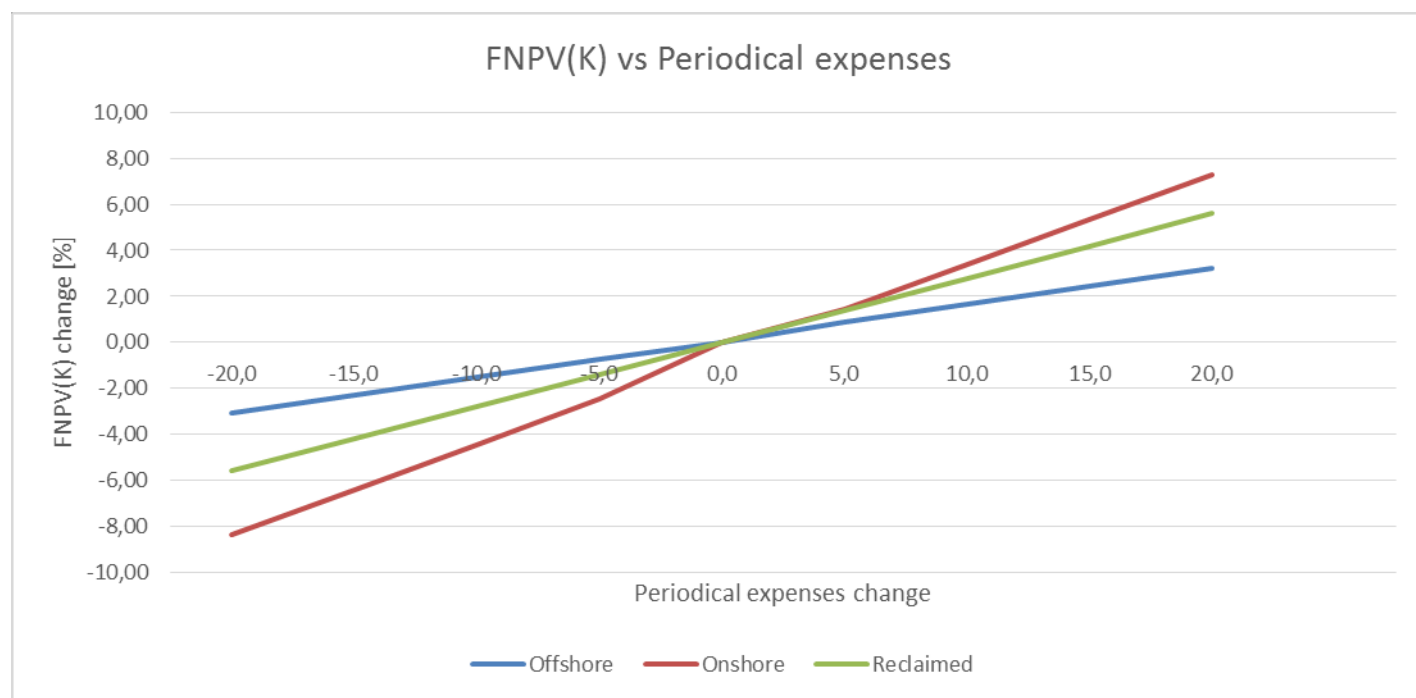rpose a Business Risk Register is developed. Once a risk is identified, a probability of occurrence of a risk event needs to be estimated. For the high level of a business case a low, medium and high scale is more suitable. The same scale can also be used to assess the risk impact. The performed sensitivity analysis provides valuable insight regarding the potential impact of a risk. If applicable, the effect of a risk to cash flows is also recorded. A heat map, as the one shown in Figure 17, can then be used for assessment of risk level. Risks falling under the red color category exhibit a high risk level. For these risks a proactive response plan is needed. Risks with yellow color have medium risk level and a response plan for them might be or might not be developed. Risks with a green color exhibit low risk level. They are usually only monitored without adopting a specific response plan until their status changes.

Figure 17: Risk prioritization heat map [6]

5.2.1 Financial risks

The financial data risks are presented in Table 20. The low rated risks include loan duration, interest rate and the initial payback period. The impact of these loan parameters on $FNPV_C$ and $FNPV_K$ is minor. Similarly, the probability for them to alter is not very high. On the other hand, all financial data relating to discount rates and EU and public contributions and private loan amounts have a significant impact on the business case and probability of occurrence/differentiation is high, so their risk level is accordingly high as well.

