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Framework for standardized design of a biorefinery

Implementing a standardized refinery modification design considering differences in local and global effectiveness & the presence of heterogenous stakeholders

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Preface

First of all, I would like to thank Mr. van der Bij from the engineering company Worley Nederland BV, for the opportunity he gave me to write my thesis under his tutelage. I learned a lot from this experience, and it will greatly help me in my future career.

Next, I acknowledge the help and guidance of Professor Gonzalez and Professor Warnier from the Technological University of Delft. The opportunity that they gave me to show my skills and knowledge in this thesis as Complex Systems Engineer is something that I will always cherish.

This paper has been written to help organizations in aligning stakeholders to contribute to the successful implementation of a standardized refinery modification design. However, the framework that came out of this study is also applicable to other complex systems where stakeholder alignment is missing or lacking. As such, this paper is primarily of interest to them.

Finally, I also would like to express my gratitude to my loved ones, my father, my mother, my sister, and my best friend who supported me during my entire research. To you, I dedicate this paper along with my gratefulness. I hope I made you proud.

Gerel Abergas
The Hague, June 2023

Executive Summary

When it comes to the modification of a fossil- to bio-refinery, the reuse of a standardized design is unprecedented. This is primarily due to the nature of the design, which is usually bespoke for a certain location or site. A design is generally site specific so that technical and political conditions present in each location can be met. Trying to meet these conditions are already challenging on their own. Now, consider a refinery modification design that is supposed to be standardized so that it can cater to all the technical and political differences of each site. Overdesigning is an undesirable option as it can lead to an ineffective design. The standardized refinery modification design should be composed of elements that are globally applicable to all refinery sites and at the same time, it will also encompass site-specific elements. Thus, this is an extremely complicated problem as there are a plethora of aspects that must be considered for the design to be effective locally and globally. However, the challenges that can be encountered in the creation of a sustainable and reusable standardized refinery modification design do not end here. Add heterogenous stakeholders in the equation, then one would get not merely a complicated problem but a complex one. This problem lies in the core of this thesis, which is illustrated by the main research question. To answer this, sub-research questions are also formulated.

"How can a standardized refinery design be implemented keeping local and global effectiveness in mind and considering different stakeholders?"

<u>Sub-research questions:</u>

1. Who are the different stakeholders and what are their interests and roles in the implementation of a standardized refinery design?
2. What aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?
3. How can the aspects discovered be used to identify the requirements needed to help implement a standardized refinery design in different geographic locations?
4. Which stakeholders are relevant for the implementation of the identified requirements?
5. How can the interest and priority of the relevant stakeholders be aligned to achieve maximum repeatability of the standard design?

The first sub-question is designed to distinguish who among the various stakeholders involved in such a system are critical and who are not. It is essential to discover who the critical stakeholders are as they hold the power to greatly influence the system (i.e., delay, expedite, terminate, etc.). From the critical stakeholders, the information as to which aspects must be considered technically and politically by the implementation of a standardized refinery modification design can be acquired. The reason why this information is being elicited from them and not everyone else lies in their power to significantly influence the progress of the refinery modification. Out of the relevant aspects that shall be identified from the second sub-question, requirements will be created. These are requirements that need to be satisfied to ensure the successful implementation of a standardized refinery modification design. Bear in mind that the focus of this thesis is not the technical design itself, but all the other elements relevant to its implementation technically and politically (e.g., space, logistics, etc.). After the requirements have been identified, the following step is to determine who the relevant stakeholders are that must be considered and aligned for the implementation of the said requirements. Finally, in the last sub-research question, the alignment methods that can be implemented to help align the stakeholders in the previous sub-question are examined. If the alignment of the stakeholders can be achieved, then the

complexity of the problem can be reduced, and this can help in increasing the chances of a successful refinery modification.

Out of all the data retrieved from sub-questions one to five, a framework has been developed. This framework is the first ultimate outcome of this thesis. The framework illustrates the steps that must be followed by any organization to achieve stakeholder alignment in a system that will undergo change due to the implementation of a design. A large copy of the framework can be seen in Figure 3 in Appendix 8.5. The data coming from all the sub-questions have been gathered via interviews with experts from the industry and literature study. Currently, no other study out there looks at the implementation of a standardized refinery modification design. Also, there is no paper that looks at multiple aspects at once (knowledge gap) and especially considers stakeholders as a relevant aspect. Therefore, the framework that comes out of this thesis is unique. It has been created to enable the implementation of a standardized refinery modification design while considering technical, political, and personal aspects. Hence, the research fills the knowledge gap by conducting a study that considers three aspects. At the same time, the framework has been created in a generalized way so that it can also be applied to other systems, and not just for refinery modification. Such are systems where stakeholder alignment is lacking or missing, and where a design needs to be created and implemented. The framework is also particularly useful for a system where trade-offs between local and global effectiveness exist.

The second main outcome of this thesis is the result of applying the framework in a case, which has already been hinted at a few times in the previous paragraphs. For this research, one of the projects of the engineering company Worley Nederland BV has been used as the case. In this specific project, Worley has been contracted by a client to modify some of their refineries from fossil to bio. The framework illustrated in Figure 3 (see Appendix 8.5.) has been applied to the project of Worley. For such a project it's discovered via a stakeholder analysis that the critical stakeholders are the Engineering Manager, Appraisal General Manager, Project Director, and Requirements and Standardization Manager. On the other hand, the problem owner, or the stakeholder that greatly matches the proposed main research question is the Program Delivery Manager. Then, tackling the second sub-question, the relevant aspects that came out of it are Space, Utilities, Logistics/Accessibility, Site Specificity, Permitting, and Management/Labour. Out of these aspects, requirements have been formulated in sub-question three via requirement analysis. It is through these requirements that the local and global effectiveness of the standardized refinery modification design can be compared. Then, the relevant stakeholders to be aligned with these requirements are identified in the following sub-question. Finally, in the last sub-question it's discovered that stakeholder alignment is needed in different stages namely, Cooperation, Control, Coordination, and Collaboration. Form the case of Worley, alignment in the cooperation stage is lacking the most. This does not say however that the alignment of the stakeholders in the other stages is perfectly going well. Out of this, advice for Worley has been created to elevate the alignment of their stakeholders in the different stages, considering what they already have in place and what not.

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1. Introduction

Standardization can significantly help with the speed at which humanity can tackle climate change (Appendix 8.4. – Program Delivery Manager). How this can be made possible will be explained here in Chapter 1. The introduction starts by explicating the problem faced by society around climate change. Then, it will be explained what can be done about it and how standardization can help. Finally, the research topic's origin and relevance are discussed in the last subchapter.

1.1. Problem at hand

The effects of anthropogenic activities on the climate have already reached an irreversible point for the current human beings alive (NASA, 2023). However, this does not mean that nothing can be done anymore for the next generations. Actions taken now can still help to reduce the otherwise catastrophic effects of climate change in the future. There are two main options to fight climate change: mitigation and adaptation. Mitigation strategies are actions that lower greenhouse gas concentrations whether it be via the addition of carbon sinks or reduction of emissions (Zhao et al., 2018). On the other hand, adaptation measures focus on effectively implementing means to reduce one's vulnerability to the effects of climate change (Zhao et al., 2018). In more simple terms, mitigation tries to prevent the causes of climate change while adaptation is all about adjusting to the potential impacts of climate change. Looking at both options, it seems that mitigation techniques are future-proof since the supposed root of the problem will be tackled instead of just adjusting to whatever climate change may bring.

Sticking to mitigation strategies, one of the most discussed options is decarbonization; a technique that directly reduces CO_2 emissions (Fawzy et al., 2020). The simplest way to lower carbon emissions is by replacing fossil fuels with renewable sources of energy or by removing carbon in any process. For some sectors, this is something relatively easily doable. Those in the industry sector that do not use carbon in any of their processes contribute to carbon emissions by using fossil fuels to power their activities. Thus, for them, the solution is to transition from using grey to green energy. The same thing can be said about the commercial and residential sectors, however, that is not the case for all sectors. The transportation sector has the highest reliance on fossil fuels and will surely struggle to immediately transition from grey to green (IEA, 2022). This is because the technology needed to enable the decarbonization of the entire transportation sector is still not scalable to the desired level (Brand, 2021).

To give an example of this technology, consider batteries, an option that has rapidly gained popularity over the last years as means of energy storage of renewable energy for a vehicle. This however works best for smaller vehicles and shorter distances (Thomas, 2009). For vehicles such as ships and airplanes that travel over longer distances, batteries are not suitable due to the large mass and volume that they will require (Thomas, 2009; Moseman, 2021). This is where hydrogen comes in, a sustainable and abundant fuel that can replace fossil fuels in the shipping and aviation industry (Qazi, 2022). Unfortunately, the implementation of hydrogen on such a large scale is still far away as there are challenges that must be overcome. First, producing hydrogen from low-carbon energy is currently still expensive (IEA, 2019). To add on that, the challenge of the slow development of hydrogen infrastructure hinders its wide uptake, according to IEA (2019). Finally, regulations to support the development of hydrogen are lacking (IEA, 2019). As such, having a half measure that can be implemented in the short term as an alternative to fossil fuels is desirable. A very attractive option is the use of biofuels (EPA, 2022).

“Biofuels are liquid or gaseous transport fuels made from biomass” according to the European Commission (2022). There are arguably four kinds of biofuels. 1st generation biofuels are those made from food biomass like corn and wheat, 2nd generation from non-food such as agricultural, forestry, or municipal waste, 3rd generation from algae, and finally 4th generation from genetically modified algae (Alalwan et al., 2019). The 3rd and 4th generation biofuels are proving to be the promising choice because these options do not compete with the space used for growing food, however, they are still in the development stage (Alalwan et al., 2019). On the other hand, the competition that the 1st generation biofuel causes with the food supply is undesirable according to Gasparatos et al. (2013). This leaves us with the 2nd generation of biofuel produced from waste as the short-term alternative to hydrogen. This option is abundant, and on top of that, it also contributes to reducing emissions, due to its lower greenhouse gas emissions compared to fossil fuels (Alfano et al., 2016; Jeswani, 2020).

1.2. Topic origin & relevance

Oil companies like bp, ExxonMobil, and Shell plan to take advantage of this by making sustainable aviation fuel or SAF out of (household) waste and waste oils (BP, 2022; Shell, 2009; Bailey, 2022). Little to no land-use change would occur here as the feedstock would be coming from established resources. Time however is ticking and to take full advantage of the benefits of SAF, then, actions must be taken now. In general, SAF cannot directly be produced in existing fossil-based refineries, hence modifications must first take place. Building biobased refineries to specifically produce SAF on the other hand will take much longer, so this approach is less desirable compared to the other. This is due to the shortage of engineering services worldwide and the high investment costs needed for such a greenfield project (Mannan, 2021; Su et al., 2022). On top of that is the project duration difference, revamping or modernizing a refinery is quicker than a new construction project considering similar scope and size (Shell, 2020). In the current state of the globe where there is a shortage of engineers (Mannan, 2021), then innovative solutions are needed to deliver the projects on time. A paper published by McKinsey & Company suggests fundamental changes in a project approach to significantly reduce costs and speed up large capital projects (Chandrasekaran et al., 2021). From these fundamental changes, there is one that is particularly intriguing and considered unprecedented when it comes to large-scale biorefinery modification, namely standardization.

Standardization is defined as a framework of agreements that certain people in an organization must comply with to guarantee that every process (and potentially scope) with regard to the creation of a product, or performance of a service is done in accordance with a set of guidelines (Grant, 2021). Standardization is nothing new, as a matter of fact, its existence can even be traced back to 260 BC, when a Chinese emperor standardized a system of units and measurements (Zeltwanger, 2015). In modern times, standardization is present in almost any product or service. Standardization’s wide uptake and application are due to its many benefits. Among others, standardization helps in increasing productivity, lowering process delays, improving customer service quality, reducing cost, and using resources more efficiently (Indeed, 2022). However, not every sector is taking full advantage of what standardization can offer. For instance, in the construction sector having a standardized plan and requirements helps infrastructures to be built, as in the case of wind turbines, that has the standard IEC 61400. However, for modifying the infrastructures such as refineries into biorefineries this has not been explored (Appendix 8.4. – Engineering Manager). Standardization can thus be seen as a crucial element.

Zooming in from the construction sector to engineering contractors, standardization can be applied in various ways. Mainly in project approaches where standardized procedures are followed. This, however, can be improved by going a step further. In Princeton’s research with an engineering contractor, action points have been identified on how to further facilitate standardization (Anderson et al., 2022). These are (1) to learn from other industries, (2) mandate standardization, (3) develop a global set of design standards, (4) collision of energy supply and process industries, (5) redeployment of exiting designs to new technology and finally (6) strengthen the supply chain. From these action points, some are currently less achievable than others. Points 2 and 3 require the involvement of international governmental agencies and other relevant organizations to be realized. Point 4 about the collision of energy supply and process industries is an action point deemed irrelevant for the creation of a standardized refinery modification design. This action point is about trying to utilize some form of a buffer energy source, whenever there isn't enough generation by renewable energy sources. That way the process industry can remain operable continuously. Next is the redeployment of existing designs to new technologies or point 5 which is currently limited. Within an engineering contractor's company, various projects that share similarities exist. Collaboration of data among these projects to redeploy existing designs does not or hardly take place, especially when the clients are competitors in their market. Only licensors share data internally regardless of the company or project. But as mentioned, collaboration among the competing companies themselves does not take place. Regulations that facilitate such collaboration are needed first to enable it. This leaves us with action points 1 and 6 as something that an engineering contractor can work on and implement without it being too complex and political.

A means to apply both action points 1 and 6 is in the creation of a standardized design to be reused in multiple projects. From action point one, standardized parts and strategies to speed up delivery can be learned from other industries (Anderson et al., 2022). While from action point six, it's all about the preparation of standardized designs in advance so the engineering contractor does not need to start from scratch every time (Anderson et al., 2022). Once a standardized design has been created then this can repeatedly be implemented, for example in the project of modifying fossil-based refineries to biorefineries. Implementing a standardized design in multiple refineries simultaneously will greatly reduce cost and construction time in accomplishing refinery modifications (Appendix 8.4. – Program Director), if done successfully. First, from a supplier perspective, making one standardized item or equipment and selling multiple units of it reduces cost. From an engineering point of view, once a standardized design already exists, then theoretically only site-specific adjustments would be needed. This would drastically reduce working hours (design, construction, planning, etc.), provided that the site to be modified is somewhat like the site where the standardized design was based on.

Reusing a standardized refinery modification design, however, is something that has never happened yet, especially on such a large scale based on interviews with industry experts (Appendix 8.4.). Refineries usually operate individually, even those owned by the same company (Appendix 8.4. – Project Operations Engineer). Therefore, such modifications will normally take place per refinery as well. With a shortage in engineering services, approaching such modifications on a global scale (i.e., multiple refineries simultaneously) seems to be the way to go. Considering that time is money, reusing the same standardized design and adapting only what is needed, will surely lead to a substantial reduction of time, and hence cost as mentioned earlier. This is not that simple as each site can be unique. The refinery that needs to be modified might be completely different technical-wise from where the design is being based on. The difference in the location of the refineries signifies a difference in laws and regulations (Appendix 8.4. – Program Director). This means that the institutions at play are also something that cannot be ignored.

Furthermore, the presence of various stakeholders that are invested in the project with possibly diverse interests and priorities must not be neglected (Appendix 8.4. – Appraisal General Manager). That, accompanied by the hierarchical structure in place, even more, increases the potential for workplace politics to exist (Stanier, 2018). Workplace politics is defined as the manifestation of power dynamics within the office among co-workers (Schooley, 2023). Workplace politics are inevitable, but the desire is to avoid having the negative kind and have more of the positive one. One of the ways to accomplish this is by aligning the stakeholders with the organizational goal (Lavoie, 2014). In such a complex system, some form of alignment or unity from the local and global stakeholders is therefore desired to achieve optimal results. This, therefore, is the aim of this research paper, to establish alignment among the multiple stakeholder perspectives considering their different roles when implementing a standardized refinery modification design.

Looking at this from a socio-economic perspective, the study is relevant, because it promotes higher pace and lower effort. Such projects can stimulate other companies to consider modifying their fossil-fuel-based refineries as well. Also, if a reusable design can be created, then this may lead to the reduction of resources needed in terms of workforce. Less resources used means more available for other projects which ultimately can be beneficial for the improvement and development of the society. From a scientific perspective, such an accomplishment is also desired as it advances the knowledge and understanding of design reuse and standardization. This is useful, considering that advancement of any sort can be applied in other aspects of science. Especially in these times when certain materials are becoming scarcer, and recirculation is gaining popularity. Design reuse might be able to offer a solution to the scarcity problem. But mostly, this research can help in advancing the knowledge on standardization, so the use of a standardized design itself and the standardization of its implementation. Both can help in promoting the delivery of complex projects (Chandrasekaran et al., 2021).

As a master thesis for the study of Complex Systems Engineering & Management (CoSEM), this topic fits perfectly. The deliverable of this research is a design that will try to tackle a complex technical issue to enable the reuse of a standardized refinery modification design. To make this possible the problem will be addressed systematically by considering the relevant processes, the presence of heterogeneous stakeholder perspectives, and the institutions at play. Various CoSEM methods (e.g., interviews, literature research, stakeholder analysis, requirement analysis, etc.) will be implemented along with their corresponding tools. As mentioned earlier the topic is also of relevance for the public and private domain. In the next chapter, background research is conducted to help identify the knowledge gap and formulate the research questions.

2. Literature Research

This chapter of the paper presents the background research conducted. It starts by showing the search approach used to discover the knowledge gap in 2.1. This is followed by the result of the literature review in 2.2. In the next subchapter (2.3.) the knowledge gap is identified.

2.1. Search approach

As stated in the previous chapter, a literature review will be conducted. The literature review aims to discover what the current practice is with regard to the implementation of a standardized refinery modification design. The first step is to come up with a set of search words that will accurately represent the topic at hand. Due to familiarity reasons, the database Scopus is used. The first set of keywords used is TITLE-ABS-KEY (refinery AND (modern* OR modif* OR revamp* OR standard* OR adjust*) AND biofuel AND (repeat* OR reproduc*)). The words modern*, modif*, revamp*, standard*, and adjust* are used to signify a change in a refinery, in other words, conversion of a refinery from producing fossil fuels to biofuels. Finally, repeat* and reproduce* are used to look for literature where some form of repetition or reproduction occurs. This topic is the repetition of a refinery modification design usage in different locations. This yielded a total of three papers and from those three none are deemed relevant to the topic. The same search words are used in Google Scholar, but it generated irrelevant papers as well.

It is hypothesized that a project such as the reuse of a standardized refinery modification design in different locations has not been done yet or that details are just kept internally by the parties involved. The lack of scientific papers available on this topic already points out an existing knowledge gap. Therefore, a different approach is tried out to test this hypothesis. Instead of directly looking for refinery modifications, more general concepts are used to look for papers namely economies of scale, learning curve, and streamline. Economies of scale is chosen as it pertains to any means of cost reduction by a company while increasing their production (Organisation for Economic Co-operation and Development, 2019). Reusing a standardized design and using it in multiple refineries can be seen as applying economies of scale. Next, the learning curve also applies as this illustrates how experience leads to less labour or time needed for a task (Hirschmann, 2014). Designing multiple refineries will provide experience to any contractor, which hopefully will result in familiarity and hence reduce the resources (e.g., manpower and time) needed for the next design. Furthermore, there is streamlining which is also somewhat related to the previous two concepts. Streamlining is the process of optimizing business processes within an organization which can help save time and be efficient (CFI Team, 2023). Different processes and even the design itself can therefore be streamlined to help a contractor cut time and reach its goal. For refineries that share a lot of similarities, streamlining can prove to be very beneficial.