Table 20: Financial risks register

Financial data	Impact	Probability	Risk level
Discount rate	High	Medium	High
EU assistance on initial costs	High	Medium	High
Public contribution	High	Medium	High
Private equity	High	Low	Medium
Private loan	High	Medium	High
Loan interest rate	Low	Medium	Low
Loan duration	Low	Low	Low
Payback start period	Low	Low	Low

5.2.2 Offshore terminal risks

Table 21 below presents the risk register for the T&L@Sea hub. As was evident from the results presented throughout chapter 4, the highest impact on the business case comes from the module construction and the RMG acquisition costs. However, RMGs are unlikely to have a significant change in costs, since they are an already established equipment used for years under different circumstances, leading to a medium risk level overall. The module construction costs however are likely to change substantially, since the research and development phase is still ongoing, leading to a high risk level.

Other categories with a medium impact on the business case are the foundation and mooring of modules, and the overall periodical expenses. The probability of those changing significantly though is low, as is their risk level. Finally, labor costs are bound to change significantly throughout the business case timeframe, but their impact on the overall case is low, leading to a low overall risk level as well.

Table 21: T&L@Sea hub risk register

Cost categories	Impact	Probability	Risk level
Civil works & construction			
Module construction	High	Medium	High
Foundation & mooring	Medium	Low	Low
Towing & installation	Low	Low	Low
Equipment			
Large STS cranes	Low	Low	Low

RMG cranes	High	Low	Medium
Small STS cranes	Low	Low	Low
Other infrastructure	Low	Low	Low
Labour	Low	Medium	Low
Other periodical expenses	Medium	Low	Low

5.2.3   Onshore terminal risks

Compared to the T&L@Sea hub, the risk register of the onshore terminal looks completely different, see Table 22. While the construction and equipment costs have a medium impact on the business case, the probability of them increasing or decreasing significantly is low.

In this case, it's the labour and other periodical costs that have the highest impact on the FNPVs. As explained above, the periodical costs are unlikely to change significantly, while labour costs will, leading to a medium and high risk level respectively.

Table 22: Onshore terminal risk register

Cost categories	Impact	Probability	Risk level
Civil works & construction			
Quay	Medium	Low	Low
Yard	Medium	Low	Low
Equipment			
Large STS cranes	Medium	Low	Low
RMG cranes	Medium	Low	Low
AGVs	Low	Low	Low
Other infrastructure	Low	Low	Low
Labour	Medium	Medium	Medium
Other periodical expenses	High	Low	Medium

5.2.4   Reclaimed land terminal risks

The reclaimed land terminal shares the same risk register with the onshore terminal, with the added exception of the land reclamation category. Land reclamation represents the highest cost related to this type of terminal, and the actual costs relate to many factors, such as location, water depth, size of reclaimed land, mobilization of equipment needed etc., leading to a medium probability rating and a high risk level overall.

Table 23: Reclaimed land terminal risk register

Cost categories	Impact	Probability	Risk level
Civil works & construction			
Land reclamation	High	Medium	High
Quay	Medium	Low	Low
Yard	Medium	Low	Low
Equipment			
Large STS cranes	Medium	Low	Low
RMG cranes	Medium	Low	Low
AGVs	Low	Low	Low
Other infrastructure	Low	Low	Low
Labour	Medium	Medium	Medium
Other periodical expenses	High	Low	Medium

5.3   Risk management

For the risks mentioned in the prior sections, with possible negative impacts to the business case, we have four choices as to a strategy for handling them [6]. These choices are summarized as:

- **Accept** - We will accept that the risk may occur and decide not to take any preventative action (no response plan will be provided). The risk will still be monitored
- **Mitigate** - We will take preventative action to reduce the impact and/or probability of the risk occurring
- **Avoid** - We will take preventative action to completely avoid the chance that the risk can occur
- **Transfer** - We will take preventative action to transfer the risk to a third party, e.g. buying an insurance policy

In the case of financial risks, it is clear that active effort needs to be made in order to secure an as high as possible discount rate as it has a significant effect on the financial metrics of this business case. Similarly, for such a huge project, it is important to secure a high EU contribution, while at the same time minimizing public and private loans. Financial risks cannot be avoided, but they need to be mitigated as much as possible.

In the case of the T&L@Sea hub, and since the project is still in the research phase, steps need to be taken in order to ensure the lowest construction cost possible for the modules, since they have the highest risk level. The impact of the cost of equipment is also high, but the costs of RMGs is relatively set, and is unlikely to change significantly, so this is a risk that needs to be accepted and monitored only. The rest of the risk levels are all low, so monitoring them is enough at this phase.

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Labour and periodical costs have the highest risk level for the onshore terminal. Labour and salary increases are something that is hard to avoid, so will have to be accepted, however periodical expenses can be mitigated either through securing better land lease contracts, lowest insurance premiums and/or reducing the general overheads as much as possible. The rest of the risk levels are all low, so monitoring them is enough.

Finally, for the reclaimed land terminal, the situation is similar to the onshore terminal as far as risk levels are concerned, with the added exception of one major risk component – the land reclamation costs. Here, preventative action is needed in order to mitigate the risk level to the minimum.

6 Conclusions and Recommendations

This business case is a detailed comparison between the modular floating Transport & Logistics (T&L@Sea) hub that is being developed in the Space@Sea project and 2 container terminals situated onshore, a conventional container terminal and a terminal situated on reclaimed land. Taking into account that the port of Antwerp is already considering expansion further along the river Scheldt the T&L@Sea hub is examined as a potential alternative to normal onshore expansion or via land reclamation. The question to be answered was whether the T&L@Sea hub is able to fulfill the purposes of a container terminal, and under which circumstances it can be beneficial than the 2 major alternative solutions, an onshore terminal and a terminal situated on reclaimed land.

Based on the results of a scenario to handle 4.690.000 TEU/year (2.931.250 moves/year), the T&L@Sea hub cannot achieve the lower costs of either of the 2 alternatives, resulting in 1,8 to 4,1 times higher FNPVs in all cases. The main reason is the high construction costs of the modules that comprise the platform, and the constraints of the modules requiring an equipment unit present on each module, leading to significant equipment acquisition and maintenance costs. The sensitivity analysis performed confirms these results, as all the scenarios respond with the same way to parameter alteration. However, if the module related costs and the on-platform handling of containers can be improved via smarter design (leading to a reduction in equipment required), the T&L@Sea hub can potentially become an attractive alternative for land reclamation onshore terminals.

The results from the smaller cases examined, a smaller scale T&L@Sea hub off the coast of Genoa and as a temporary disaster relief effort, still not favor the T&L@Sea hub as a direct competitor of onshore ports from a financial point of view. However, in cases of deep water and extremely limited possibilities for expansion, such as the Genoa port, or for short lived specialized operations, a T&L@Sea hub might be the best available choice.

Looking at the T&L@Sea hub as an independent project, it is clear from the results throughout this business case that short term efforts need to be focused on reducing the cost of modules, securing high EU contributions and/or low public and private loans, and a low discount rate for the duration of the project. Focus should also be put in other efforts to lower the direct costs involved, such as designing smarter solutions, or researching alternatives for the on-platform handling of containers.

The T&L@Sea hub offers numerous non-monetary benefits nevertheless, which may make it a viable option for certain cases, either as an extension of the Antwerp port or as a standalone project. The reduced vessel turnaround times, the flexibility in size/operations, the use in deep sea areas where a land extension would be more costly or even impossible, the low environmental impact and the opportunities for temporary deployment only may be deciding factors for the realization of such a project (sections 4.1.1 and 4.3).

Despite higher costs, the existence of such a project may be an inevitability due to insufficient land for expansion or other reasons mentioned in chapters 1 and 2. In order to enhance the business case for the T&L@Sea hub, future research must focus on optimizing module construction and relaxing some hard constraints relating to module connectivity, in order to reduce platform and equipment initial costs and maintenance. Additionally, the numerous qualitative benefits must be given appropriate weight in the decision to materialize such a project.

Several assumptions had to be made for this business case, relating to analysis periods, operating hours, terminal size, infrastructure and costs taken into account etc. With further research, a more solid business case can be made for it, focusing on more sophisticated data. The investment and operational costs of the terminals can be more detailed and expanded. Simulation models can potentially be used as well, to provide another point of view of a comparative approach between the selected cases/terminals. The perspective of more stakeholders directly related to such a project (shareholders; cargo owners; government or local municipalities/authorities; community stakeholders) can be explored. Furthermore, the hinterland connections can be examined in more depth on an operational level, in order to provide a more encompassing view of the effect of a T&L@Sea hub in all transport and handling logistics.