For the other keywords like location, area, and site, they are also added hoping to find papers where projects of similar kind are implemented in different locations. What's more, the words actor* OR stakeholder* are also initially included, but this resulted in just one paper. For that reason, it was decided to exclude both words as search terms. The new set of keywords used is therefore: TITLE-ABS-KEY (("learning curve" OR streamline OR "economies of scale") AND (design OR process OR project) AND (location OR area OR site) AND (biofuel OR refinery)). To clarify, economies of scale, learning curve and streamline are not considered synonyms. The operator OR is used to ensure that a least one of the said concepts is present. The final set of keywords used resulted in 43 papers. Limiting the results to subject areas energy, engineering, and chemical engineering, then viewing only English papers and considering only articles and conference papers delivered 30 document results. The 20 most cited and relevant papers are chosen for pre-selection where the abstracts are read. From the 20 papers reviewed, only 10 are deemed to have a relevant topic. The aim of each paper, the methodologies & tools used, and the key takeaways of the authors are all presented in Table 1.

***Table 1** Literature review result*

Author(s)	Research aim	Methodology & Tools	Major findings of author(s)
Santibañez-Aguilar et al., 2014	To create an optimal and sustainable biorefinery supply chain that considers various relevant factors like availability of feedstocks, location for processing plants, price, location of storage, and others.	The problem was approached using a computational model – a multi-objective, multi-period, mixed-integer linear program that was applied to a case study in Mexico. GAMS was used to model the problem.	Implementing a biorefinery supply chain should consider (a) economic, environmental, and social objectives; (b) cost and availability of bioresources; (c) production technologies and (d) biomass processing.
Ekman et al., 2013	A case study that shows how a sustainable and straw-based refinery can be implemented by utilizing excess heat.	Review of environmental and policy issues using Aspen Plus to model simulations with Sweden as its case.	2nd generation biofuels (e.g., straw) are becoming popular options. Important things to consider are the regional availability of raw materials and heat sinks.
Bridgewater, 2007	A paper that gives a thorough explanation of fast pyrolysis, focussing on the reaction systems.	A case study of pyrolysis is conducted.	(Fast) Pyrolysis is a promising thermal processing of biomass for biofuels, however, quite a bit of efficiency improvement is still required.
Laude, 2011	Looks into the environmental and economic performance of CCS incorporated into two refineries in France.	The Impact 2002+ methodology was used. Carbon energy footprint and discounted cash flow analyses were also conducted.	Testing CCS in biorefineries is a good opportunity for early deployment. Financial aid from the government is needed to guarantee rates of return.
Stephen et al., 2010	Discover the size by which a biomass-to-liquid biofuel setup is maximized while keeping the logistical perspective in mind.	Logistical analysis was done to find out how much feedstock and deliveries would be needed depending on the size of the setup.	Biorefineries can learn a lot from oil refineries, but not when it comes to feedstock delivery, management, handling, and industrial production model.
Memişoğlu & Üster, 2016	Provide a comprehensive model that minimizes logistical costs associated with the supply chain.	Uses a Benders algorithm to solve the problem and solves it using C++. Then implements it in a case study in the state of Texas.	Decomposition based on biomass supply and network design produces suboptimal results, hence integration is preferred.
Li et al., 2018	To investigate the design and process simulation of a pilot bio-jet fuel facility.	Aspen Plus was used for simulation and process design.	Bio-jet fuel is currently still unprofitable even with government subsidies, due to high material and utility consumption.
Mupondwa, 2017	A paper that tries to create a business case for the viability of cellulosic ethanol biorefinery.	A case study of Canadian Prairies that uses a modeling approach to determine the feasibility of a region concerning a large-scale commercial production.	Government support is needed to advance downstream commercialization and to reduce the cost of lignocellulosic feedstock utilization.
Brinsmead, 2015	Analyses the costs of advance biofuel technologies that do not compete with food production in Australia.	Via a calculation model, a cost analysis was conducted to find the optimum scale of a plant for different types of fuel.	Research on how feedstock harvesting-, and collection costs can be lowered is lacking
Amigun & Musango, 2011	Looks into the potential of biodiesel feedstock in Southern Africa.	An analytic hierarchy process methodology was implemented to aid in the	The choice of crop(s) blending to produce feedstock (oil) is crucial for a sustainable

	decision-making using Expert Choice 2000™	production system.

2.2. Literature review result

The papers in Table 1 can be classified into three kinds when talking about (standardized) refinery design. The papers of Santibañez-Aguilar et al. (2014), Ekman et al. (2013), Bridgewater (2007), Stephen et al. (2010), Li et al. (2018), and Mupondwa (2017) primarily focus on the technical elements of the refinery. Others like Memişoğlu & Üster (2016) and Brinsmead (2015) look more into the economic side, while Laude (2011) and Amigun & Musango (2011) put their attention to social and environmental aspects. It must be noted that there are papers in Table 1 that can have more than one classification. Such as the paper of Laude (2011) that also considers economic factors to be important, in this case, the discounted rate for a discounted cash flow. These papers are all considered to be important as evident in their high citation count.

As mentioned in the previous subchapter, the literature review aims to discover the current approach when it comes to implementing a standardized refinery modification design. The first paper analyzed is that of Santibañez-Aguilar et al. (2014) and from the said paper the approach of using mixed integers or considering multiple aspects is done. This is deemed to be relevant as considering multiple aspects in such complex projects will all the more increase its's chances for successful implementation. Santibañez-Aguilar et al. (2014) also mention that there are multiple things to be considered in implementing a biorefinery supply chain (economic, environmental social, availability of bioresources, and technology). Stakeholder perspectives on the other hand are something not considered, something this thesis will. In the paper of Ekman et al. (2013), the use of political aspects in refinery implementation is present. It is discovered that there are crucial policies that must be considered with the use of 2nd generation biofuels. This became a reminder that there are most certainly regulations as well when it comes to implementing a standardized refinery modification design globally. The said paper motivated the use of political aspects as part of this research. Bridgewater (2007) focuses on fast pyrolysis and explains this technology thoroughly. This gives the idea that technological aspects are something that must be given thought to and not neglected. The paper also shortly discusses the barriers present and how efficiency improvements are still lacking. In contrast to the previous paper, Bridgewater showcases the significance of technology in biorefineries, whereas Ekman et al. (2013) focus on policies. Neither paper however looks at both technology and policy simultaneously.

In the paper of Laude (2011), the focus lies on carbon capture and storage implementation in biorefineries. The said paper shares similarities with that of Santibañez-Aguilar et al. (2014), which considers environmental and economic aspects as relevant. However, just like Santibañez-Aguilar et al. (2014) the paper of Laude (2011) does not look into the impact of various stakeholder perspectives in the uptake of carbon capture and storage in biorefineries. Next is that of Stephen et al. (2010) which investigates optimizing the logistics of feedstock delivery. They admit that biorefineries can learn a lot from oil refineries but not when it comes to feedstock delivery, management, handling, and industrial production model. These elements are all very interesting and arguably closely related to stakeholders. A factor that cannot be ignored in such complex projects and this study as well. The paper of Memişoğlu & Üster (2016) is another optimization paper that uses a model to minimize logistical costs. From the paper, it is concluded that integration (of a network) is important, as it produced a more optimal result. The concept of integration is also very relevant to this study. Integration in the form of stakeholder integration is surely needed in terms of the implementation of a standardized refinery design. The papers of Laude (2011), Stephen et al. (2010), and Memişoğlu & Üster (2016) all look at optimization from a technical point of view only.

Li et al. (2018) is a paper that investigates techno-economic aspects primarily. It looks over the design and process simulation of a pilot bio-jet fuel facility. Their outcome states that even with government financial support, bio-jet fuel is still unprofitable. Mupondwa (2017) on the other hand sees that government support will help in advancing commercialization and reducing the cost of lignocellulosic biomass. Both papers of Li and Mupondwa highlight the different impacts the government and politics can bring concerning the success of technology implementation. Brinsmead (2015) explores lowering the cost of advance biofuel technologies using a model. From that paper what can be taken over to this research is the knowledge there are various means to lower cost. Although it may seem farfetched, the same thought can be applied in this paper, when it comes to alignment methods of stakeholders – there are various ways to achieve stakeholder alignment. Finally, Amigun & Musango (2011) explores the sustainability and the potential of biodiesel in Sothern Africa using a decision-making model. What is beneficial from this paper is the knowledge that each country in that region has different biodiesel potential. This means that a standardized refinery cannot so easily be implemented in such a region and careful study of the possibilities, technically, economically, environmentally, etc. is needed.

2.3. Knowledge gap

Out of the reviewed papers, various things are taken over as explained in the previous paragraphs and utilized in this paper. Some papers solely look at the technical aspects of a refinery and how it can be optimized. Also, some are papers that look at the social and political aspects of a refinery implementation. However, when it comes to (implementing) a refinery, standardization is not associated with it in the papers that have been reviewed. Understandable as standardization in biorefinery implementation is very limited. Moreover, from all these papers none include stakeholders' perspectives. The involvement of this element is something that cannot be ignored. The dissertation of Palmeros Parada (2020) stresses that stakeholders (and their values) should already be included in the early-stage design of biorefineries. Now consider that what's being talked about here is a standardized refinery modification design, then the involvement of stakeholders becomes of paramount importance. This is because every refinery is unique and so are the people working in that refinery. This means that a standardized refinery design cannot just be so easily implemented in any arbitrary refinery. On top of that, none of the papers reviewed in Table 1 look at multiple elements simultaneously. There might be a few that do study two elements at once, like Laude (2011) that looks at economic and environmental elements, but not more than that. Various elements need to be considered at the same time.

In light of the limited research found when conducting a literature review in subsection 2.2., it was found that a study considering the reuse or reapplication of a standardized technical refinery modification design is missing and should therefore be conducted. The hypothesis introduced earlier in subchapter 2.2, about this statement being a knowledge gap is thus correct. Therefore, research is being proposed in this paper that will not only look at the technical and political elements of a standardized design but will also involve stakeholders. Thus, three elements will be taken into account, unlike the papers in Table 1 that look into one or at best two elements at a time. The knowledge gap discovered here became the foundation upon which the main research question is based upon.

3. Research Design

Chapter 3 of this paper will showcase the methodology to be applied in creating the framework. It starts by sharing the main research question along with the sub-questions to be tackled in this study. Then, the research approach and methods of the research in 3.2. Finally, the scoping and case of Worley in 3.3. and 3.4. respectively.

3.1. Research Questions

Reusing an existing standardized technical design of a refinery is not that simple. First of all, the refinery on which the standardized technical design was based can have differences with the refinery to be modified. The greater these differences, the harder it becomes to just use a standardized design. Then, there is also the issue of possibly different institutions due to differences in site location. What is allowable in country A, where the standardized design is based, might not be the case for country B, where one of the refineries that need to be modified is located. Lastly, there is a potential clash between the varying stakeholders present. Global actors like the design contractor might want to implement a standardized design that will lead to a global optimum across all refineries to be modified. Locally, however, those from the refinery might want to approach the modification differently, in a manner that will maximize their local optimum. Aligning therefore the global and local actors is deemed necessary to enable an effective implementation of the standardized technical refinery design. How all these factors interplay is what makes the system entirely complex and yet very interesting. Considering all this information and the knowledge gap established in 2.3., a main research question is formulated as follows:

> ***"How can a standardized refinery design be implemented keeping local and global effectiveness in mind and considering different stakeholders?"***

To answer the proposed main research question, sub-research questions are also created. Tackling these sub-research questions will allow a systematic step-by-step approach to gathering information that will be used to answer the main research question.

<u>Sub-research questions:</u>

1. Who are the different stakeholders and what are their interests and roles in the implementation of a standardized refinery design?
2. What aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?
3. How can the aspects discovered be used to identify the requirements needed to help implement a standardized refinery design in different geographic locations?
4. Which stakeholders are relevant for the implementation of the identified requirements?
5. How can the interest and priority of the relevant stakeholders be aligned to achieve maximum repeatability of the standard design?

3.2. Research Approach and Methods

This paper aims to contribute to the implementation of a standardized refinery modification design considering technical aspects, political aspects, and the various stakeholder perspectives. To achieve this the overall research approach to be followed is the design science cycle (Hevner, 2007). A conceptual model of this approach is illustrated in Figure 1.

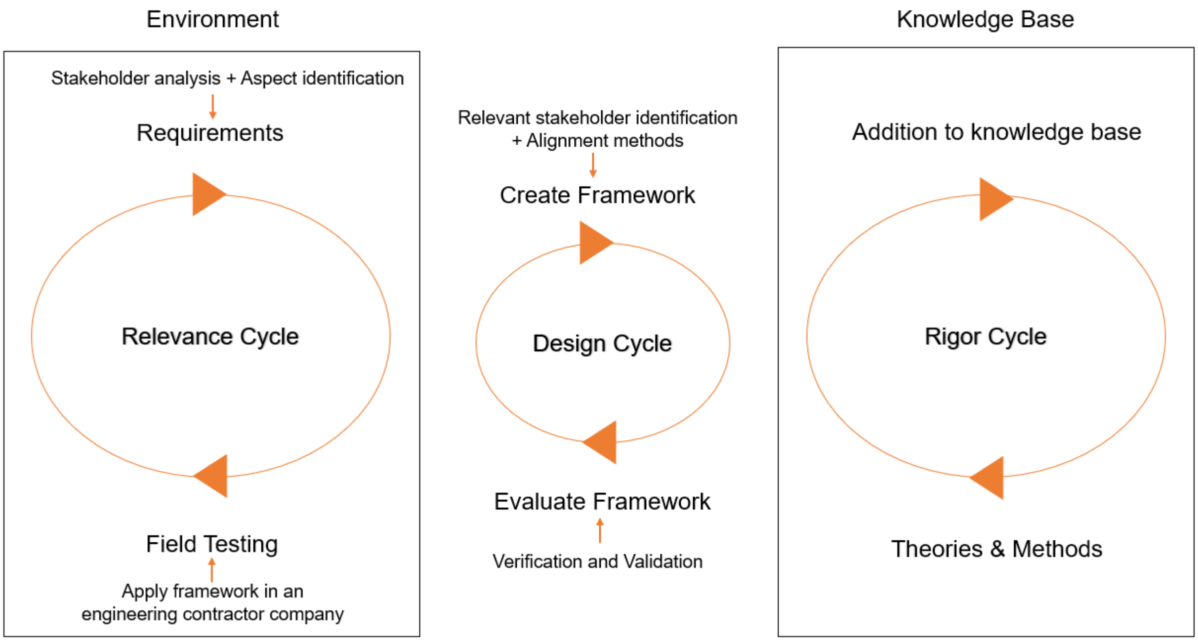

***Figure 1** Design Science Cycle*

A design science approach involves the process of designing artifacts to solve a problem (Peffers et al., 2007). This is a fitting approach since the overall objective of the research is to enable the reuse of a refinery modification design while considering different aspects using an artifact in the form of a framework. The design research cycle to be followed is that of Hevner (2007) composed of three cycles, Relevance cycle, Design cycle, and Rigor cycle. The relevance cycle begins the research by presenting the potential problems or opportunities to be addressed. During this cycle, requirements coming from the environment are presented as inputs to the artifact. The last element of the relevance cycle is the testing of the artifact in the environment. Along with this are acceptance criteria, introduced to determine if there is any improvement by the implementation of the artifact. The framework to be created in the design cycle can be tested in the field by applying it in an engineering contractor company.

Next is the design cycle where the design artifact, in this case the framework, is created and evaluated. The requirements from the relevance cycle are the input for the design cycle. Along with it are the results of the relevant stakeholder identification and alignment methods. Once the framework has been created, it must be evaluated before testing it in the field. This evaluation can be done by verification and validation of the framework. As last, there is the rigor cycle, which is the connection of the artifact to the literature. In this cycle, the appropriate theories and methods to be used in the creation and evaluation of the artifact are identified and utilized. During this cycle, contributions to the knowledge base are also achieved once the field testing of the designed artifact turned out to be successful.

The framework to be created focuses not on the technical design or the blueprint of the standardized refinery modification, but rather on the entire complex system of design implementation. The implementation mentioned in the main research question goes beyond the mere installation of the refinery design. It also investigates how the entire refinery system can be operated and managed optimally, which means that the local performance of the refinery is crucial as well. All refineries are unique, the people working in them and their respective environments, and all these can have an impact on the standardized design. What's more, relevant aspects from the political side will also be included. This can greatly vary as the refineries are in different countries and continents. On top of that, the creation of a standardized design is something that cannot be neglected. It is important for the contractor that's responsible for modifying the refinery, that all relevant stakeholders be unified concerning the entire project (planning, implementation, and operation) while keeping local and global effectiveness in mind. By designing an artifact in the form of a framework, it is hoped that this can be achieved, and the main research question be answered.

3.2.1. Stakeholder Analysis

Before discussing the stakeholder identification method, the word stakeholder will first be explained. A stakeholder which is sometimes also referred to as an actor, is a person or group who has a certain interest in a particular system. Actors and stakeholders, depending on who is asked, can also have some differences definition-wise. However, for this research, the two words will be considered interchangeable and so whenever the word actor is mentioned, then this will refer to a stakeholder and vice versa.

The first sub-question "*Who are the different stakeholders and what are their roles in the implementation of a standardized refinery design?*" targets to find out who the stakeholders are along with their roles in the implementation of a standardized refinery design. To discover who these stakeholders are, an actor analysis shall be conducted. This step is crucial as this is the starting point of the entire research. Stakeholder analysis is done for various reasons. Mainly, it is used in the fields of management, policy, and project implementation (Varvasovszky & Brugha, 2000). With the latter applying to this research. Stakeholder analysis used in project implementation aims to increase the chance of success of the project by informing the stakeholders of the design, preparation, and implementation (Varvasovszky & Brugha, 2000). This is what this research will try to do as well with the case of Worley.

The book written by Enserink et al. (2010) explains in six steps how an actor analysis can be conducted. It starts by (1) formulating the problem, then creating an (2) inventory of all involved actors will take place. The third step is to (3) map out the relationship of these stakeholders in a formal chart. Afterward, the (4) interests, objectives, and problem perceptions of everyone are noted. As the last steps, all the (5) interdependencies of the stakeholders will be determined and the (6) result of each step will be communicated to the problem owner to relay all the findings along with the consequences. Not every step mentioned in the book is necessary to be conducted. The first one about formulating a problem is in essence already done. This entire research is based on the problem perceived by a problem owner. Which is about implementing a standardized design keeping local and global effectiveness in mind and considering the different stakeholders in play. Out of this problem, a main research question along with sub-research questions have been formulated. The question that rises now is, "*Who is the problem owner?*". The problem with the implementation of the standardized design will initially be viewed from three perspectives as suggested by an industry expert. That from an engineering contractor as the standardized design creator, the client (oil company) as the owner of the refineries to be modified, and from a refinery's point of view with regards to the operation of the refinery. A problem perception from these different perspectives will be created. Out of the said problem perception, it can be discovered which perspective fits best the proposed research question and hence the problem formulated that this research aims to tackle. It is for this reason that the first step of overall problem formulation is no longer required as this has been done already.

Then, there is also the last step which is about communicating with the problem owner the result of the stakeholder analysis. This is also another step that will not be taken yet. The reason behind it is that after conducting the stakeholder analysis, the main research question remains unanswered. Frankly, only one sub-question will be answered by the stakeholder analysis. Completing the entire research and answering all research questions shall be done first before the results are presented and communicated with the problem owner. After eliminating these two steps (first and last), then there are four remaining left that will be conducted as part of the stakeholder analysis. These are stakeholder identification, problem perception discovery, creation of a formal chart, and development of a power-interest matrix. A minor change will be made in terms of the order of the steps to be conducted. The stakeholder identification along with the problem perception will be combined in one section. A specific problem perception for each stakeholder will be done to get to know them better (i.e., discovering their interests and desired situation). The perceived current situation of the stakeholders will be placed in the introduction of this paper to indicate the research topic's relevance. Afterward, the formal relation of the stakeholders is identified and will be illustrated using a formal relations chart. Finally, the stakeholders' interdependencies will be identified and mapped in a matrix based on their power and interest. This step will allow the identification of the most critical stakeholders, those that have high power and high interest in the project. They are deemed to be critical for the project because they are the key players. They have to capability to block or support a project (Enserink et al., 2010).; hence it's best if they share the same interest with the problem owner.

The needed information will be collected by interviewing experts from an engineering contractor, an oil company, and the Technological University of Delft and supplementing it with literature research wherever needed. Conducting such interviews is very time-consuming due to all the practicality involved like looking for the right person to be interviewed and contacting them (Thompson, 2016). Also, Thompson (2016) mentions that there is the potential for bias to arise. To counteract these two drawbacks, careful planning will be conducted to reduce delays that could be caused by interviews and literature verification will be done, if possible, to verify the provided answer of the experts. Also, when it comes to conducting interviews, the target is to interview as many stakeholders as possible with different backgrounds, expertise, task, and position from different stakeholder groups (e.g., engineering contractor, refinery owner, refinery operator, etc.). The reason here is to prevent the entire data from getting biased and one-sided results. The only tool needed for this method is recording materials like a cell phone or computer to record the interviews. The data coming from the said interviews will be analyzed and then used in the stakeholder analysis.

3.2.2. **Aspect Identification**

The second sub-question "*What aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?*" is formulated to discover all the aspects that must be considered to allow a successful implementation of a standardized refinery modification design. Only technical and political aspects will be considered in the second sub-question, the reason here is explained in subchapter 3.4. The technical difference between the refineries and the institutions in place in their location can vary greatly. Therefore, these aspects will be used to ensure that nothing is overlooked, and every important thing is considered.

First, a literature review will be conducted, then an interview with experts to verify the information gathered during the literature research. A literature review will be done in this research to describe the materials that provide an examination of the current literature (Grant & Booth, 2009). This method will be used here to consolidate and summarize the necessary information, in this case, the aspects that must be considered (i.e., technically, and politically). A weakness of this method however is the possibility of bias due to the limited scope (Grant & Booth, 2009). Also, a literature review may present aspects that are not specifically relevant to this unique case. As observed in the literature review conducted for this research in Chapter 2, knowledge of how a standardized design can be reused is missing. That is why there is a high possibility that such case-specific aspects are also missing. Therefore, interviews will be conducted to counteract these weaknesses. The plan is to conduct interviews with experts from the technical and political field to verify if the information found in the literature review are accurate and not biased. If it turns out that such information is not present in the literature, then the information provided by the interviewees will not act as a verification anymore. Rather, this information will be seen as the answer to the sub-question itself. The interview for the first and this sub-question will take place simultaneously. This means that during this interview, the critical stakeholders are not yet identified. Afterward, once the stakeholder analysis has been completed, then only the answers of the critical stakeholders regarding the relevant aspects will be considered in this sub-question.

The number of interviews to be conducted throughout this entire research is not unlimited. Still, there is a high likelihood that a lot of people will be interviewed which means that plenty of data would be analyzed. The interview data will be processed as follows, first, an interview transcript is made, then from that a summary of the transcript is created (Appendix 8.4.). The summary is read a few times to get familiarized with the interview participants' answers. Afterward, out of the interview summaries, the essential information needed in answering the sub-questions will be extracted. As mentioned in the previous section, the tool to be used in answering this sub-question is recording material. On the other hand, for the literature review, the database Scopus shall be used due to familiarity reasons.

3.2.3. Requirement Analysis

Section 3.2.3. tries to tackle the question of *"How can the aspects discovered be used to identify the requirements needed to help implement a standardized refinery design in different geographic locations?"*. The next step after defining the aspects in section 3.2.2. will be to create a list of requirements out of it. A method to be followed is that proposed by Brazier et al. (2018) which is composed of Requirements design, Artifact design, and Design process coordination. The first step is requirements design and during this step, the needs and desires of stakeholders are translated into a requirement (Brazier et al., 2018). An initial list of the requirements will be created by carefully analyzing the interview data of the critical stakeholders gathered in the previous sub-questions Once the initial requirements list has been finished, another round of interviews with the critical stakeholders identified in the stakeholder analysis will be conducted to verify the initial requirements list.

There is a reason why the interviewees were not right away asked to come up with a list of requirements. Firstly, developing a list of relevant aspects (e.g., space requirement, site specifics, permits, etc.) beforehand creates an overview that can help in classifying the requirements. Going the opposite route of requirements to aspects might be more challenging, especially if the requirement is composed of a plethora of items. Secondly, asking the interview participants to come up with a requirement right away might limit their answers to just their expertise. In such a complex system where different experts are needed to interact and work together, then this will not be that ideal as certain items might easily be overlooked. An interview participant might hesitate to give a certain item for the requirement list, thinking that the others will do it anyways. Hence, it is better to first show the interview participants the list of important aspects generated along with the list of the initial requirements. During the interview, the participants will be asked to look at the aspects discovered based on sub-question two. After that, they will inspect the list of the initial requirements that has been created. The experts shall be asked whether the items listed in the requirements are correct or not and if anything is missing. Once all the interviews have been finished the feedback received from all the interviewees will be combined and incorporated into the initial requirements list. The updated requirements list will then be converted into a requirements tree to get a better overview.

The next step is artifact design where the requirements identified during the requirements design are utilized as input to shape an artifact. This artifact being mentioned will be used to fulfill or meet the requirements. However, for this research, the focus is not directly on the fulfillment of the requirements. But rather, the aligning of the stakeholders with the relevant technical and political aspects to contribute to the implementation of a standardized refinery modification design. Therefore, the artifact to be designed here is a framework that will enable this alignment being sought of. The framework to be created will be used to visualize the entire process of stakeholder identification down to stakeholder alignment. It will show a step-by-step approach to how a standardized refinery modification design can be implemented considering stakeholders and political- & technical aspects. For this reason, artifact design will be done differently. Instead of fully designing an artifact that will tackle the requirements, this step will only go as far as identifying possible means to accomplish the requirements.

The last step in requirements analysis presented by Brazier et al., (2018) is design process coordination. They defined it as the formulation of strategies to coordinate the tasks and responsibilities between requirements design and artifact design. It also points out the proper allocation of the available resources (e.g., time, expertise, budget, a team, etc.). This step's importance is clear, but it falls outside the scope of this study for a few reasons. The first and most important reason is that design creation will be done by only one researcher, hence, coordination on how resources will be allocated is not needed. Idem, when it comes to coordinating tasks and responsibilities. Second, examples of the resources mentioned like expertise, budget, and a team are not at the disposal of the researcher. Therefore, after considering these reasons, it has been concluded that the step design process coordination can be excluded.

3.2.4. **Relevant Stakeholder Identification**

To answer the fourth sub-research question ("*Which stakeholders are relevant for the implementation of the identified requirements?"*), interviews will also be conducted to gather the information. From the point of view of an engineering contractor, this is very beneficial. A refinery on its own is already a very complex system. Many technical units must be maintained, monitored, and operated. Besides that, all the people work in such a local refinery with varying tasks and responsibilities. For example, there are technical stakeholders like refinery workers that operate the different units (e.g., hydrocracker, hydrotreater, etc.), there is a maintenance crew that looks after and maintains the units, and engineers that try to enhance a unit's performance. Then, there are those from the management position such as shift leaders that arrange the working schedule of the employees, a refinery manager that oversees the entire plant, and so on. Together they try to optimize the performance of the entire refinery system. Bringing a change in such a system by modifying it, especially by someone from the outside will surely disrupt the harmony and order in place. This is because the party from the outside responsible for bringing change may not have all the data and information about the refinery. Again, this is why it is crucial for an engineering contractor to identify who the relevant stakeholders are that must be involved in each step of the framework.

Rather than wait for the entire requirements list to finish before conducting the interviews, this step will take place simultaneously with the third sub-question. After the experts are asked about their thoughts concerning the requirements, then they will be queried as to who the relevant stakeholders are that need to be involved. To help the interview participants with this, the result of the stakeholder identification in the first sub-question can be shared with them. Answering such questions is clearly not that simple. Therefore, the interview participants will always be informed in advance as to what is expected of them during the interviews (e.g., by sending the interview questions in advance).

In answering the previous four sub-questions, dissent among the stakeholders may arise. Looking at sub-question four as an example, Stakeholder A might find X, Y, and Z as the relevant stakeholders to be considered for the implementation of an arbitrary item in the requirements list, while stakeholder B might say X, Y, and Q are the relevant ones. Such differences in opinion may exist, however, this will not be seen as a problem. The people to be interviewed have different expertise and experience. What person A thinks can be totally different from what person B does, as everyone is unique. In the scenario given above about stakeholder selection, then stakeholders X, Y, Z, and Q will all be considered relevant. To also allow the interview participants to be fully impartial, then they will be informed that their answers will remain anonymous. That way, they can fully voice out their thoughts without being influenced by the opinions of other stakeholders.

3.2.5. **Stakeholder Alignment**

The last sub-question: *"How can the interest and priority of the relevant stakeholders be aligned to achieve maximum repeatability of the standard design?"* is all about trying to align the priority and interest of all the identified relevant stakeholders, discovered in the previous sub-question. Stakeholder alignment is the process of creating an agreement or consensus regarding project-related decisions among all the relevant stakeholders (Slaney. 2022). To try and find an answer to this, a literature review will be conducted. The stakeholders coming from an engineering contractor and an oil company are those that will be seen as striving for a global optimum. On the other hand, the stakeholders from the local refineries will be striving for local optimum. It must be noted that it is not being assumed here that there will always be a misaligned interest and priority between the stakeholders. Although, dissent among the stakeholders is not always negative. Experts found that competition and tension, within acceptable boundaries, foster creativity, and innovation (Joni & Beyer, 2009).

However, in the cases where agreements cannot be reached, then the alignment of the stakeholders will be in demand. The purpose of this sub-question is to present alignment methods that could be useful if ever that would be necessary. There are various ways as to how this can be done and so the last sub-question will also try to find out which method(s) would work optimally considering the relevant stakeholders. Also, it will allow the identification of methods (if there are any) already being implemented at the moment and to what extent these methods are working. After the appropriate stakeholder alignment methods have been discovered, then these can be added to the framework. The framework can be seen as a combination of the answers from the sub-questions. Hence, some form of synthesis method will be used there.

3.2.6. Synthesis

In the previous sections, the necessary steps to be undertaken to answer each sub-research question have been described. Here in 3.2.6. it will be explicated how a conceptual model will be created to visualize the framework development procedure (see Figures 13 – 18). In the end, the same type of conceptual model will be used to illustrate the developed framework (see Figure 3). Take note that the developed framework will be presented first in the beginning of Chapter 4 before breaking it down in sub parts, that way the chronological flow of the development is easier to follow.

The framework to be created must be able to illustrate the necessary steps along with all the necessary information relevant to it. A fitting methodology for this is the use of IDEF0 (Integration Definition for Function Modelling). IDEF0 is normally used to model and analyze complex systems, system life cycles, and enterprise operations, additionally, it can be used to study the function and the interrelation among system components (Waissi et al., 2015). Putting this into context, the purpose of the proposed framework in this research is to find a way to enable the implementation of a standardized refinery modification design, through alignment of the heterogeneous stakeholders. Implementing such a standardized design is very complex (Appendix 8.4. – Program Director). There is a plethora of people involved with possibly varying interests and priorities. Forget the fact that creating a standardized design is already complicated on its own, but adding people to it is what makes the system complex. IDEF0 can help with this by showcasing the steps or processes that must be undertaken to enable the alignment of the relevant stakeholders.

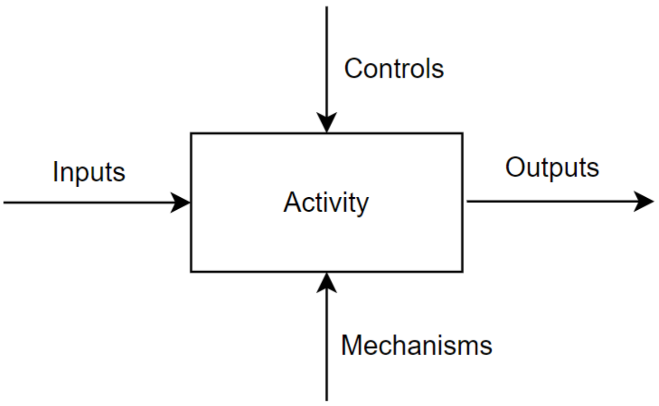

***Figure 2** IDEF0 building blocks*

Figure 2 here shows the building blocks of IDEF0 (Waissi et al., 2015). It is basically composed of a rectangle and four arrows. The rectangle in the middle of Figure 2 is where an activity is located. An activity can be a process, a transformation, a function, etc. that describes what must be fulfilled. The incoming arrow on the left, named input, dictates something (e.g., object, data, etc.) that must undergo change. Once it goes through the activity and has undergone change, then it comes out as output (arrow on the right side of the activity block). From the top into the activity block enter controls (e.g., laws, agreements, etc.). These are conditions that must be met when converting the input into output. Finally, from under come mechanisms into the activity block. Mechanisms (e.g., employees, machines, skills, etc.) are the means that can be used to change the input to an output.

The framework to be developed will contain the steps that must be undertaken from identifying the critical stakeholders, the relevant aspects, the requirements that need to be considered for the implementation of a standardized refinery modification design, and the alignment mechanisms. By answering all the sub-questions and developing a framework, it is hoped that the main research question can be answered.

3.3. Scoping

The literal implementation of a standardized refinery modification design will take much longer than the allowable duration period of this research which is 21 weeks. Therefore, the temporal scope of the research is only up until the creation of a framework to be used to answer the main research question. When it comes to the geographical scope, the research will cover multiple refineries spanned across the globe. Hence, geographical constraints are not present. When it comes to interview participants, stakeholders from an engineering contractor, an oil company (along with its local refinery), and political experts are the ones who will be interviewed.

To add to that, iteration is assumed to likely happen. Stakeholders discovered in the first sub-question will indicate which aspects are important. These aspects on the other hand can be pertinent for stakeholders who are not included in the stakeholder list. It is hence possible for the researcher to come across a crucial stakeholder that was not included in the stakeholder analysis. That unrepresented stakeholder can also have aspects that he/she finds important but not yet incorporated into the list of aspects to be considered. Hence, iteration is much desired to ensure that all the crucial stakeholders and aspects are identified and included.

When it comes to stakeholders, an essential assumption being made here is that the global and local stakeholders will surely try to optimize their respective systems and so a clash between the local and global system can occur. The local system here pertains to the local refinery, while the global system is composed of all the local refineries combined. It is believed that once all the relevant stakeholders are unified, then the implementation of the standardized refinery design can be made possible.

Another important element of scoping that must not be overlooked in this research is the engineering project life cycle. Such a cycle represents the stage at which a project currently is. Depending on the stage of the project, different requirements exist and it’s not always the same people working together. As much as possible though, the aim is to have the same people who worked on the previous stages to also work in the consecutive stages. Moran (2017) names five typical stages in an engineering project life cycle: (1) Conceptual Design, (2) Front End Engineering Design, (3) Detailed Design, (4) Construction Design, and (5) Post Construction Design. For this research the distinction between these stages is irrelevant. This is because it is assumed in this research that the answers of the interview participants will be relatively the same irrespective of the engineering project stage.

In reality, this may not be the case as the task of, for example, an Electrical Engineer, is not entirely the same in each stage. Looking at Front End Engineering Design and Detailed Design, a significant difference in terms of work detail is present and so an Electrical Engineer might have to do more specific tasks during stage three than in stage two. On the other hand, there are also stages where an Electrical Engineer might not be entirely needed at all, say the Conceptual Design part. This means that if the focus of this research was Detailed Design, then an Electrical Engineer would be a perfect candidate to interview. Whereas if it was Conceptual Design, then interviewing an Electrical Engineer might be irrelevant. In other words, focusing on just one specific engineering project stage can eliminate the chances of interviewing multiple relevant stakeholders. This is counterproductive in a stakeholder analysis where one aims to identify as many stakeholders as possible. With the aim of developing a framework that will align all relevant stakeholders in implementing a standardized design, it is greatly desired to not miss or overlook any stakeholders. Hence, it becomes logical for this study to not consider the engineering project life cycle. Rather the different stages will be combined and seen as one continuous process with no changes in the involvement of stakeholders. It is for the very same reason that the various stages of an engineering project life cycle are no longer explained.

3.4. Case of Worley

To get a better understanding of the problem and to apply it in the real world, an engineering contractor, such as Worley, will be used as a case study. In one of Worley's projects, they have connections with relevant stakeholders in a project with refinery modification. In the said project, a standardized design is being created to be utilized to modify existing fossil-based refineries to biobased ones. Modification in this context pertains to the addition of refinery capacity in the shape of biofuels. The standardized technical design is partially going to be based on a refinery that the company modified earlier. From this point onwards, the said refinery shall be called the base refinery. In this project of Worley, the standardized technical design derived from the base refinery needs to be implemented in different refineries. The use of Worley as a case means that the majority of the interview participants will come from Worley and its connections. Hence the framework to be developed will also be tested out in the project of Worley.

The refineries to be modified are not identical, nevertheless, the similarities between them are greater than their differences in technical and political wise. These two factors are chosen for certain reasons. Technical factors are important as the project is heavily technical based. In this current project of Worley, the focus of this study will not be on the technical design itself but on its implementation and the factors that can affect it from the technical and political side. To reiterate, the word implementation in this context does not only point out the literal usage of the technical design. It also encompasses the creation of the design. Exclusion of the standardized technical refinery design means that other technical aspects will then become the focus of this paper like utilities (e.g., water, electricity, etc.) and available space among others. From the political side, this mainly refers to factors that need to be considered before permits from the government and regulators can be acquired such as sustainability and safety to name a few.

Other factors that will not be included in this research are societal and economic-related factors. Societal factors are those that can affect one's lifestyle like education level, religion, wealth, and others (Betts, 2016). On the other hand, economic factors are those that affect the economy (e.g., inflation, wages, interest rate, etc.) and in turn influence a business (Srivastav, 2019). These factors were excluded to limit the scope of the research and make it manageable. Otherwise, the research will get too broad and possibly not doable within the allotted time schedule. There are also other reasons upon which this decision is based on. First off, looking at societal or sometimes known as social factors, it is no secret that going from fossil-based to biobased will lead to an overall positive effect on society. This is mainly due to the reduction of carbon emissions and hence the reduced impact on the climate. Therefore, it is assumed in this research that no barrier or hindrance would be coming from the citizens to oppose the modification of a refinery, as the said modification will result in the collective betterment of the society. Even though there is still the possibility for a few to be negatively affected by this project. Next is the economic factor, another one that's left out of this study. In this research, economic factors are seen as those that can affect the decision of an oil company to proceed or not with a refinery modification project. There is probably not a single project out there of a company where the business side does not play an important role in. After all, no one would be willing to invest in a project, if that project will ultimately lead to a loss or worse bankruptcy. This same principle also applies in the project of Worley. A potential client will not decide to modify their fossil-based refineries and hire Worley if the project seems to be unprofitable. This means that before Worley would have received a go signal from a client, then they surely had already conducted some business case studies. It is therefore assumed that the modification of the fossil-based refineries will lead to a profit for a client, otherwise, it would not have hired Worley. Hence, it becomes superfluous to further consider economic factors in this study. For clarification, the disregard of economic factors mentioned here strictly refers to the exclusion of the economic feasibility of the implementation of a standardized design. This means that any other economic related elements like the use of monetary incentives or compensation can still be relevant and present in this research.

4. Framework Development

As shown in Figure 1 in subchapter 3.1., various steps need to be undertaken before the framework can be created. But before these steps can be shown, the overall framework that has been developed will first be illustrated. Afterward, the various steps on how the framework is created will be explained in more detail, step-by-step in the coming subchapters. The framework starts with the stakeholder analysis (A1 in Figure 3) in subchapter 4.1. Afterward, in subchapter 4.2. the process of important aspect identification is explicated (A2 in Figure 3). With the help of these aspects and the would-be result of stakeholder analysis, a requirement analysis (A3 in Figure 3) will be done in 4.3. Then, how the relevant stakeholders per requirement will be identified is explained in 4.4 or A4 in Figure 3. Afterward, the appropriate alignment method is presented in the subchapter thereafter, A5 in Figure 3. This chapter will ultimately conclude with 4.6. where all the information from subchapters 4.1. to 4.5. are synthesized (A6 in Figure 3). A larger version of Figure 3 can be seen in the Appendix 8.5.