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Annex 1: Cost results over 25 years

Table 24: T&L@Sea hub cost results over 25 years

Period	Operational [€]	Maintenance [€]	Labor [€]	Periodical [€]	Total [€]
1	2.490.000	51.802.935	2.874.144	16.284.200	73.451.279
2	2.491.992	52.061.950	2.929.902	16.365.621	73.849.465
3	2.493.986	52.322.259	2.986.743	16.447.449	74.250.437
4	2.495.981	52.583.871	3.044.685	16.529.686	74.654.223
5	2.497.978	52.846.790	3.103.752	16.612.335	75.060.855
6	2.499.976	53.111.024	3.163.965	16.695.396	75.470.361
7	2.501.976	53.376.579	3.225.346	16.778.873	75.882.774
8	2.503.978	53.643.462	3.287.918	16.862.768	76.298.125
9	2.505.981	53.911.679	3.351.703	16.947.082	76.716.445
10	2.507.985	54.181.238	3.416.726	17.031.817	77.137.767
11	2.509.992	54.452.144	3.483.011	17.116.976	77.562.123
12	2.512.000	54.724.405	3.550.581	17.202.561	77.989.547
13	2.514.009	54.998.027	3.619.462	17.288.574	78.420.072
14	2.516.021	55.273.017	3.689.680	17.375.017	78.853.734
15	2.518.033	55.549.382	3.761.260	17.461.892	79.290.567
16	2.520.048	55.827.129	3.834.228	17.549.201	79.730.606
17	2.522.064	56.106.264	3.908.612	17.636.947	80.173.888
18	2.524.082	56.386.796	3.984.439	17.725.132	80.620.449
19	2.526.101	56.668.730	4.061.737	17.813.758	81.070.326
20	2.528.122	56.952.073	4.140.535	17.902.826	81.523.557
21	2.530.144	57.236.834	4.220.862	17.992.341	81.980.180
22	2.532.168	57.523.018	4.302.746	18.082.302	82.440.235
23	2.534.194	57.810.633	4.386.220	18.172.714	82.903.760
24	2.536.221	58.099.686	4.471.312	18.263.577	83.370.797
25	2.538.250	58.390.185	4.558.056	18.354.895	83.841.386
	62.851.281	**1.375.840.109**	**91.357.626**	**432.493.941**	**1.962.542.958**

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Table 25: Onshore terminal cost results over 25 years

Period	Operational [€]	Maintenance [€]	Labor [€]	Periodical [€]	Total [€]
1	2.233.412	5.234.170	3.343.732	10.877.400	21.688.714
2	2.235.199	5.237.576	3.408.600	10.931.787	21.813.162
3	2.236.987	5.240.999	3.474.727	10.986.446	21.939.159
4	2.238.776	5.244.439	3.542.137	11.041.378	22.066.730
5	2.240.567	5.247.896	3.610.854	11.096.585	22.195.903
6	2.242.360	5.251.370	3.680.905	11.152.068	22.326.703
7	2.244.154	5.254.862	3.752.315	11.207.828	22.459.159
8	2.245.949	5.258.372	3.825.109	11.263.867	22.593.298
9	2.247.746	5.261.898	3.899.317	11.320.187	22.729.148
10	2.249.544	5.265.443	3.974.963	11.376.788	22.866.738
11	2.251.344	5.269.005	4.052.078	11.433.672	23.006.098
12	2.253.145	5.272.585	4.130.688	11.490.840	23.147.258
13	2.254.947	5.276.183	4.210.823	11.548.294	23.290.248
14	2.256.751	5.279.799	4.292.513	11.606.036	23.435.099
15	2.258.557	5.283.433	4.375.788	11.664.066	23.581.844
16	2.260.364	5.287.085	4.460.678	11.722.386	23.730.513
17	2.262.172	5.290.756	4.547.215	11.780.998	23.881.141
18	2.263.982	5.294.444	4.635.431	11.839.903	24.033.760
19	2.265.793	5.298.152	4.725.359	11.899.103	24.188.406
20	2.267.605	5.301.877	4.817.031	11.958.598	24.345.112
21	2.269.419	5.305.622	4.910.481	12.018.391	24.503.913
22	2.271.235	5.309.385	5.005.744	12.078.483	24.664.847
23	2.273.052	5.313.167	5.102.856	12.138.876	24.827.950
24	2.274.870	5.316.968	5.201.851	12.199.570	24.993.259
25	2.276.690	5.320.787	5.302.767	12.260.568	25.160.813
	56.374.621	**131.916.272**	**106.283.965**	**288.894.118**	**583.468.976**

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Table 26: Reclaimed land terminal cost results over 25 years