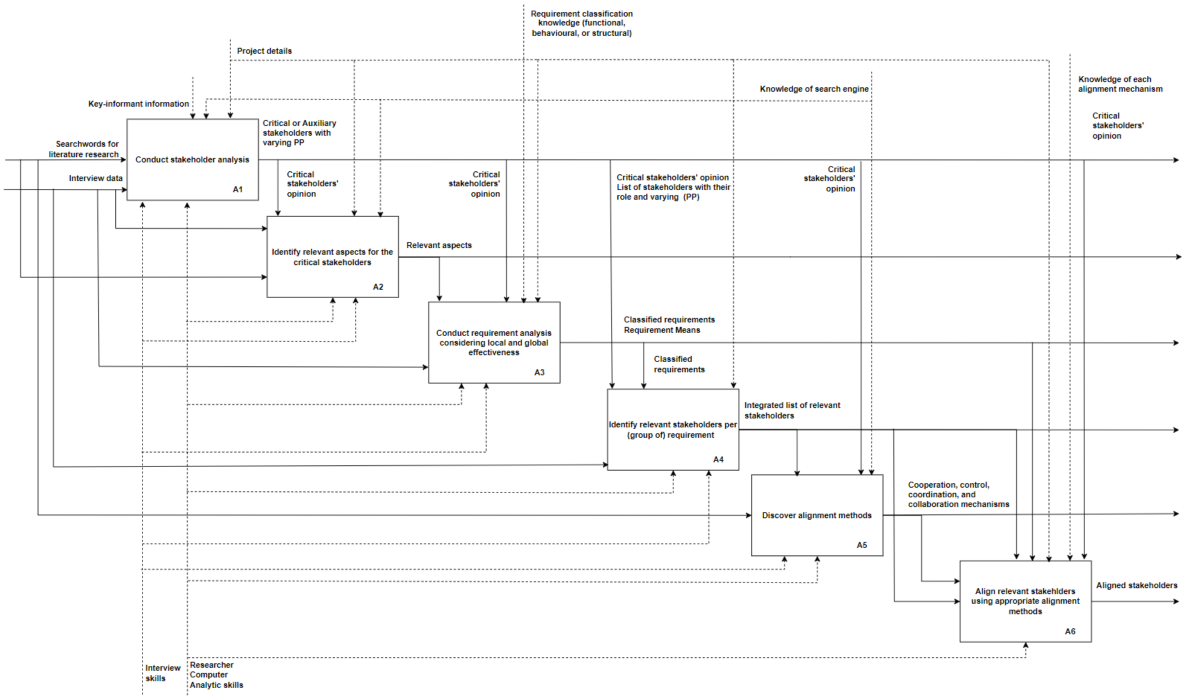

Figure 3 IDEF0 Level 1

Each activity shown in Figure 3 is comprised of multiple lower-levelled activities. This means that each activity can be split into other activities. For example, A1 or the conducting of stakeholder analysis can be broken down into three sub-activities A11 – A13 (see Figure 13 in Appendix 8.5.). The same type of breaking down is done for all the other activities (A2 – A6) which can be seen in Figures 14 to 18. Going the opposite route of zooming out will lead to Level 0, which is the highest level of IDEF0 shown in Figure 4. Level 0 depicts the entire framework as one activity (A0) that transforms interview data and search words for literature into the outputs. Compared to other IDEF0 figures, the control and mechanism arrows in Figure 3 are given as a dashed line in to differentiate them from inputs and outputs. In the coming subchapter, the first part of the development of the framework takes place.

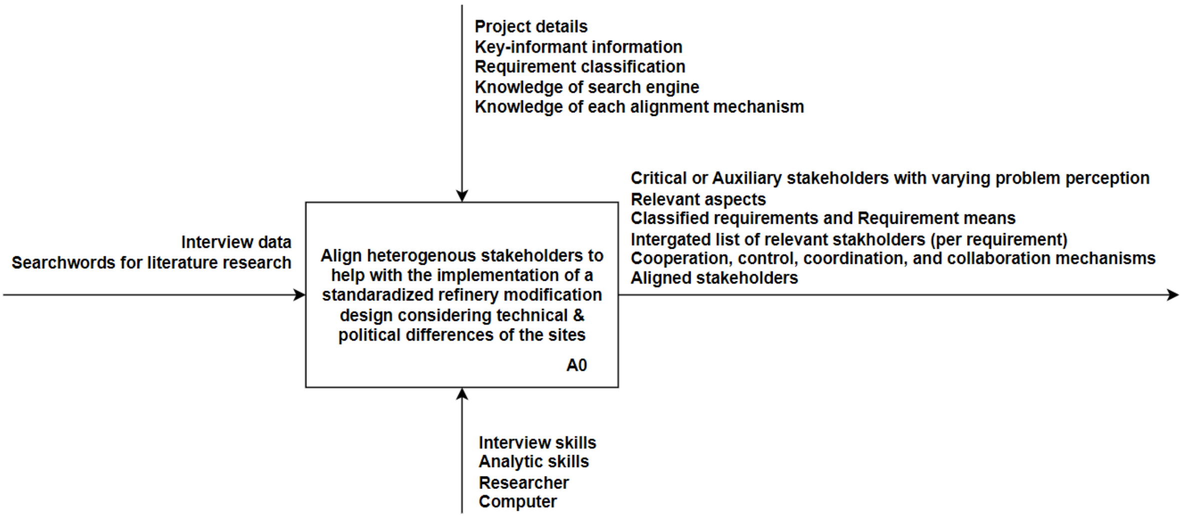

Figure 4 *IDEF0 Level 0*

4.1. Stakeholder Analysis

In this subchapter, the first step in the development of the framework or A1 in Figure 3 takes place. This step is crucial as it is here where the stakeholders are classified based on their interest and power. This allows the potential problem owner to discover who the important stakeholders are who can greatly affect or influence the system. It starts with stakeholder identification in section 4.1.1. Then, in 4.1.2. a method on how the relationships of the stakeholders can be illustrated is explained. The final step of stakeholder analysis is distinguishing the interdependencies of the stakeholders, and this is explicated in 4.1.3.

4.1.1. Step 1: Identify stakeholders and their problem perception

The very first step in stakeholder analysis is the identification of the stakeholders. This process is all about determining who the stakeholders are in the implementation of a standardized refinery modification design. In identifying these stakeholders two ways are applied in this paper, via interviews and literature research.

Enserink et al. (2010) present various means on how the inventory of the stakeholders can be made. Out of all the approaches mentioned in their book, the approach called *reputational* is selected for the framework development. A reputational approach uses the key informants related to the problem and asks them to identify the stakeholders. Key informants are people who can act as proxies or representatives for their colleagues in the organization (Parsons, 2008). During the interview, these proxies will simply be asked as to who they think the stakeholders are in the implementation of a standardized refinery modification design. To verify if the list generated via interviews with the key informants is accurate, then literature research is also conducted. During the literature research, a careful selection of the appropriate search words must be done. That way, a relevant list of stakeholders will be generated. If ever any pertinent stakeholder is missing from the list of stakeholders created via interviews, but present in the list made through literature review, then this stakeholder must be added to the prior list.

Once a list of stakeholders has been generated, then interviews with as many stakeholders as possible must be conducted. Keeping in mind to interview as diverse stakeholders as possible, with diverse here pertaining to different professional backgrounds and expertise.

During the interviews, the research should first be briefly explained to the participants. Then, they will be asked about their problem perception, so concerning their desires regarding the situation, the status of the current situation, the cause of the difference between the existing and desired situation, and finally the possible solutions to reach their desired situation. The situation being mentioned here pertains to the implementation of a standardized refinery modification design. The desired situation is what a stakeholder wishes to achieve regarding the implementation of a standardized refinery design. While the existing situation points to how it would normally occur, ceteris paribus. It is also during this step that the problem owner shall be identified. The problem owner to be chosen must have a problem perception that (closely) matches the formulated research question. All the steps mentioned from the beginning up until now correspond to A11 of Figure 13 (see Appendix 8.5.). Out of these steps, the output is a list of stakeholders with varying problem perceptions.

4.1.2. Step 2: Determine stakeholder relations

After discovering who the stakeholders are and how they perceive the problem, then the next step is to discover what their professional relationships are mutually. This professional relationship in terms of who works directly with whom can be visualized using a formal relations chart. In a way, it can also be seen as an organizational chart. The difference, however, is that in an organizational chart, relationships within the organization itself are shown excluding that of the outsiders. For a refinery system where multiple stakeholders from different organizations work together, then an organizational chart will not be able to provide a full view of all stakeholders involved. Besides the professional relationships between the stakeholders, their formal positions, tasks, and roles are also shown. Finally, the most important legislations that shape the system are also present in a formal relations chart.

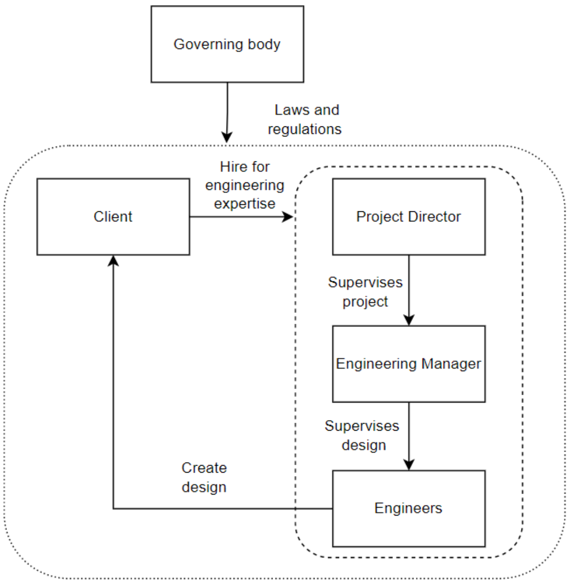

Figure 5 *Formal relations chart*

A simple example of a formal relations chart is shown in Figure 5. A formal relations chart depicts hierarchy in a system; hence the government is situated at the top. As mentioned in the previous paragraph, a governing body shapes the system by providing legislation. This is given as an arrow from the governing body to the entire system (small-dotted dashed line).

Inside the system, a client hires an engineering contractor for a specific project. All the stakeholders within the engineering contractor's company are placed inside a big-dotted dashed line. A project director receives the client's request and proceeds to instruct employees to work on the project. Constant supervision will be done by the project director to the engineering manager and they in turn to the engineers to make sure that the design created by the engineers meets the requirements of the client. The process of determining the stakeholder relations is shown in Figure 13 (Appendix 8.5.) under A12. All the necessary information to guide this process will come from the top as an incoming arrow, and these are the details of the project and the information on each stakeholder's role (coming from A11). The input is the interview data from the same stakeholders in A11. This interview data will be converted into an output which is the professional relationship of each stakeholder. This in turn will be used as information to discover the stakeholder interdependencies in section 4.1.3.

4.1.3. Step 3: Discover stakeholder interdependencies

The next step after identifying the professional relationships among stakeholders is to determine unto whom the problem owner is highly reliant on when it comes to solving his/her problem. Before such interdependencies of the stakeholders can be established, quite a few steps must also be taken. The book of Enserink et al. (2010) presents that first the importance of the resources of each stakeholder must be distinguished. A resource is any means that a stakeholder can utilize to help him/her accomplish his/her goal or desired situation (Enserink et al., 2010). A highly important resource is defined as one that can greatly influence the problem whether it be positively or negatively. In other words, it can help contribute to the solving of the problem or the exact opposite of it. On the other hand, a low-important resource is something that can barely affect or influence the problem. While the degree of importance of a resource is being examined, at the same time, the resource's replaceability is also evaluated. An easily replaceable resource translates to an easily replaceable stakeholder. This means that his/her absence will not affect the problem or that someone can step up and do his/her responsibility. If a stakeholder is easily replaceable and has a resource of low importance, then the problem owner has a low dependency on him/her (third quadrant of Figure 6). If it is the other way around, so hard to replace and high importance of resources, then the relationship will be classified as a high dependency (second quadrant of Figure 6). A mixture of these options results in medium dependency as shown in the first and fourth quadrants of Figure 6.

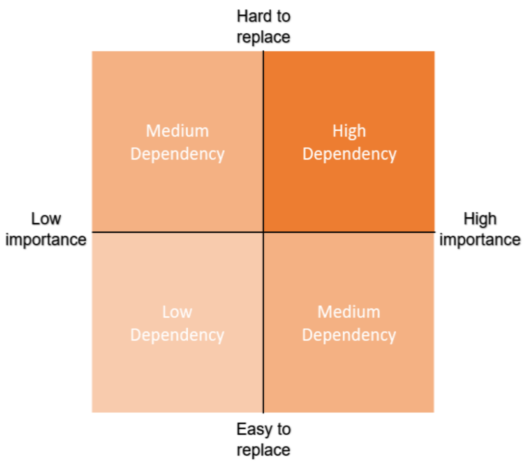

Figure 6 *Resource dependency*

Stakeholders that are hard to replace and have highly important resources are called critical stakeholders. Critical stakeholders are those on whom the problem owner highly relies for the solving of his/her problem. They are important due to their power to block or realize the project (Enserink et al., 2010). Looking at Figure 6, critical stakeholders are situated in the second quadrant. All the other stakeholders on which the problem owner has a low or medium dependency on are called auxiliary stakeholders. They have varying contributions in the realization of the project, but they are not considered critical as they do not have the power to greatly affect the project in terms of hindering or facilitating it.

Table 2 *Critical stakeholder identification*

Stakeholder	Important resources	Replaceable?	Dependency?	Critical stakeholder?

To clearly illustrate the classification of low-medium-high dependency, a table can be used. Table 2 illustrates an example of how such resource classification can be done. In the first column, stakeholders are listed. Beside it in the second column, their important resource in terms of contribution to solving the problem is shown. The third column classifies to what extent a stakeholder's resource(s) and hence a stakeholder him-/herself is replaceable. Depending on how important the resources and how replaceable a stakeholder is for the problem owner shall determine how dependent the problem owner is on that stakeholder. The final column shows who the critical stakeholders are, so those on whom the problem owner has a high dependency.

Table 3 *Classification of interdependencies*

Stakeholder	Dedicated stakeholder		Non-dedicated stakeholder	
	Critical stakeholder	*Non-critical stakeholder*	*Critical stakeholder*	*Non-critical stakeholder*
Similar interest				
Conflicting interest				

After determining whether a certain stakeholder is critical or not, the following step is to figure out what the problem owner's interdependency is with them. To do that a classification procedure will be done. First, a stakeholder's interest will be checked whether he/she has a similar or conflicting interest with the problem owner. This information shall come from the interviews with the stakeholders about their problem perception. After that, it will be determined if a stakeholder can be classified as a dedicated one or not. A dedicated stakeholder is someone who will be directly affected by the implementation of a standardized refinery design. In contrast to that, a non-dedicated stakeholder is someone who will clearly not experience the benefits or drawbacks of the standardized refinery design implementation. The information for this shall also be acquired during the interview with the stakeholders about their problem perception.

The result of Table 3 can be visualized in a graph. This conversion can be done by noting the actor's interest from Table 3 and their *criticalness* (the state of being critical or not) and then plotting it. The graph will look like the one in Figure 6, except the x-axis will be interest and the y-axis power. Such a graph is called a power-interest (PI) grid and it gives the problem owner a quick glance as to who the stakeholders are along with their respective positions (interest and power wise). The PI grid also informs the problem owner who the stakeholders are that he/she should try to form an alliance with to help with the solving of the problem. These are none other than the critical stakeholders. In the graph, the critical stakeholders are placed in the second quadrant, so high power and high interest. The problem owner needs to engage with them and manage them closely (Enserink et al., 2010). Auxiliary stakeholders are a mix of high power – low interest or low power – high interest and they are located in the first and fourth quadrants respectively. The stakeholders in the first quadrant are called context setters and according to Enserink et al. (2010) precaution is needed with them, and they should be kept satisfied. Otherwise, they might '*wake up'* and decide to get involved in the system. The more stakeholders involved, the harder it becomes to manage the system. Those in the fourth quadrant are called the subjects, the problem owner should keep these stakeholders informed and consider their opinions or thoughts (Enserink et al., 2010). Finally, stakeholders with low power and low interest are named crowd and monitoring them would be enough according to Enserink et al. (2010). All the steps undertaken in this section fall under A13, in Figure 13 of Appendix 8.5. The ultimate outcome is a distinction of the stakeholders between critical and auxiliary. This distinction is important for the study as the critical stakeholders will be involved in other parts of the research as well. In the next step of aspect identification, the critical stakeholders will be the ones to determine what the relevant aspects are that must be considered before a standardized refinery modification design can be implemented.

4.2. Aspect Identification

The following step of aspect identification or A2 in Figure 3 is explicated here. The aspects that need to be identified are those that must be considered before a system can be modified or changed. The opinion of the critical stakeholders identified in A1 are relevant here, hence this step comes after A1. The aspects that need to be identified are focused on technical and/or political-related aspects. It all starts in section 4.2.1. which explains how the aspects are identified by conducting a literature review. Then, in 4.2.2. the aspects will be identified via interviews with the critical stakeholders.

4.2.1. Step 4: Aspect identification via literature review

Aspect identification via literature review is not that different from the literature research done in Chapter 2 and section 4.1.1. Search words that accurately depict the aspects to be searched will be composed. For example, applying it to the implementation of a standardized refinery modification design, the following search words can be used: (aspect* OR factor* OR element*) AND refinery AND standard* AND (consider* OR "taken into account") AND (modif* OR modern* OR adjust* OR revamp*)). The selected keywords aimed to look for aspects that should be considered when modifying a refinery. The search word standard* can also be added to include projects where standardization of refinery modification is possibly applied. The result of this literature review can be presented in a table to give a good overview. This step can be seen under A21 in Figure 14 of Appendix 8.5.

4.2.2. Step 5: Aspect identification by critical stakeholders

Step 5 is similar to step 4 in terms of goals, but the means are different. In this step, the aspects will be identified by conducting interviews with the critical stakeholders (i.e., stakeholders with high power and high interest). In eliciting the aspects, the stakeholders can be asked directly what they think the (technical and political) aspects are that must be considered before implementing a standardized refinery modification design. What can help the stakeholders here is by giving a few examples of the aspects identified via the literature. Again, a table can be used to present the results of this step. Much like the previous step, this activity can be seen in Figure 14 as well in A22.

4.2.3. **Step 6: Aspect comparison and selection**

The last step in aspect identification is the comparison of the aspects identified via the literature review and the interviews. The first thing that must be checked is whether there is an overlap present between the aspects that have been identified. Discovering that no overlap is present is quite alarming and should signal the researcher to consider checking whether the appropriate search words were used and/or if the right question was asked to the critical stakeholders during the interview. The overlap should not only be checked between the literature review and interview but also with each other. This means that the aspects identified via the literature review should be compared amongst themselves and the same with the aspects identified via interviews. If an overlap of aspects is present, then the next step is to consider looking at the differences among the aspects. This step of comparing the similarities or differences is a means to verify if the aspects that the stakeholders value is present in the literature and if his/her co-critical stakeholders share the same idea.

Afterward, the list of aspects can be combined to create a novel list of aspects. Redundancies will be eliminated and combined under one aspect. Depending also on the scope of the research, all these aspects can be included in the next step. For this research, however, the scoping explained in Chapter 3 will be followed. This means that aspects that are too technical and are more so related to the standardized design itself will not be included. Also, the focus is on stakeholders and technical & political aspects, which means that aspects belonging to these are very relevant. After this filtering of the aspects and it still seems that there are too many, then further selection methods of the aspects can be done. A method suggested is by using a selection criterion, which means that an aspect must meet any of the criteria selected by the researcher Examples of such criteria are listed below. Aspects that do not meet any of these criteria can be excluded in the following step of requirement analysis in subchapter 4.3. This entire step is A23 in Figure 14 of Appendix 8.5. and out of this step, the relevant aspects will be determined.