Period	Operational [€]	Maintenance [€]	Labor [€]	Periodical [€]	Total [€]
1	2.233.412	15.394.870	3.343.732	15.058.800	36.030.814
2	2.235.199	15.398.679	3.408.600	15.134.094	36.176.572
3	2.236.987	15.402.508	3.474.727	15.209.764	36.323.986
4	2.238.776	15.406.355	3.542.137	15.285.813	36.473.082
5	2.240.567	15.410.222	3.610.854	15.362.242	36.623.886
6	2.242.360	15.414.108	3.680.905	15.439.054	36.776.427
7	2.244.154	15.418.014	3.752.315	15.516.249	36.930.731
8	2.245.949	15.421.939	3.825.109	15.593.830	37.086.827
9	2.247.746	15.425.883	3.899.317	15.671.799	37.244.745
10	2.249.544	15.429.848	3.974.963	15.750.158	37.404.514
11	2.251.344	15.433.832	4.052.078	15.828.909	37.566.163
12	2.253.145	15.437.836	4.130.688	15.908.054	37.729.723
13	2.254.947	15.441.860	4.210.823	15.987.594	37.895.225
14	2.256.751	15.445.905	4.292.513	16.067.532	38.062.701
15	2.258.557	15.449.969	4.375.788	16.147.869	38.232.183
16	2.260.364	15.454.054	4.460.678	16.228.609	38.403.705
17	2.262.172	15.458.159	4.547.215	16.309.752	38.577.299
18	2.263.982	15.462.285	4.635.431	16.391.301	38.752.999
19	2.265.793	15.466.432	4.725.359	16.473.257	38.930.840
20	2.267.605	15.470.599	4.817.031	16.555.623	39.110.858
21	2.269.419	15.474.787	4.910.481	16.638.402	39.293.089
22	2.271.235	15.478.996	5.005.744	16.721.594	39.477.569
23	2.273.052	15.483.226	5.102.856	16.805.201	39.664.335
24	2.274.870	15.487.477	5.201.851	16.889.228	39.853.426
25	2.276.690	15.491.749	5.302.767	16.973.674	40.044.880
	56.374.621	**386.059.593**	**106.283.965**	**399.948.401**	**948.666.580**

Annex 2: FNPVs

Table 27: T&L@Sea hub FNPV results

Period		DCF [€]	Loan payback [€]		DCF [€]
0	Initial investments	-1.357.109.825		Initial contributions	-271.421.965
1		-70.626.230	0		-70.626.230
2		-68.277.982	0		-68.277.982
3		-66.008.368	13.571.098		-79.579.466
4		-63.814.743	13.571.098		-77.385.841
5		-61.694.551	13.571.098		-75.265.649
6		-59.645.323	13.571.098		-73.216.421
7		-57.664.672	13.571.098		-71.235.770
8		-55.750.293	13.571.098		-69.321.391
9		-53.899.957	13.571.098		-67.471.055
10		-52.111.511	13.571.098		-65.682.609
11		-50.382.876	13.571.098		-63.953.974
12		-48.712.041	13.571.098		-62.283.139
13		-47.097.063	13.571.098		-60.668.162
14		-45.536.067	13.571.098		-59.107.165
15		-44.027.237	13.571.098		-57.598.335
16		-42.568.823	13.571.098		-56.139.921
17		-41.159.129	13.571.098		-54.730.227
18		-39.796.521	0		-39.796.521
19		-38.479.416	0		-38.479.416
20		-37.206.287	0		-37.206.287
21		-35.975.658	0		-35.975.658
22		-34.786.101	0		-34.786.101
23		-33.636.239	0		-33.636.239
24		-32.524.738	0		-32.524.738
25		-31.450.313	0		-31.450.313
	FNPV$_C$	**-2.569.941.961**		**FNPV$_K$**	**-1.687.820.575**

Table 28: Onshore terminal FNPV results

Period		DCF [€]	Loan payback [€]		DCF [€]
0	Initial investments	-269.000.525		Initial contributions	-53.800.105
1		-20.854.533	0		-20.854.533
2		-20.167.494	0		-20.167.494
3		-19.503.832	2.690.005		-22.193.838
4		-18.862.734	2.690.005		-21.552.739
5		-18.243.414	2.690.005		-20.933.419
6		-17.645.118	2.690.005		-20.335.123
7		-17.067.115	2.690.005		-19.757.120
8		-16.508.701	2.690.005		-19.198.707
9		-15.969.198	2.690.005		-18.659.203
10		-15.447.949	2.690.005		-18.137.954
11		-14.944.323	2.690.005		-17.634.328
12		-14.457.709	2.690.005		-17.147.714
13		-13.987.519	2.690.005		-16.677.525
14		-13.533.186	2.690.005		-16.223.191
15		-13.094.161	2.690.005		-15.784.166
16		-12.669.915	2.690.005		-15.359.920
17		-12.259.939	2.690.005		-14.949.944
18		-11.863.740	0		-11.863.740
19		-11.480.844	0		-11.480.844
20		-11.110.791	0		-11.110.791
21		-10.753.141	0		-10.753.141
22		-10.407.465	0		-10.407.465
23		-10.073.353	0		-10.073.353
24		-9.750.407	0		-9.750.407
25		-9.438.244	0		-9.438.244
	FNPV$_C$	**-629.095.349**		**FNPV$_K$**	**-454.245.008**

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Table 29: Reclaimed land terminal FNPV results

Period		DCF [€]	Loan payback [€]		DCF [€]
0	Initial investments	-851.630.775		Initial contributions	-170.326.155
1		-34.645.013	0		-34.645.013
2		-33.447.275	0		-33.447.275
3		-32.291.892	8.516.308		-40.808.199
4		-31.177.343	8.516.308		-39.693.651
5		-30.102.165	8.516.308		-38.618.473
6		-29.064.944	8.516.308		-37.581.252
7		-28.064.320	8.516.308		-36.580.628
8		-27.098.982	8.516.308		-35.615.289
9		-26.167.664	8.516.308		-34.683.972
10		-25.269.149	8.516.308		-33.785.457
11		-24.402.263	8.516.308		-32.918.571
12		-23.565.873	8.516.308		-32.082.181
13		-22.758.890	8.516.308		-31.275.198
14		-21.980.261	8.516.308		-30.496.569
15		-21.228.974	8.516.308		-29.745.282
16		-20.504.052	8.516.308		-29.020.360
17		-19.804.553	8.516.308		-28.320.861
18		-19.129.570	0		-19.129.570
19		-18.478.228	0		-18.478.228
20		-17.849.685	0		-17.849.685
21		-17.243.128	0		-17.243.128
22		-16.657.773	0		-16.657.773
23		-16.092.865	0		-16.092.865
24		-15.547.677	0		-15.547.677
25		-15.021.507	0		-15.021.507
	FNPV$_C$	**-1.439.224.824**		**FNPV$_K$**	**-885.664.820**

Annex 3: Business case canvas for the T&L@Sea

BUSINESS CASE MODEL CANVAS

Problem
Provide an alternative solution for the de-congestion of container port terminals

Solution
An offshore, floating, modular transport and logistics platform: the T&L@Sea hub

Strategic Align
- Innovation as part of Port of Antwerp's strategy
- Predicted increase in shipping traffic needs to be addressed efficiently
- Cost reductions for transshipment
- Flexibility in expansion
- Climate change impact on coastal areas
- Customer satisfaction

Key Stakeholders
- Terminal operators — Industry
- Port authorities — Environmental agencies
- Shipping & logistics companies
- Cargo owners — Press
- Government

Economics
- Higher costs than both considered alternatives
- Focus on securing high contributions & low
- Focus on securing high discount rates
- Module construction major cost component
- Platform stability constraints increases equipment

Opportunities
- Attractive for ULCVs - reduced travel/moor time
- Flexibility to adapt
- Port traffic expected to increase so new solutions are needed
- Other uses (bunkering facilities, O&M hub)

Strengths
- Modular/scalable concept
- Less environmental impact
- Vessel turnaround time reduced
- Maintenance hub
- Port decongestion
- Disaster relief efforts

Weaknesses
- High costs
- Unproven concept
- Personnel conditions
- Highly dependent on environmental conditions

Threats
- Stakeholder interests may not be enough
- Unproven concept
- Strict safety protocols
- Qualitative benefits may not be enough to industry
- Efficiently enable personnel to live close

Costs €		
Investment costs [€]		**FNPV$_C$ [€]**
1,357,109,825		-2,569,941,961
€/TEU	**€/move**	**FNPV$_K$ [€]**
15,66	25,06	-1,687,820,575
Total T&L hub costs [€]		
3,428,221,569		

Benefits €	
Non-financial benefits	
Business flexibility	Environmental impact reduced
Vessel turnaround times reduced	Multi-use platform
Unique option for deep sea disaster relief operations	Temporary deployment