1. *Aspects are valued by >1 stakeholder.*
2. *Aspects are valued by = 1 stakeholder and present in the literature.*
3. *Aspect present in the literature and not valued by any stakeholders.*

4.3. Requirement Analysis

The third activity to be explained is the conducting of requirement analysis or A3 in Figure 3. The requirements to be identified in this step will stem from the aspects discovered in the previous step. For requirements analysis, the steps presented by Brazier et al. (2018) will be followed. Looking back at the main research question, then at the framework in Figure 3, then one might wonder where local and global effectiveness are incorporated in. In A3 in Figure 3 it is stated that the requirement analysis to be conducted must consider local and global effectiveness (of the standardized design). The aim is therefore to come up with a list of requirements that puts local and global effectiveness into consideration. This step of A3 in Figure 3 will start with the requirements design in 4.3.1. Then, the requirements will be used to generate an artifact in section 4.3.2. As mentioned in section 3.2.3., design process coordination will not be included in this study.

4.3.1. Step 7: Requirements design

Brazier et al. (1994) explain how a requirement design can be conducted. It starts with the creation of a list of requirements, then analyzing and comparing them. There are plenty of ways as to how a list of requirements can be generated. Robertson (2001) explicates multiple kinds, but for this research what will be used are interviews, mind mapping, and brainstorming. The creation of the requirements list can begin by once more carefully examining the response of the interview participants given during the interviews for stakeholder analysis and aspect identification. First, the relevant aspects mentioned by a critical stakeholder will be noted. Then, whichever requirement they mention related to that aspect will be included in the requirements list of that respective aspect. For example, interview participant A mentions that safety is an important aspect of implementing a standardized design. Earlier, interview participant A already said that wearing appropriate clothing before entering the refinery is mandatory for the person's protection. Therefore, it will be concluded that wearing appropriate clothing is a requirement under the aspect of safety. This method is what will be used to create the initial requirements list (see Table 4). Whether this requirement is relevant or not will be determined later on when interviews are once again conducted.

Table 4 *Initial requirement list*

Aspect	Requirements
Safety	1. Establish the wearing of appropriate clothing as mandatory before entering the refinery. 2. X.

The next step is to go through the requirements list and identify any potential contradicting requirements. If possible, exclude requirements that are contradicting. If this cannot be done, then the contradicting requirements can be presented to the critical stakeholders during the next interview. All the steps explicated from the start of this section down to here belong under A31 in Figure 15 (see Appendix 8.5.).

After creating the list of the initial requirements and comparing them, then the following step is to verify these requirements via interviews with the critical stakeholders. Any suggestion they give, whether it be addition, subtraction, or adjusting of requirements will be implemented in the list. This step corresponds to A32 in Figure 15, where the input of the draft requirement list (output of A31) is converted in A32 into a refined requirement list. Also, during this interview, a very important step is to ask the stakeholders which requirement(s) (or aspect(s)) is the hardest when it comes to aligning the stakeholders. This is crucial information that will be useful in the later stage. Once all the feedback from the critical stakeholders has been implemented, then the requirements list will be transformed into a requirements tree as shown in Figure 7. Presenting the requirements in such a way gives a great overview in comparison to a list. Potential associations among the requirements can also be more easily identified. Before the requirements list can be converted into such a tree, classification into functional, behavioural, or structural requirements must first take place.

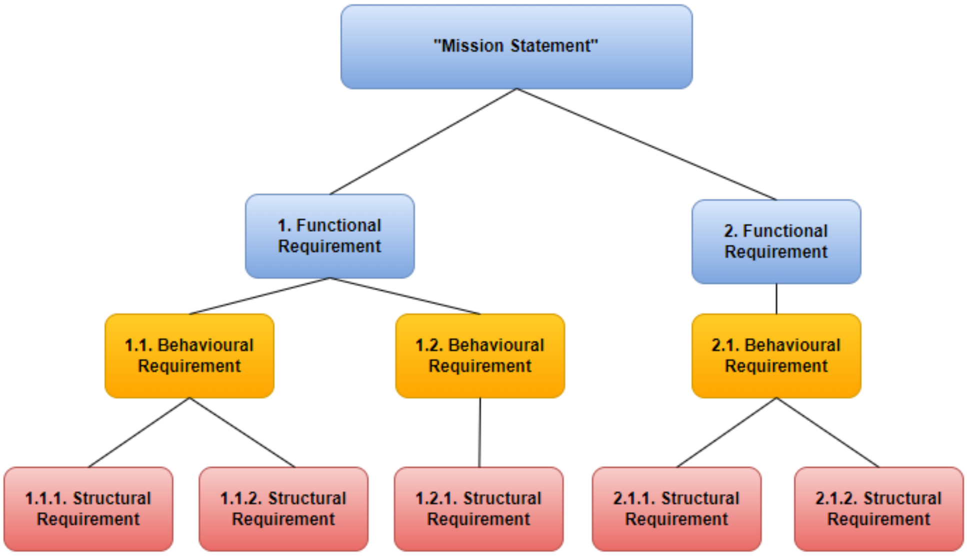

Figure 7 *Requirements Tree*

At the top of the requirements tree is the mission statement. The mission statement specifies the main function to be achieved by an artifact. In a mission statement, the needs and desires of stakeholders are expressed (Brazier et al., 2018). The mission statement can be derived from the main research question. Under the mission statement are functional requirements – these specify the functions that must be provided by a system/artifact (Brazier et al., 2018). Under a functional requirement are behavioural requirements and these, in turn, determine the way a system/artifact is supposed to act (Brazier et al., 2018). Under behavioural requirements are structural requirements and these relate to the components of the system and their interdependencies/relationships according to Brazier et al. (2018). Functional requirements answer the questions: *why, for whom,* and *where,* behavioural requirements look at *how* and *when* questions, while structural is paired with *what* queries. Once the distinction among the requirements is clear, then the classification can begin. Looking at each requirement, does it try to answer the why, the how, or the what. This is not a simple task, and it will surely require multiple iterations before getting it correct. Also, numbering should be present to show consistency. If a functional requirement is numbered 1, then the structural requirements under it shall be numbered 1.1., 1.2., etc. Then, the same thing applies to the behavioural requirements under it (i.e., 1.1.1., 1.1.2., etc.), see Figure 7.

While creating the requirements tree, it is possible to see some gaps in terms of missing requirements. There is a chance for a branch of the requirements tree to be incomplete, e.g., having only a functional requirement without behavioural nor structural. Therefore, if needed, brainstorming and mind mapping can be applied to the requirements tree to add more requirements. Looking back at the desires or interests (and potential values) of the critical stakeholders can greatly help here. Check whether their desires have already been translated as a requirement in the requirements tree. This process takes place in A33 of Figure 15 and from this comes out a requirements tree that illustrates the different requirements and their respective association.

4.3.2. Step 8: Artifact design

Sticking to the methodology proposed by Brazier et al. (1994), the next step to requirement design is artifact design. The artifact to be designed mentioned here is not the same artifact to be created during the design cycle (see Figure 1). The artifact to be created in the design cycle is meant to synthesize the information from requirement analysis, relevant stakeholder identification, and stakeholder alignment (i.e., the framework). The artifact being mentioned in this section is anything that can enable the fulfillment of the requirements in section 4.3.1. Here in section 4.3.2., it will be explained how such an artifact typically can be designed and created. The method to be used to create the design is a morphological chart. To do this, a table must be created, and in the first column are all the requirements presented. Beside it are columns where the means are listed as to how the respective requirements can be achieved (see Table 5). The identification of the means can be via brainstorming, interviews, and other options.

Table 5 *Morphological Chart*

Requirements	Means		
Requirement 1	Means 1	Means 2	Means 3
Requirement 2	Means 1	Means 2	Means 3
Requirement 3	Means 1	Means 2	Means 3

Looking at Table 5, the requirements to be listed in the first column will come from the requirements tree created in the previous step. In the table, the requirements will be arranged numerically to maintain order. After the morphological chart has been completed, potential (partial) designs can be explored. This signifies a combination of means that can go together are selected and assigned under a design. Looking at Table 5, two designs have been identified, design Yellow and design Red. These so-called designs need to be evaluated and compared. However, simply assigning weights to the requirements and the means is not possible as these do not have comparable values. Therefore, one cannot straightforwardly state that Requirement 1 is more valuable than Requirement 2 and the same goes for Means 1 and Means 2. Even if a stakeholder does think that Requirement 1 is more valuable than Requirement 2, he/she can still not easily quantify how much the one is more valuable than the other.

As mentioned at the start of this section, there are basically two kinds of design being talked about. The first one is a design (a framework) to be created during the design cycle in Figure 1. While the second kind is a design that can be generated by combining means together to fulfill the requirements that have been identified. For this research, the focus of the study is not to combine means to create the second kind of design. Rather it is the first one where a framework will be created to showcase how the relevant stakeholders for the implementation of a standardized refinery modification design can be aligned. It is for this reason that artifact design or step 8, when implemented in a case later, will not feature any design creation nor comparison, so nothing like red vs yellow will be done. Instead, means will be identified per requirement to showcase the complexity of such a system. A34 in Figure 15 (see Appendix 8.5.) illustrates this process of means identification.

4.4. Relevant Stakeholder Identification

For this part of the framework (A4 in Figure 3), nothing entirely new in terms of methodology will be done. It is all about identifying who the relevant stakeholders are for the implementation of the requirements identified in the previous subchapter. To elicit this information, interviews with the critical stakeholders will be done. This **interview where critical stakeholders are asked as to who the relevant stakeholders are for the implementation of each requirement is step 9** of the framework development. During the interview, the requirements tree and the generated stakeholders' list can be shown to the critical stakeholders to help them identify who the relevant stakeholders are for the implementation of the requirements (A41 and A42 in Figure 16 in Appendix 8.5.). Keeping in mind that implementation of requirements does not only consider the literal implementation of it but maybe even more so, the decision-making required behind it.

There is a high likelihood for the critical stakeholders to have difficulty identifying who the relevant stakeholders are per requirement, as this can be an extensive task. On top of that, such professionals do not have plenty of free time. If this is the case, then the suggestion is to conduct the interview for relevant stakeholder identification simultaneously with the requirement identification. Thus, first, the critical stakeholders will be asked, "*What are the requirements that must be considered under aspect X?"*. After that, they can be asked a follow-up question, "W*ho are the relevant stakeholders for the implementation of that requirement you just mentioned?"*. If ever it still seems too substantial for the critical stakeholders, they can also be asked to identify the relevant stakeholders per group of requirements or even per aspect. The critical stakeholders can have varying opinions when it comes to the question of who the relevant stakeholders are per requirement. Every critical stakeholder's answer is valued equally. Therefore, all answers will be included in an integrated list (see A43 in Figure 16). Whenever similar relevant stakeholders are identified, then the list will be simplified.

4.5. Stakeholder alignment

After identifying who the relevant stakeholders are for the implementation of the requirements, the next step (A4 in Figure 3) is to discover how well aligned they are. The essence of this step lies in the fact that stakeholders are heterogenous. This means that everyone can have varying interests and priorities, combined with different background and expertise. With that comes different ways of thinking, approach to work, and so on. Lack or absence of alignment of the relevant stakeholders can therefore delay any progress. What 's worse is that it can even cause the derailment of the entire project. To discover how well aligned the relevant stakeholders are, the first step will be to inspect what alignment mechanisms are implemented by the organization. Then, this must be compared with what is present in the literature to see if anything is lacking.

4.5.1. Step 10: Discover alignment methods in the organization

This step is all about discovering what alignment methods are present and in use in the organization being used as a case. The critical stakeholders that are interviewed during step 9 (relevant stakeholder identification) shall be asked how the relevant stakeholders that they identified are usually aligned. Then, the critical stakeholders will be asked if the methods they mentioned do work and if they have other suggestions as to how the relevant stakeholders can be aligned. This step corresponds to A51 in Figure 17 in Appendix 8.5.

4.5.2. Step 11: Compare stakeholder alignment mechanisms

Before the stakeholder alignment mechanisms discovered in the organization can be compared with what is in the literature, first the alignment mechanisms present in the literature will be sought out. In the upcoming subsections this has been conducted. The reason here for is to ensure that the same alignment methods will be used by every organization that will use the framework developed in this thesis.

Ali & Haapasalo (2023) present a conceptual framework in their paper that demonstrates how stakeholder relationships can be developed. Figure 8 is a self-created figure to showcase the said framework. What's more, from the paper of Ali & Haapasalo (2023), it is discovered that alignment can take place in different stages of stakeholder relationships. In collaborative projects, four development levels or stages of stakeholder relationships are identified: Cooperation, Control, Coordination, and Collaboration (Ali & Haapasalo, 2023). Therefore, the desire is to find alignment among stakeholders in all stages in Figure 8, wherever possible. In the following sections (4.5.2.1. – 4.5.2.4.), these development levels or stages will be explained further.

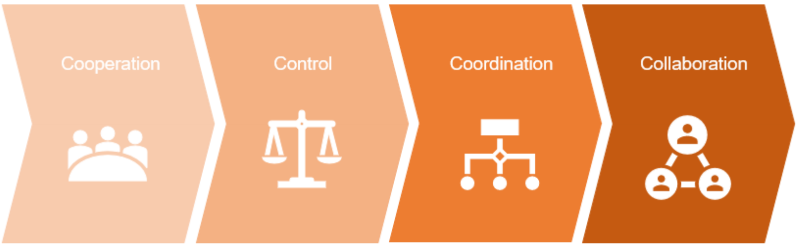

Figure 8 *Relationship development framework*

4.5.2.1. Discover Cooperation Mechanisms

The first stage or *Cooperation* is defined as the stage where organizations swap crucial information to build long-term relationships with potential partners (Spekman et al., 1998). During this stage, alliances can be formed and common benefits among the parties are prioritized over individual ones (Castaner and Oliveira, 2020). It is also in this stage where the alignment of interests takes place according to Ali & Haapasalo (2023). In the Introduction in Chapter 1, it is mentioned that one of the goals of this research is to find ways how to align stakeholders among others in interests and priorities. Cooperation is thus considered to be very relevant for this study. However, it should not stop here as alignment must be established at every stage.

To achieve stakeholder, buy-in, Jergeas et al. (2000) present four action points that they discovered from the literature. The first one is to enlighten the stakeholders on what the purpose of the project is. After that, let them know what the project is supposed to do. Then, adapt the project whenever necessary depending on the feedback of the stakeholders. Finally, if needed, compensate the stakeholder that will experience the adverse effects resulting from the project. In the book of Watt (2014), tips are given on how to build relationships with the stakeholders. These tips (listed below) share a great resemblance with the action points of Jergeas et al. (2010).

1. Conduct a stakeholder analysis.
2. Assess the influence of stakeholders.
3. Understand stakeholder expectations.
4. Define what is (project) success for a stakeholder.
5. Keep stakeholders involved and consider their input.
6. Keep stakeholders updated.

Casey (2017) agrees with both options, she presents that first the stakeholders must be identified. After that, is to get the stakeholders to participate in the project and to understand their needs respectively. Fourth is to prepare how you would approach them and what to say to them. Finally, as the last step, stakeholder alignment must occur continuously, it shouldn't be seen as a one-time approach. Out of the three options presented here (Jergeas et al., 2010; Watt, 2014; Casey, 2017) that from Watt (2014) is selected to be included in the framework for stakeholder alignment. This is because the action points given by Watt (2014) encompass both Jergeas et al. (2010) and Casey's (2007). The discovery of cooperation mechanisms takes place in A52 in Figure 17 in Appendix 8.5.

4.5.2.2. Discover Control Mechanisms

The next stage is *Control* and it can be defined as the delegation of the decision-making capacity to the stakeholders (Marcum et al., 2012). Control mechanisms are implemented to check whether the parties involved comply with the rules in place. Depending on the governance structure, different control mechanisms exist (Ferrer et al., 2020). In the paper of Dekker (2004), he presents a list of formal and informal control mechanisms (see Table 6) for interorganizational relationships. When talking about outcome control, Dekker (2014) suggests setting the goal and using an incentive system. For behaviour control, planning, procedures, rules & regulation, and behaviour monitoring and rewarding are the options. Finally, looking at social control, he proposes the use of partner selection, building up of trust, joint decision-making, and problem-solving. Ali & Haapasalo (2023) concur with these and even suggest the use of a contract to bind the parties involved and to prevent any misconduct. A contract can primarily be seen as a form of behaviour control instrument.

Table 6 *Control Mechanisms (Dekker, 2004)*

Outcome control	Behaviour control	Social control
Goal setting	Planning	Partner selection
Incentive system	Procedures	Trust build-up
Performance monitoring/rewarding	Rules & Regulation	Joint decision-making
	Behaviour monitoring/rewarding	Joint problem solving

As mentioned earlier, the control mechanisms are needed to control whether parties comply with the rules in place. A completely different and yet identical in a way are public policy control instruments. The basic classification of such control mechanisms are the famous *stick*, *carrot,* and *sermon* instruments. Even though these control mechanisms are mainly used for policies, these can still be implemented inter-organizationally to influence the people. A stick instrument, also known as regulations, is a means used by the government to influence the people to act and behave according to the rules in place (McCormick, 1998). An example is the prohibition to steal, non-compliance by anyone will result in an offense that is punishable according to the legislations. Next are economic instruments or carrots that usually involve the granting or the taking of resources, usually in the form of money (McCormick, 1998). As a punishment for non-compliance with the emission regulations, the government can impose a fine on the offender. Last is sermon or information instruments which are all about trying to convey information to the people to influence their actions (McCormick, 1998). Consider a municipality warning the citizens and tourists to be careful of pickpockets via posters.

There are other control mechanisms present in the literature. But the two discussed here share great similarities with those not included. Therefore, choosing from these two is deemed sufficient. Out of the two classifications, that of Dekker (2004) was selected as this offers a wider range of options. These instruments are also not as limited, compared to McCormick's (1998) that primarily was developed for policies. In A53 in Figure 17, the process of finding out applicable control mechanisms is illustrated.

4.5.2.3. Discover Coordination Mechanisms

Coordination is the alignment of the stakeholders' actions to achieve mutual goals (Gulati et al., 2012). Formation of consensual goals will be made possible by having aligned interests. This showcases the importance of enabling cooperation before coordination can be facilitated. Through coordination, a structure on how stakeholders can divide and arrange their resources to accomplish their interdependent tasks is made possible (Klessova et al., 2020). In other words, this can be interpreted as the alignment of the stakeholders' actions (Castaner and Oliveira, 2020).

Mintzberg (1980) describes five kinds of coordinating mechanisms in his paper. These are: (1) *Direct supervision*, (2) *Standardization of work processes*, (3) *Standardization of outputs*, (4) *Standardization of skills*, and (5) *Mutual adjustment*. The first one or direct supervision is a coordinating mechanism where an individual (e.g., manager or supervisor) closely looks after the employees, coordinates their work, and gives particular instructions to them. Standardization of work processes is done by following standards (usually made by analysts) that specify how the work should be done. Standardization of outputs and skills is quite like the previous one. In essence, the third kind is about following standards that shape the output of the work and the fourth one is the bringing in of experts with a standard set of skills and/or knowledge. Mechanism number five or mutual adjustment is the option where employees themselves directly communicate and coordinate their own work. Another classification of coordination mechanism is that of Martinez & Jarillo (1989) showcased in Table 7. The first five (departmentalization – output and behaviour control) are the structural and formal mechanisms, while the last three are informal and subtle mechanisms. The coordinating mechanisms of Mintzberg (1980) can be found in the list of Martinez & Jarillo (1989) and therefore theirs will be considered for the framework development. Again, in Figure 17 the discovery of the control mechanisms is shown. The input of this activity are the search words to be used to look for the right literature.

Table 7 *Coordination Mechanism (Martinez & Jarillo, 1989)*

Coordination Mechanism	Explanation
Departmentalization	labour division or the creation of groups based on activities/tasks of the stakeholder
(De)Centralization,	decides which level has decision-making authority
Formalization and Standardization	extent to which a task, description, rule, etc. are documented and the standard routines/procedures
Planning	guide the activities of interdependent units
Output and Behaviour Control	evaluation of the product/service and personnel
Lateral or Cross-Department Relations	direct contact from different departments that share task/problem/teams/commitment, etc.
Informal Communication	networking
Organizational Culture	the habit or way of doing things in a company

4.5.2.4. Discover Collaboration Mechanisms

The last stage is Collaboration, and it is defined as the process through which actors work together interdependently to reach their desired common goals (Bedwell et al., 2012). Therefore, collaboration is seen as a key element in large and complex projects. For construction projects, the emphasis lies on the involvement of different stakeholders from different disciplines at the start and during each phase of the project (Engebø et al., 2020). The collaboration framework of Lambert (2010) is composed of six steps. First, the parties involved must assess their drivers or their goals for the project/partnership. Next is to align the goals determined in the first step. After that, an action plan needs to be developed. This action plan will contain the actions to be undertaken, a timeline of the project, the responsibilities of stakeholders, etc. The 4th step is to create the rules of engagement where the action plan is summarized. Following that is the measurement of performance and finally a regular check if the drivers (identified in step one) are being fulfilled. Another collaboration framework is that of the International Organization for Standardization (2017) which is composed of 8 stages:

1. Operational Awareness
2. Knowledge
3. Internal Assessment
4. Partner Selection
5. Working Together
6. Value Creation
7. Staying Together
8. Exit Strategy

Operational awareness is about trying to identify among others the values and objectives that are important for the project/company. Knowledge focuses on the viability of a project (e.g., business cases, implementation plan, strategies, etc.) The third step or internal assessment considers what (and who) the enablers are of the project, the capabilities, strengths, and weaknesses of the employees, and the policies in place. The following stage is partner selection, which entails how the potential partners for a project are chosen. This considers the missing roles and capabilities that need to be fulfilled. After the partners have been selected then they will work together (stage 5). In this stage, the governance and management structure, conflict resolution, key performance indicators, and others are determined. The stage value creation puts importance on the continuous improvement of the processes, so the experience learned from the project. The seventh stage is staying together or the measure of performance of the teams collaborating. Finally, there is the exit strategy that looks at how and when the collaboration can end. Also, what the possible future opportunities are. From two alternatives discussed in section 4.5.4. that of ISO (2017) will be used in framework development. This selection is due to its extensiveness compared to that of Lambert (2010). The second to the last activity of Figure 17 is the discovery of collaboration mechanisms (A55), and it is like the previous activities in terms of input, mechanism, and control needed.

Even though collaboration is shown as a separate stage in Figure 8, Ali & Haapasalo (2023) mention that it should not be considered a "*stand-alone static process*" because it integrates and interacts with the other three stages. What attests to this is the similarity of some of the cooperation, control, and coordination mechanisms with the collaboration steps mentioned in this section. As an example, consider the first step or operational awareness in ISO (2017). This step is fixated on trying to identify the values and objectives crucial for a project. A comparable, if not exactly similar step, is goal setting under outcome control of Dekker (2004) in Table 17. Such resemblance can be found across different stages with different mechanisms. A compilation of the selected mechanisms and steps discussed through subsections 4.5.2.1. – 4.5.2.4. are displayed in Table 8.

Table 8 *Stakeholder Alignment Mechanisms*

Cooperation	Control	Coordination	Collaboration
1. Conduct a stakeholder analysis. 2. Assess influence of stakeholders. 3. Understand stakeholder expectations. 4. Define what is (project) success for a stakeholder. 5. Keep stakeholders	1. Outcome control (Goal setting, Incentive system, Performance monitoring/rewarding) 2. Behaviour control (Planning, Procedures, Rules & Regulation, Behaviour monitoring/rewarding	1. Departmentalization 2. (De)Centralization 3. Formalization and Standardization 4. Planning 5. Output and Behaviour Control 6. Lateral or Cross-Department Relations 7. Informal Communication	1. Operational Awareness 2. Knowledge 3. Internal Assessment 4. Partner Selection 5. Working Together 6. Value Creation 7. Staying Together 8. Exit Strategy

involved and consider their input. 6. Keep stakeholders updated.	3. Social control (Partner selection, Trust build-up, Joint decision-making, Joint problem solving	8. Organizational Culture

Now that the alignment mechanisms have been identified, the next step is to compare what has been discovered from the organization with that in Table 8. After this comparison step, the last step of synthesis will take place in subchapter 4.6.

4.6. Synthesis

Out of all the activities in Figure 3, the only one left unexplained is A6, or the alignment of relevant stakeholders using appropriate alignment methods. This is the step that integrates all the most relevant information gathered throughout the research. A6 can be divided into four sub-activities. Looking at the copy of Figure 18 below, A6 level 2 starts with A61. In A61 the output is a list of consolidated alignment mechanisms. To come to this list, the result of the comparison between all the alignment mechanisms implemented by the organization used as a case and what is out there in the literature will be discussed.

The gaps or the alignment mechanisms present in Table 8 but not implemented by the case will be taken note of. The impact of having such gaps can also be explained to showcase their importance Combining all the gaps results in the consolidated list of alignment mechanisms being searched for. All the other mechanisms are already being implemented by the case; hence they are not needed to be included anymore. The next step or A62 will be to apply the consolidated list to the case. All the other essential information that will be needed in this activity is the result of the previous analyses conducted. Out of this case application, advice can be formulated and given to the organization studied as a case.

After A62, the following step is to verify and validate it. Verification is about checking if the requirements imposed at the beginning (of research) are met. It is usually implemented to control if a (computer, simulation, computational, etc.) model matches the requirements set during the conceptual phase. In this research the output is not a computer model nor anything like it, but a conceptual model in the form of an IDEF0 model (framework). Hence, the only verification that can be applied here is to check if it complies with all the requirements concerning IDEF0 model creation. More than that is not applicable, as no other requirements were made beforehand. The IDEF0 models created in this research are checked multiple times for consistency, correctness, and content. All mistakes discovered are corrected right away during the verification process. That is why verification is no longer present in the case.

Next is validation or the process of inspecting whether the created output meets the expectations of its user(s). The framework being developed here can ultimately be used by organizations that wish to find the means how to align stakeholders in a complex system. Particularly, a system where a standardized refinery modification design can be implemented and reused in different sites around the globe while keeping an eye on the possible technical and political differences of each site. To validate the framework, the critical stakeholders, and especially the problem owner can be approached after implementing the framework in a case to ask if the designed framework has fulfilled its intended purpose. To clarify, this step of validation is not a one-time procedure. As a matter of fact, this should be done regularly, especially with the critical stakeholders. Validating only in the end once everything has been done already is not advisable as this leaves little room for error. For research with a limited schedule, this is undesirable. Throughout the development of the framework, many verification and validation rounds must take place.

Hence, it is not only limited to this part of the research. For example, in subchapter 4.3., data coming from the literature is verified by comparing it with the answers of the interview participants. Such verification or validation steps are done in different instances of the research.

Once the critical stakeholders and especially the problem owner is satisfied with what he/she can expect from the framework, then the final step will be to implement the advice generated from A62 and A63. In the last activity, A64, the advice can be implemented which is aimed at aligning the relevant stakeholders. This process already falls outside the scope of this research but is nevertheless added to show what the next step is.

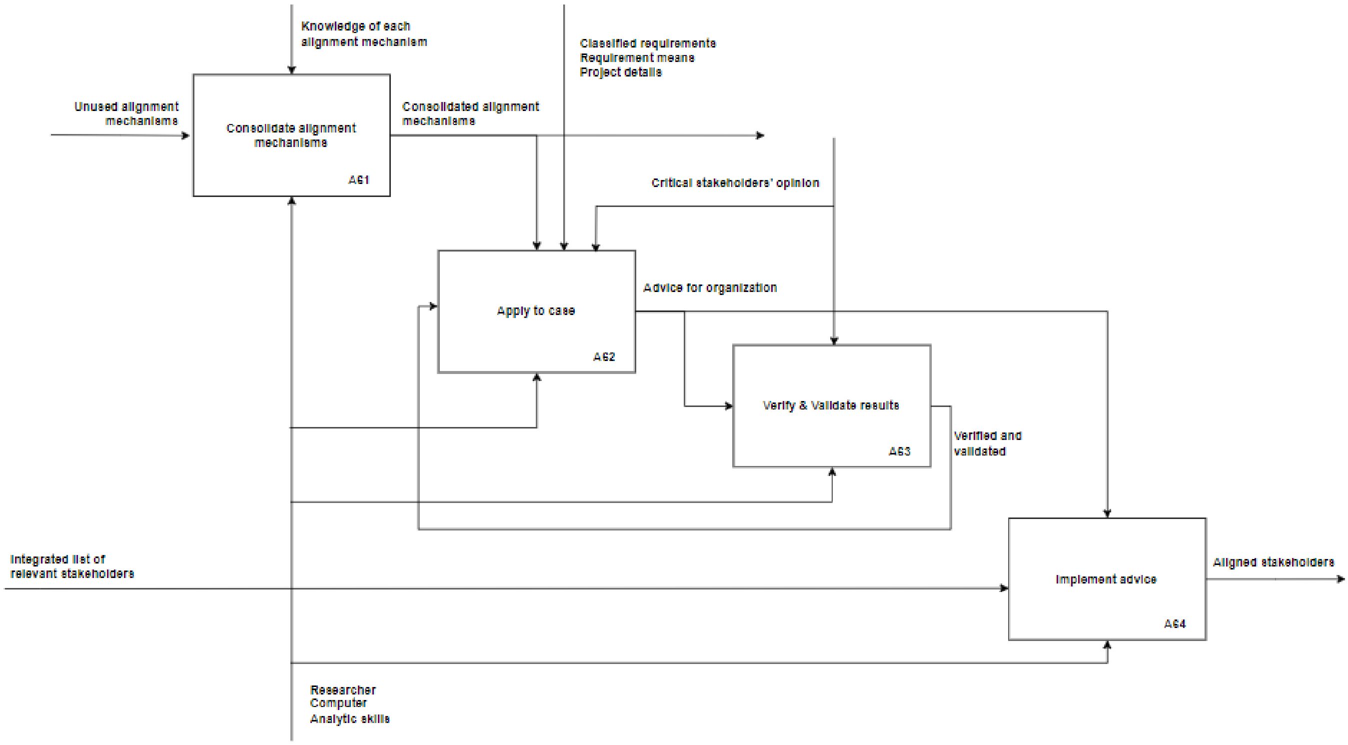

Figure 18 IDEF0 A6 Level 2

5. Framework Implementation Worley

In this chapter, the developed framework is implemented for the case of an engineering contractor called Worley. This corresponds to the field testing of the relevance cycle in Figure 1. It starts with the stakeholder analysis in subchapter 5.1. Afterward, aspect identification is done in 5.2. Requirement analysis and identification of relevant stakeholders follow in 5.3. and 5.4. Appropriate alignment methods are discovered in 5.5 and the advice to be given to the company is formulated in 5.6.

5.1. Stakeholder Analysis

The steps on how to conduct stakeholder analysis mentioned in subchapter 4.1. are followed. It starts with identifying the stakeholders in play in 5.1.1. Then. In the section thereafter, the professional relations of the stakeholders are discovered. In 5.1.3. the problem owner's interdependency with the other stakeholders is brought to light.

5.1.1. Stakeholder Identification

The stakeholders that have been identified along with their problem perceptions via interview are shown in subsection 5.1.1.1. In the following subsection, the data from subsection 5.1.1.2. are validated via a literature review. Then, in subsection 5.1.1.3. data from the previous two subsections are compared and a new list of stakeholders is made.

5.1.1.1. Interview

To identify who the stakeholders are, a reputational approach is implemented. As explained in 4.1.1., such an approach makes use of "key informants" in identifying the stakeholders. In this case, the key informants are stakeholders from each of the three perspectives (engineering contractor, client, and refinery) mentioned in section 3.2.1. with a relatively high position. They are the ones interviewed to make an inventory of stakeholders. A complete list of all stakeholders identified can be found in Appendix 8.1. This list of stakeholders is extensive but not all-inclusive. From this list, a concerted effort is made to interview the most relevant stakeholders in the time available. The aim is to interview a set of stakeholders that are as diversified as possible. In Table 9, the stakeholders who are interviewed together with their problem perceptions are presented. A summary of their interviews is included in Appendix 8.4.

During the interviews, the research is first briefly explained to the participants. Then, they are asked about their problem perception, so concerning their desires regarding the situation, the status of the current situation, the cause of the difference between the existing and desired situation, and finally the possible solutions (see Appendix 8.4.). The situation mentioned here pertains to the implementation of a standardized refinery modification design. The desired situation is what they wish to achieve with the implementation of a standardized refinery design. While the existing situation points to how it will normally occur, ceteris paribus. The existing situation is not present in Table 9 as it has been included in the introduction to express the relevance of the research topic. The possible solution points out how the stakeholder thought he/she can achieve his/her desired situation.

***Table 9** Problem perception identified via an interview with stakeholders*

Stakeholder Group	Stakeholder	Desired situation	Possible solution(s)
Engineering Contractor	Program Director	Standardize as much as possible to reduce cost and work hours	Modularization and available yards for it.
	Program Delivery Manager	Finish the refinery modification tasks on time, without needing more people and supervision	Develop a blueprint design that can be copied and implemented in other sites
	Engineering Manager	Success in each phase of engineering	Change in the organizational structure from decentralized to centralized
	Lead Piping Engineer	Get the best result for the least effort and the least time	Tackling issues and making refinery workers accept change
	Lead Process Engineer	Build a best practice – set a standard by developing a basis that can be replicated	Capture the know-how, access predecessors' files, and make information a deliverable
	Civil Engineer	Reduced engineering effort and cost-effectiveness	Use a modular construction approach.
	Workstream Coordinator	More collaboration between the government and companies	Spread the risks and share the findings
Client	Appraisal General Manager	Global optimality of the refineries being standardized	Come up with a common design envelope to decide what is conducive to standardizing
	Project Operations Engineer	Identical implementation of policies and procedures in every site	Instruction from top – down to adhere to changes, no self-interpretation
	Requirements and Standardization Manager	Standardization done for value- standardization in technical design and process of delivery	Improve international codes and standards, understand data needed, understand tradeoffs in decision-making, agree on sequencing
Refinery	Refinery Shift Team Leader Oil Movement	A well-thought-out plan implemented in the refinery	Sticking to plan and avoiding micromanagement
	Delivery Lead Site-Specific Scope	Solving issues through the collaboration of refineries	Have one contractor locally and globally

The three perspectives mentioned in section 3.2.1. are present in Table 9. From the stakeholder group of Engineering Contractor, various stakeholders are interviewed. Those operating in a management position like the managers and director, and those working on the standardized design itself like the engineers. There is a difference in the desired situation of these two groups. Those belonging to the management position (Program Director and Program Delivery Manager) have a more holistic perspective. They look far beyond the standardized design itself, like a Program Director who wants standardization to the maximum extent to lower cost and working hours for the entire project (Appendix 8.4. – Program Director). On the other hand, the people working on the standardized design like the engineers have a more bounded view, essentially focusing on parts of the project that they work on (i.e., their engineering discipline). Looking at the Lead Piping Engineer as an example, the said employee wants to get the best result for the least effort and time with regard to his/her task in the implementation of a standardized design (Appendix 8.4. – Lead Piping Enigneer).

Moving on to the Client perspective, these stakeholders are mostly composed of people who monitor or manage the project's progress. They (e.g., Appraisal General Manager and Delivery Lead Site-Specific Scope) are the ones who work closely with the management group of an Engineering contractor. They define on a global level what needs to be accomplished and delivered by an Engineering Contractor (Appendix 8.4. – Appraisal General Manager, Deliver Lead Site-Specific Scope). Finally, there’s the Refinery perspective, the stakeholders who work closely with the standardized design makers. Basically, they are the ones who will operate the refinery. Engineering contractors strive to create a design that caters to all the needs of the sites. Those from the refineries on the other hand try to influence the design as much as possible to make it fit perfectly with their site (Appendix 8.4. – Refinery Shift Team Leader Oil Movement). The better the fit, the more optimal their local refinery will perform (Appendix 8.4. – Appraisal General Manager).

5.1.1.2. Stakeholder verification

In section 3.2.1. it is mentioned that a literature review shall be conducted to verify the results of the interviews. Such verification is relatively challenging, especially since a lot of the answers from the interview participants are quite case specific. That is why out of all the steps that need to be undertaken in answering sub-research question one, the creation of stakeholder inventory is identified as something relatively verifiable in the literature. The complete list of the stakeholders that the key informants identified is displayed in Appendix 8.1. On the other hand, the stakeholders that are identified via literature research are shown in Tables 10 and 11.

The book of Winch (2010) gives a categorization of construction project stakeholders. In the said book, the stakeholders are classified into four groups: Internal-Demand, Internal-Supply, External-Private, and External-Public. Those belonging to the internal group are stakeholders that are directly involved in the construction project where the legal contractual relationship is included (Molwus, 2014). They are the ones who own or finance the project, like the client and financers, or those that design and build it (e.g., engineers, contractors, etc.). The stakeholders belonging to the external-private and external-public on the other hand are those that have no contractual relationship with the project owner but still share an interest in the project (Molwus, 2014). Examples of these stakeholders are the residents, NGOs, the government, and others. Under the umbrella of government, there are departments like the Ministry of Social Affairs and Employment whose interest isn’t necessarily on the construction project itself, but on the working condition (e.g., safety and health) of the employees of the construction project (Rijksoverheid, 2010). Another example is a Permit Approval Authority like the Dutch Emission Authority that strives for climate neutrality (Dutch Emission Authority, 2018). Depending on the type of project, the classification of the stakeholders can vary. Like the government which can be a client (internal-demand) and a regulator (external-public) at the same time. Usually, though, different branches of the government are involved in such a project.

The general interests of each respective classification have also been identified and presented in the second column of Table 10 (Leung et al., 2010). For Internal-Demand stakeholders it is all about the success of the project in terms of construction, procurement, and monetary. For the Internal-Supply stakeholders, their interest lies also in the success of the project, but specifically in carrying out their responsibilities and tasks to their employers. The classification External-Private with its stakeholders value the impact of the project on their daily living. Finally, External-Public stakeholders look more into how the project complies with the institutions in place.

Table 10 Identified stakeholders in construction projects via literature review

Classification	Interests	Stakeholders
Internal-Demand	The successful construction of the project and procurement, return on investment, and proper use of funds	• Client & Financers
Internal-Supply	Carry out professional responsibilities to employers, perform contractual obligations	• Engineers • Architect • Principal/Sub/Trade Contractors • Material Suppliers
External-Private	Impact of the project on amenity and the environment	• Residents, Landowners • Environmentalists & Non-Governmental Organizations (NGOs) • Media
External-Public	Compliance of the project to the institutions. Climate neutrality (Dutch Emission Authority, 2018)	• Local/Regional/National/International Government (e.g., Ministry of Social Affairs and Employment) • Regulatory Agencies (e.g., Dutch Emission Authority)

Besides identifying stakeholders from the construction point of view, it is also important to consider looking from the perspective of those who will operate it. Bioenergy Career Grid (2017) presents a good overview of different stakeholders working in the bioenergy industry. It does so by dividing the bioenergy industry into five sub-sectors: (1) *Engineering & Manufacturing*; (2) *Agriculture, Life & Physical Sciences*; (3) *Infrastructure*; (4) *Operations, Management, & Business*; and (5) *Education, Communications, & Outreach*. Out of these five classifications, two are directly engaged and involved in refinery operations, namely Engineering & Manufacturing, and Infrastructure. For this reason, only stakeholders from these two sub-sectors are further considered in Table 11. Their respective interests are also noted in the second column.

Stakeholders from the Engineering & Manufacturing sub-sector are those who are involved in the technical side of bioenergy. Primarily, they are engineers that work on the design of a refinery with its components. On the other hand, those from the Infrastructure sub-sector are composed of stakeholders who build the refineries along with the people that operate them.

Table 11 Identified stakeholders in biorefineries via literature review

Sub-sectors	Interests	Stakeholders
Engineering & Manufacturing	• Application of biochemistry • Design, construct and maintain infrastructure • Provide design for mechanical hardware • Computational modeling	• Chemical/Biological Engineer • Civil/Environmental Engineer • Mechanical Engineer • Computational Scientist
Infrastructure	• Carry out construction successfully • Maintaining the biorefinery machinery • Transportation of products via vehicles • Directing operation, maintenance, and administration of the refinery • Maximize safety and industrial hygiene	• Construction Foreman/Manager/Worker • Industrial Equipment Mechanic • Motor Vehicle Operator • Plant Manager/Operator • Safety and Occupational Health Specialist

Looking at the contents of Table 9, and comparing it with Tables 10 and 11, not every stakeholder identified in the literature is interviewed. However, the aim of interviewing a set of stakeholders that's as diversified as possible has been achieved.

5.1.1.3. Stakeholder identification integration

In this subsection of the paper, different stakeholders from Tables 9 – 11 are taken and combined to create a novel classification of stakeholders that will be used in this research. This is done because the contents of Table 9 are missing a few relevant stakeholders that are present in Table 10 or 11. Whenever possible, stakeholders from Table 9 are directly incorporated into Table 12. Also, generalization and simplification are done. As an example, a lead piping engineer and lead process engineer in Table 9 were combined and changed to a lead engineer in Table 12. Such modifications are conducted to keep Table 12 as general as possible and therefore applicable to other refinery modification (and standardization) projects. Hence, a great degree of overlap can be observed between Tables 9 and 12.

Initially, the implementation of a standardized design will be viewed from three perspectives as explained in section 3.2.1. That of an engineering contractor, the client, and from a refinery's point of view. In essence, there is nothing wrong with this classification, but a different classification has been applied in Table 12. The reason for this composition of a new classification is to clearly convey the similarities or differences in the stakeholders' objectives or interests[1]. The classification made is Program Management, Design Responsible, Refinery Operation, and the Government. The similarity between both project managers in terms of their project objective is greater than that between a manager and an engineer. However, this doesn't mean that an engineer does not give importance to the project's success, but it is more so that the engineer's focus is only a smaller part of the entire project. Such a comparison is more easily done because of the new classification method used.

5.1.1.3.1. *Project Management*

The stakeholders belonging to the classification Project Management are those that work together in ensuring the entire project's success. They keep an overview of the entire project to ensure the targets are met. They are high-positioned directors and/or managers assigned to work on the project either from an engineering company or the client. In the case of Worley, these people primarily look at the implementation of a standardized refinery design from a global perspective, so they consider multiple refineries. This can be seen in their answers concerning their objective in Table 12 (e.g., Appendix 8.4. – Engineering Manager). A Program Director and a Program Delivery Manager both want the reduction of cost along with the number of working hours of the employees (Appendix 8.4. – Program Director, Program Delivery Manager). On the other hand, a Requirements and Standardization Manager want standardization in the technical design and the process of delivery, but only if it adds value (Appendix 8.4. – Requirements and Standardization Manager). Finally, an Appraisal General Manager desires global optimality of all the refineries during operation (Appendix 8.4. – Appraisal General Manager).

5.1.1.3.2. *Design Responsible*

The following classification was that of the Design Responsible. This group of stakeholders works for the Project Management and works with the Refinery Operation to come up with a standardized refinery modification design. In other words, these people are responsible for creating the final deliverable, which is the design. The Design Responsible is basically made up of engineers from different disciplines (e.g., civil, process, electrical, etc.) and other

[1] *Note that objectives and interests are considered to be similar*

supporting members that work on a standardized design. In every engineering discipline, there is usually an assigned lead engineer guiding and supervising the engineers. All the lead engineers are directed by an engineering manager. In creating a standardized design, engineers try to maintain the global perspective of the Project Management. Trying to create a design that leads to global optimality, while considering the varying local condition of each site.

5.1.1.3.3. *Refinery Operation*

After that is the Refinery Operation group, the people working in the refineries. They are mostly the operators of the refinery along with their supporting colleagues. The Refinery Operations group is only composed of people from the client's side, unlike the Project Management and the Design Responsible which is made up of the client and the engineering contractor employees. The Refinery Operation is generalized in this classification, but in truth, each refinery has its own. Essentially this also means that each Refinery Operation group will strive (whether intentionally or not) to influence the standardized design toward what will be most beneficial for their own site (Appendix 8.4. – Refinery Shift Team Leader Oil Movement). As part of the Refinery Operation, there is the Refinery Shift Team Leader Oil Movement who wants a solid plan for his/her refinery with regards to standardization. The Plant Manager desires something similar, to have the best design for the local refinery. A Delivery Lead Site-Specific Scope is also interviewed, and he/she desires (more) collaboration among the refineries (Appendix 8.4. – Delivery Lead Site-Specific Scop. Then there is a Project Operations Engineer identified who likes to have an identical implementation of policies and procedures to every site (Appendix 8.4. –Project Operations Engineer). These stakeholders might have been classified in the Refinery Operation but some of them are also an integral part of the Design Responsible.

5.1.1.3.4. *Government*

Lastly, there is the Government group which is made up of a plethora of levels and departments. In Table 12, a few stakeholders from the Dutch government have been identified, the Ministry of Social Affairs and Employment, a Permit Approval Authority like the Dutch Emission Authority, and the Provincial Government. Although these examples are specific for the country of the Netherlands, similar institutions exist as well in other countries. These stakeholders are recognized by political experts from the Technological University of Delft as relevant in the implementation of a standardized refinery modification design. There are way more stakeholders from the government involved but the aim here is to showcase a few relevant ones and indicate how they potentially can affect the project. The Ministry of Social Affairs and Employment will prefer to have the local (in this case the Dutch) workforce hired instead of expats from another country. The said Ministry will also want healthy and safe working conditions for the employees (Rijksoverheid, 2010). Questions from the Ministry might rise as to how a standardized design will have an impact on working conditions. In contrast, the Dutch Emission Authority will be less interested in the working condition and more so in the impact of the refineries on the climate (Dutch Emission Authority, 2018). The Provincial Government on the other hand will be more interested in environmental laws like the Dutch Emission Authority, but at the same time, this branch of the government is responsible for implementing the spatial planning law (Rijksoverheid, 2013). Construction of potential new units and therefore changes in the plot of land utilized by a refinery will be something of interest to the Provincial Government (Rijksoverheid, 2013).

Everything explained in the past subsections is displayed in Table 12 to give a better overview. In the first column, the stakeholder classification can be found. One column to the right are the identified stakeholders belonging to different classifications. Each stakeholder has his/her respective objective and a suggestion as to how their objective can be achieved (proposed solution). Most of the information present in the table comes from interviews (see Appendix 8.4.). The information from the stakeholders that can't be interviewed is taken from the literature. The role of each stakeholder in the system will be explicated in the next subchapter.

Table 12 *Selected stakeholders for actor analysis*

Classification	Stakeholder	Objective	Proposed solution
Project Management	Program Director	Standardize as much as possible to reduce cost and work hours	Modularization and available yards for it.
	Program Delivery Manager	Finish the refinery modification tasks on time, without needing more people and supervision	Develop a blueprint design that can be copied and implemented in other sites
	Appraisal General Manager	Global optimality of the refineries being standardized	Come up with a common design envelope to decide what is conducive to standardizing
	Requirements and Standardization Manager	Standardization done for value- standardization in technical design and process of delivery	Improve international codes and standards, understand data needed, understand tradeoffs in decision-making, agree on sequencing
Design Responsible	Engineering Manager	Success in each phase of engineering	Change in the organizational structure from decentralized to centralized
	Lead Engineer	Get the best result for the least effort and least time, and build a best practice	Tackling issues and making refinery workers accept change, capture know-how, access to predecessors' files
	Engineer	Create a standardized design	Apply engineering skills and knowledge
Refinery Operation	Refinery Shift Team Leader Oil Movement	A well-thought-out plan implemented in the refinery	Sticking to plan and avoiding micromanagement
	Plant Manager	Get the best design for the local refinery Bioenergy Career Grid (2017)	Provide requirements, work with design responsible
	Delivery Lead Site-Specific Scope	Solving issues through the collaboration of refineries	Have one contractor locally and globally
	Project Operations Engineer	Identical implementation of policies and procedures in every site	Instruction from top – down to adhere to changes, no self-interpretation
Government	Ministry of Social Affairs and Employment	Honest, healthy, and safe work in the Netherlands (Rijksoverheid, 2010)	Use legal and financial means
	Permit Approval Authority	Climate neutrality (Dutch Emission Authority, 2018)	Use legal and financial means
	Provincial Government	Implement spatial planning law and environmental laws (Rijksoverheid, 2013)	Use legal and financial means

Out of all the stakeholders in Table 12, the problem formulation of this paper fits best with that of a Program Delivery Manager. This research aims to contribute to the implementation of a standardized refinery modification design while keeping local and global effectiveness in mind and considering the presence of various stakeholders. This in a way is close to the objective of a Program Delivery Manager which is to "*Finish the refinery modification tasks on time, without needing more people and supervision".* Finishing the refinery modifications tasks can be understood as the implementation of a standardized design, at least in the case of Worley. This is because Worley is doing the refinery modification through the means of implementing a standardized design. Therefore, it goes hand in hand that once the standardized design has been completely implemented, then the refinery modification will also be finished.

Incorporating local and global effectiveness in the standardized design will contribute to the refinery modification tasks being finished on time. Imagine if a standardized design is to be created by neglecting or not accurately considering the local conditions and the local stakeholders, then this might result in an unfitting design. This statement shows the relevance and essence of conducting a stakeholder analysis. With the help of a stakeholder analysis, stakeholders along with their interests can be identified. Identification of these interests will allow the problem owner to include them in consideration, especially in the creation of a standardized design. Otherwise, the neglection of the stakeholders will lead to an unfitting design and therefore the prolongation of the overall project time as revisions will need to be made. If that is to happen, then the standardized design might be considered unsuccessful. People will think that the refinery modifications might have been better conducted individually and have a locally specific design instead of a standardized one. This is something that the Program Delivery Manager absolutely wants to avoid. Ultimately, the use of a standardized design must turn out to be more profitable, time and workforce wise than having to design an X number of times individually for each refinery.

5.1.2. Stakeholder Relations

To help better understand a formal chart, a stakeholder map in Figure 9 is first illustrated. This step of stakeholder map creation is not included in Chapter 4 since it is created as a supplementary. The stakeholder map shows all the groups identified in Table 12, the Project Management, the Design Responsible, the Refinery Operation, and the Government. Figure 9 illustrates the relationship among the stakeholder groups. The Project Management supervises the Design Responsible and facilitates the cooperation of the Refinery Operation group. Cooperation here pertains not only to working with the Design Responsible but also within the refineries themselves. Lastly, there is the Government which is given as a dashed line that shapes everything that occurs within the system. After going through these groups of stakeholders from a more general point of view, now it becomes simpler to dive deeper and take a gander at the relevant stakeholders within the system at hand.

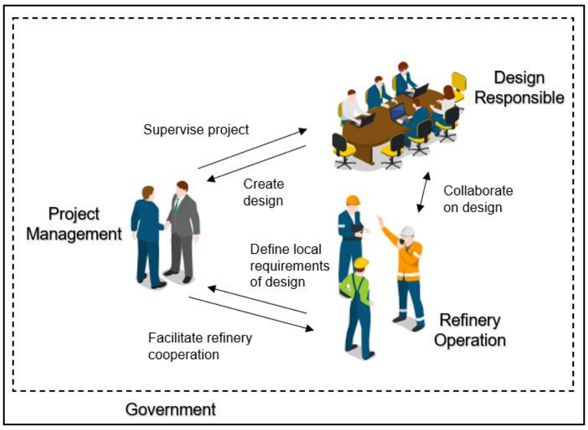

Figure 9 *Stakeholder map*[2]

[2] *Self-created via icograms.com*

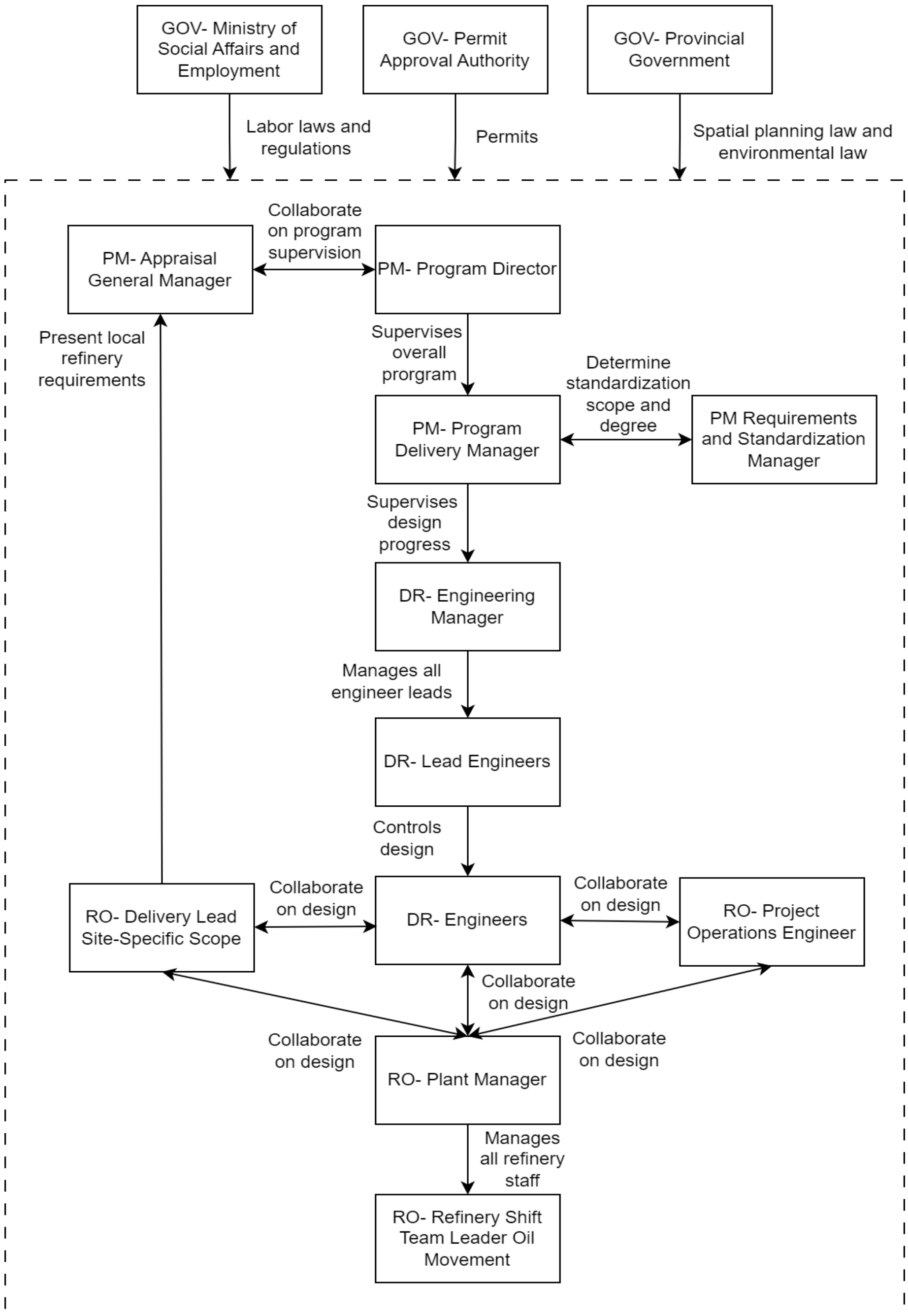

Figure 10 *Formal Relations Chart*

Legend:

GOV- Government
PM- Project Management
DR- Design Responsible
RO- Refinery Operation

In the Formal Chart in Figure 10, four prefixes are presented, GOV, PM, DR, and RO. These four are abbreviations for the classification introduced in Table 5, Government (GOV), Project Management (PM), Design Responsible (DR), and Refinery Operation (RO). Going from top to bottom, the role of the government depicted in Figure 10 is defining the boundaries of the system refinery. This is given as a dashed line by surrounding non-governmental stakeholders. Only non-governmental stakeholders are placed inside the dashed line as they are the ones that need to be regulated by the government. The governmental stakeholders themselves, in this case, are not the ones operating or working on the system refinery. The dashed line illustrates that the standardized design must fit within the boundaries that have been set up by the government via institutions (e.g., laws and regulations). The Ministry of Social Affairs and Employment creates and enforces labour laws and regulations, the Permit Approval Authority determines the permits that must be requested for the project's approval, and the Provincial Government enforces the spatial planning law and environmental law.

Inside the dashed line (top-left corner) the Appraisal General Manager and the Program Director, both from the Project Management group, collaborate among others on the supervision of the overall program. The role of the Appraisal General Manager is to oversee the development of the program (during the front-end development stage) from the client's perspective (Appendix 8.4. – Appraisal General Manager) the Program Director on the other hand is from the engineering contractor Worley. They aim for the global optimum of a standardized refinery modification design. The Program Director indirectly does this through the Program Delivery Manager (the problem owner), whose role is to realize projects for customers (Appendix 8.4. – Program Delivery Manager). The Program Delivery Manager works with the Requirements and Standardization Manager from the client's side (responsible for leveraging standardization for value, see Appendix 8.4. – Requirements and Standardization Manager) in determining the scope and degree of standardization to be applied to the project. The Program Delivery Manager supervises the design progress via an Engineering Manager from the Design Responsible group, in turn, he/she manages all the Engineering Leads that control the design of all the engineers from their respective disciplines.

The Engineers collaborate with various stakeholders from the Refinery Operation group on the standardized refinery modification design. They are mainly the Delivery Lead Site-Specific Scope, the Project Operations Engineer, and the Plant Manager. The Plant Manager is the one in charge of overseeing the entire plant or refinery. In collaboration with others, a Plant Manager will always try to influence the standardized design in a way that will be most beneficial for his/her own refinery. Among the employees under him/her is the Refinery Shift Team Leader Oil Movement who looks after the shift or working schedule of the people from the oil movement team. The last unexplained connection is that of the Delivery lead Site-Specific Scope with the Appraisal General Manager. Every refinery will have a Delivery Lead Site-Specific Scope and they will present their requirements to the Appraisal General Manager. That way these requirements can be included for consideration when planning the overall global approach for the implementation of the standardized refinery design.

5.1.3. **Stakeholder Interdependencies**

After discovering the roles of the stakeholders and what their professional relationships are, the next step will be to find out their interdependencies. Specifically, to whom the problem owner is highly dependent in terms of solving his/her problem. The steps for this are explained in section 4.1.3. Applying these steps results in a list of stakeholders shown in Table 13. The problem owner, the *Project Delivery Manager*, is excluded from this table. In the first column, the stakeholder is listed. Besides it are the important resources that they can implement to help contribute to the solving of the problem. The degree of stakeholders' replaceability and dependency is placed in the third and fourth columns. Finally, in the last column, it states whether a stakeholder is critical or not. Five stakeholders are identified as critical: Program Director, Appraisal General Manager, Engineering Manager, Requirements and Standardization Manager, and Permit Approval Authority. The cells of these stakeholders in Table 13 are shaded to easily recognize them. The rest of the stakeholders are classified as auxiliary stakeholders.

Table 13 Critical stakeholder identification

Stakeholder	Important resources	Replaceable?	Dependency?	Critical actor?
Program Director	Engineering (and procurement) team	Hard	High	Yes
Appraisal General Manager	Knowledge of operation	Hard	High	Yes
Delivery Lead Site-Specific Scope	Information, position in the network (site relations)	Hard	Medium	No
Engineering Manager	Knowledge and position in the network	Hard	High	Yes
Lead Engineer	Information	Hard	Medium	No
Engineer	Information	Easy	Low	No
Refinery Shift Team Leader Oil Movement	Knowledge of refinery and crude	Easy	Low	No
Plant Manager	Refinery project team	Easy	Medium	No
Project Operations Engineer	Information	Easy	Low	No
Requirements and Standardization Manager	Information	Hard	High	Yes
Ministry of Social Affairs and Employment	Authority	Hard	Medium	No
Permit Approval Authority	Authority	Hard	High	Yes
Provincial Government	Authority	Hard	Medium	No

A Program Director along with an Appraisal General Manager is hard to replace and has a highly important resource, hence they are considered critical actors. Their resources are needed for the overall success of the project. For both actors, the local and global aspects of a project are important. A Delivery Lead Site-Specific Scope has medium dependency because for him the focus is more on the local site along with the stakeholders there and less so for the totality of the project. An Engineering Manager and Lead Engineers are both hard to replace due to the scale of such a project. There aren't enough experts that can easily be put in such positions. In terms of their important resources a Lead Engineer only has an influence on one design aspect, unlike an Engineering Manager that is involved in all. Hence, an Engineering Manager is a critical actor, and the Lead Engineer is not. An Engineer, a Refinery Shift Team Leader Oil Movement, and a Project Operations Engineer are easily replaceable and have a low-important resource which is why they are not classified as critical actors. A Plant Manager in contrast has a relatively important resource. The said actor tries to influence the design so it can cater more to their refinery but for the overall project it is less important, therefore he/she is not a critical actor. A Requirements and Standardization Manager is an actor with a crucial perspective when it comes to standardization locally and globally. Because, as mentioned earlier, a Requirements and

Standardization manager leverages standardization for value. As he/she mentioned, standardization must not be done just for the sake of standardization (Appendix 8.4. Requirements and Standardization Manager). Such an actor is also not easily replaceable and for these reasons, he/she is classified as a critical actor. The government organizations in Table 13 are all irreplaceable. Of these three, only a Permit Approval Authority is considered to have a high dependency because the design choices for such a project need to meet all the minimum requirements. In a way, it determines the boundaries of the standard design solution.

Most of the stakeholders in Table 13 have knowledge or information as their important resource. This was not surprising as most, if not all, of them, are employed as (highly) skilled workers. Yet some of them are still considered easily replaceable. In actuality all of them admitted that they are replaceable, but some less easily than others. This was due to their experience and the set of knowledge/information that they had acquired through the years of working in their industry. From this list of stakeholders, the government organizations are the only ones who have authority as their important resource. This authority comes from the mandate given unto them by the constitution. In terms of replaceability, the entire organization as a whole is hard to replace. But individually, the majority of the people from these government organizations are also replaceable.

Table 14 *Classification of interdependencies*

Stakeholder	Dedicated actors		Non-dedicated actors	
	Critical actors	*Non-critical actors*	*Critical actors*	*Non-critical actors*
Similar interest	Program Director, Appraisal General Manager, Engineering Manager	Delivery Lead Site-Specific Scope, Lead Engineer, Engineer, Refinery Shift Team Leader Oil Movement, Plant Manager, Project Operations Engineer, Requirements and Standardization Manager	Permit Approval Authority	Ministry of Social Affairs and Employment, Provincial Government
Conflicting interest				

The next step after discovering a stakeholder's criticalness is to determine the problem owner's interdependency with them. Table 14 shows the classification of interdependencies discovered. Surprisingly, none of the stakeholders involved in the project have a conflicting interest with the problem owner. The question that can be raised from this is, how come the implementation of a standardized refinery modification design is very complex and difficult? The answer lies in the level of interest being considered. For Table 14 the interest being talked about focuses on the implementation of a standardized refinery modification design as a whole. However, zooming in on different aspects of it will show differences in meanings and opinions. This is an attachment to the importance of stakeholder alignment and how it must not be neglected.

Looking at the governmental stakeholders, they are also classified under similar interest because they would rather the project be successful than not, due to the overall benefits that it will create. For the Permit Approval Authority this is positive since such a project will reduce emissions. For the Ministry of Social Affairs and Employment, projects like these provide jobs and opportunities for the local workforce. Finally, for the Provincial Government, such a project helps in different ways (e.g., reduce emissions, economic growth, etc.) to advance the development of their respective provinces.

Of all the critical actors in Table 14, only the Permit Approval Authority, the Provincial Government, and the Ministry of Social Affairs and Employment are considered non-dedicated actors. They are seen as such because they will not be directly affected by the implementation (including design creation) of a standardized refinery design. The rest of the stakeholders are all dedicated from the get-go because they are all involved in the implementation of the design whether it is through operation of the refinery or creation of its design.

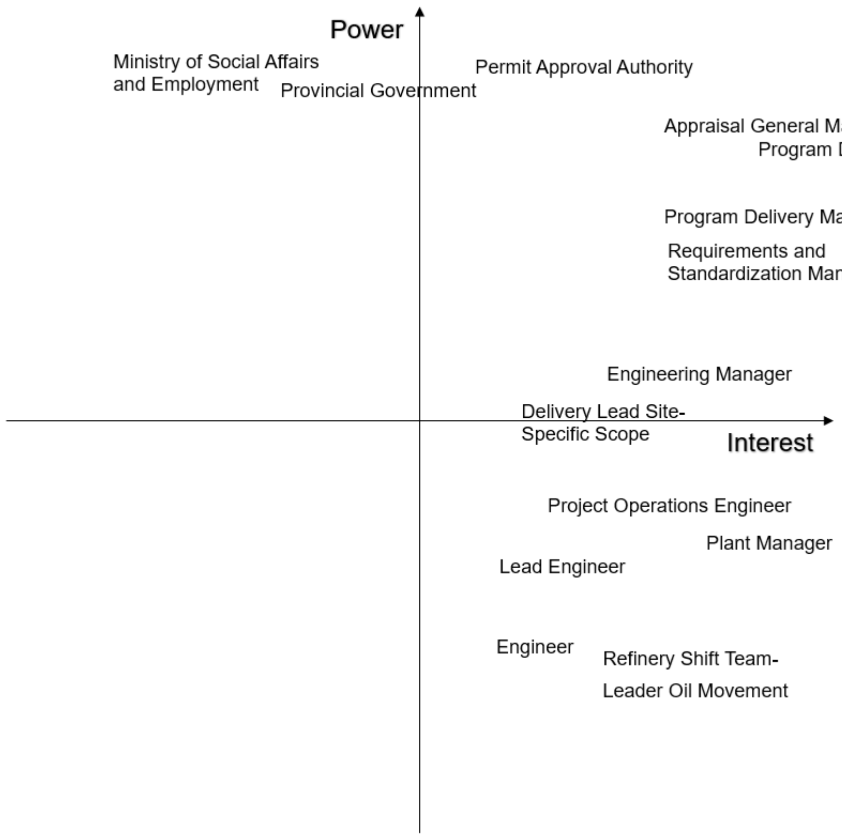

Figure 11 *PI Grid*

The results present in Table 14 are also visualized in a power-interest (PI) grid as shown in Figure 11. The result of Table 14 and Figure 11 can be used as well to identify the existing or potential coalitions and alliances that can be made. About the implementation of a standardized refinery modification design, wholistically, no stakeholder with a conflicting interest is present. This means that there is likely no one from the actors in Table 14 that will try to work against the successful implementation of a standardized design. This is also apparent in the answers of all the stakeholders interviewed. Everyone sees the successful implementation of a standardized design as something positive not just individually, but collectively as well. However, even if everyone is all for the implementation of a standardized refinery modification design, still there could be contrast in interests in different aspects or parts of such a mega project. That's why the Project Delivery Manager must continue to form a good relationship with everyone, most especially with the critical actors. That way he/she can make use of these good connections in helping him realize his goal.

The PI grid displayed in Figure 11 showcases plenty of stakeholders, but this surely doesn't encompass every stakeholder there is (see Appendix 8.1. for an exhaustive list of stakeholders). As explained earlier, not every stakeholder will be interviewed due to the limited time scope. However, the stakeholders present in the PI grid are diverse, which is the target as mentioned at the start of the stakeholder analysis. In Figure 11, it can be seen that all critical actors are situated in the top-right quadrant, so having high power and high interest. A couple of other stakeholders are in the top-left quadrant, the stakeholders with high power but not necessarily that interested in the project. Finally, there are those with high interest, but low power (bottom-right quadrant). These stakeholders in the first and fourth quadrants were classified earlier as auxiliary stakeholders. They have their part to play in the system, but their overall contribution is not as substantial as a critical stakeholder. In the following subchapter, the critical stakeholders will be interviewed regarding the relevant aspects that must be considered before a standardized refinery modification design can be implemented.

5.2. Aspect Identification

Subchapter 5.2 is all about identifying the technical and political aspects that must be considered before a standardized refinery modification design can be implemented. In section 5.2.1., a literature review is conducted to discover the said aspects. In section 5.2.2. the aspects discovered via interviews are presented. Finally, in section 5.2.3. the result of both approaches is combined.

5.2.1. Aspect identification via Literature review

The list of the relevant aspects in implementing a (standardized refinery modification) design discovered in the literature are displayed in Table 15. The procedure for the literature review was explained in section 4.2.1. The following set of keywords used is: TITLE-ABS-KEY (biofuel AND (aspect* OR factor* OR element*) AND refinery AND (consider* OR "taken into account") AND (modif* OR modern* OR adjust* OR revamp*)). The selected keywords aim to look for papers where aspects that must be considered with regard to the modification of a refinery are presented. The set of keywords used results in six papers, but of these, only one is deemed to be relevant, that of Su et al., 2022 (see Table 15).

Table 15 *Relevant aspects found in the literature*

Author(s)	Relevant Aspects
Su et al., 2022	• Hydrogen consumption • Catalyst activity • Corrosion • Byproducts and effect on desulfurization • Policy/green molecules
Prasetyo et al., 2020	• Net present value and cost • Global warming potential • CO_2 equivalent emission • Safety • Competition between agents
Oliveira & Schure, 2020	• Technology options • Site specificity • Carbon transport and storage infrastructure • Green electricity • Hydrogen supply • Biomass availability
Santibañez-Aguilar et al., 2014	• Profit • Environmental impact • Jobs created

	• Availability and cost of bioresources • Production technologies • Biomass processing

Their paper investigates the considerations in choosing a co-processing or stand-alone production strategy for a refinery. Co-processing is the conversion of biogenic feedstocks and petroleum distillates to produce lower-carbon intensive fuels like sustainable aviation fuel (van Dyk, 2022). In contrast, a stand-alone refinery is one that has been repurposed from an existing refinery to produce low-carbon intensive fuels (Su et al., 2022). Both refinery modifications (co-processing and stand-alone) are applicable in the project of Worley used as case in this research. The important considerations according to Su et al. (2022) are displayed in Table 15. Most of the aspects identified by Su et al. (2022) focus on technical matters, and only the last one (policy/green molecules) is of a political nature. An example of such an aspect is corrosion. Su et al. (2022) explain the impact that corrosion can have in terms of material choice for the unit to be designed. Another consideration is the aspect policy/green molecule. Depending on the policy in place, a stand-alone option (purely a bio-refinery) has the flexibility to blend or sell biofuel. A co-processing refinery on the other hand produces a mixture of bio- and fossil fuel. Therefore, it is difficult to obtain benefits/incentives (e.g., tax credits) for producing biofuel.

After the search for papers using a set of keywords resulted in only one relevant paper, the search strategy is replaced. This time, various combinations of keywords are tried, and three papers have been found relevant: Prasetyo et al., 2020; Oliveira & Schure, 2020; Santibañez-Aguilar et al., 2014. The paper of Prasetyo et al., (2020) investigates economic sustainability, environmental sustainability, safety, and social impacts. In adopting a biorefinery, careful decision-making is needed due to the abundance of processes and technologies. To add on that, optimization of the process is made more difficult, because of the multi-criteria sustainability aspects that must be fulfilled by a biorefinery. An example of the aspect that they talk about is safety and how it must thoroughly be considered when designing a chemical plant (Prasetyo et al., 2020).

The next paper is by Oliveira & Schure (2020) and it is a joint publication between the Netherlands Environmental Assessment Agency (PBL) and the Netherlands Organization for Applied Scientific Research (TNO). It looks into how the complex Dutch refinery sector can be decarbonized. In their publication, the internal and external aspects that needed to be considered are explicated. The internal aspects are technology options and site specificity. On the other hand, external aspects are carbon transport and storage infrastructure, green electricity, hydrogen supply, and biomass availability. In their paper, however, in-depth explanations showcasing the importance of these aspects are missing.

The last paper is that of Santibañez-Aguilar et al. (2014). which presents a model that can be used to optimize a biorefinery supply chain. This paper is also included among those analyzed in the literature review conducted in Chapter 2. According to Santibañez-Aguilar et al. (2014), the implementation of such a supply chain must consider certain aspects (see Table 15). An example of it is the aspect of production technology. Santibañez-Aguilar et al. (2014) mention that diversity in production technology in terms of producing multiple products using a variety of biomass feedstocks is important to consider when establishing a biorefinery supply chain.

5.2.2. Aspects identified by the critical stakeholders

In subchapter 8.2. of the Appendix, the complete list of aspects identified via interviews with all stakeholders is shown. Out of this list, only the ones given by the critical stakeholders are included in Table 16.

Table 16 *Relevant aspects based on interviews*

Stakeholder	Relevant Aspects
Project Delivery Manager	• Space • Utilities (steam, cooling water, water treatment, power) • Laws (IRA) • Permitting (noise, emission, water emission) • Standards (EU and USA)
Program Director	• Logistics, accessibility • Labour/Staffing
Appraisal General Manager	• Logistics, accessibility • Labour/Staffing • Space
Engineering Manager	• Units of measurement • Site specifics • Unions vs Subcontracting
Requirements and Standardization Manager	• Integration with existing site systems (Utilities) • Consequences of moving away from existing site standards (operator knowledge, human factors, contracting, spares, etc.) • Permitting (wildlife, noise, air quality, etc.)
Permit Approval Authority	• Permitting

The first aspect listed is that of a Project Delivery Manager, the problem owner for this research. For a Project Delivery Manager, the relevant technical aspects that must be considered are space, utilities (e.g., steam, cooling water, water treatment, and power), and standards. Political wise, a Project Delivery Manager finds Laws like the Inflation Reduction Act or IRA from the United States of America and permitting (noise, emission, water emissions) as important. A Program Director and an Appraisal General Manager both find logistics and labour to be important aspects. A small difference between the two is that an Appraisal General Manager considers space as another relevant aspect, which a Program Director does not. Both however do not have any political aspects on their list of relevant aspects.

For an Engineering Manager, the relevant aspects are the units of measurement, the site specifics, and the difference between unions and subcontracting when it comes to labour. Next is a Requirements and Standardization Manager and such an expert finds utilities, site standards, and permitting to be essential. Finally, there is the Permit Approval Authority and for this stakeholder, permitting is deemed important. From the answers of the critical stakeholders, some similarities can be seen. Also, there are aspects in Table 16 that can be found in Table 15 as well. This points out that certain aspects that the critical stakeholders mention are also considered to be relevant in the literature. In section 5.2.3. the results of both tables will be combined.

5.2.3. Aspect comparison and selection

The aspects identified via the literature and the interviews are presented in the previous sub-sections. Here in section 5.2.3., a table that shows the critical stakeholders that have an overlap in aspects that they value is created. Not only that but the table is also used to inform the reader which literature values the same aspect as the critical stakeholders. The aspects in Table 16 that are considered by more than one critical stakeholder and present in Table 15 are colored grey in Table 17. Next, the aspects that are valued by either more than one critical stakeholder or by one critical stakeholder and the literature are colored as well. Initially, the plan is to consider only these aspects – this results in the following aspects found to be relevant: space, utilities, permitting, logistics/accessibility, labour/staffing, and site specificity. However, after examining the aspects identified by the critical stakeholders, it appears that labour/staffing can be divided into management and labour. The aspects that are only valuable for one stakeholder remain unshaded. These aspects are laws, standards, units of measurement, unions vs subcontracting, and the consequences of moving away from existing site standards. To avoid bias, these aspects valued by only one critical stakeholder and not present in the literature will be left out of the list of relevant aspects.

Table 17 *Aspect comparison and selection*

Stakeholders	Aspect	Literature
Project Delivery Manager, Appraisal General Manager	Space	
Project Delivery Manager, Requirements and Standardization Manager	Utilities (steam, cooling water, water treatment, power)	
Project Delivery Manager	Laws (IRA)	
Project Delivery Manager, Requirements and Standardization Manager, Permit Approval Authority	Permitting (noise, emission, water emission)	Santibañez-Aguilar et al., 2014 Prasetyo et al., 2020 Su et al., 2022
Project Delivery Manager	Standards (EU and USA)	
Program Director, Appraisal General Manager	Logistics, accessibility	
Program Director, Appraisal General Manager	Labor/Staffing	Santibañez-Aguilar et al., 2014 Prasetyo et al., 2020
Engineering Manager	Units of measurement	
Engineering Manager	Site specifics	Oliveira & Schure, 2020
Engineering Manager	Unions vs Subcontracting	
Requirements and Standardization Manager	Consequences of moving away from existing site standards	

On the other hand, there are aspects identified in the literature but are not mentioned by the critical stakeholders. These aspects are checked to see if they can be included in the list of relevant aspects as well. However, some are too technical (i.e., too focused on the refinery design), or economical (e.g., profit, cost). In the second sub-research question, it is stated that the focus of this study is technical and political aspects that will affect the implementation of a standardized design and not the design itself. Therefore, such aspects as corrosion and catalyst activity are irrelevant to this research. Others like profit and net present value are also not included because economic aspects are not taken into account in this study. These aspects are surely important for the implementation of a standardized refinery modification design. But for this research, these aspects fall outside of the scope. What's more, some aspects identified via the literature already share a resemblance with the aspects identified by the critical stakeholders. For example, the aspect of *permitting* identified by the Permit Approval Authority can be seen as similar or close to the aspect of *environmental impact* discovered in the paper of Santibañez-Aguilar et al. (2014). A governing body will only provide a permit if it's proven that for instance the environmental impact of a refinery will be minimized or non-existent. After going through all the remaining aspects identified in the literature but not valued by the critical stakeholders, it's discovered that no relevant aspect has been left out. This is because the aspects valued by the critical stakeholders already encompass or share similarity with the remaining aspects identified in the literature. Also, the other aspects fall outside the scope of this study (i.e., too technical, focusing on economic factors, etc.), hence they are not relevant for this research.

Table 18 *Relevant aspects from literature and interview*

Aspect Classification	Relevant Aspects
Technical	• Space • Utilities • Logistics/Accessibility • Site specificity
Political	• Permitting
Personal	• Management/Labour

From all the aspects listed in Table 17, those shaded with grey are called the relevant aspects. Relevancy pertains here to the aspects that must be considered in implementing a standardized refinery modification design. A new table is created (see Table 18) to show the full list of the relevant aspects. Then, the aspects have been classified under political or technical to adhere to the focus of the second sub- research question. On top of that, the classification personal is created to associate the aspects that are related to the stakeholders. In the first column of Table 18, the classification of the aspect is displayed, technical, political, or personal. Besides it are the relevant aspects themselves.

5.3. Requirements analysis

After identifying the relevant aspects that must be considered in the implementation of a standardized refinery modification design, the next step is to use these aspects in requirements design as shown in 5.3.1. Then in section 5.3.2., means will be thought of for every requirement as to how it can be achieved.

5.3.1. Requirement design

In requirements design, the aim is to create a set of requirements that need to be fulfilled to ensure a successful implementation of a standardized refinery modification design. This step of the research is still part of the relevance cycle (see Figure 1). The requirements design starts in 5.3.1.1. with the creation of an initial requirement list by thoroughly examining the interview data from the stakeholder analysis and aspect identification. Thereafter, interviews will be conducted with the critical stakeholders in 5.3.1.2. to hear their thoughts on the initial requirement list. After this validation step, the requirement list will be converted into a requirements tree, supplemented with extra requirements where needed, and finally classified in 5.3.1.3.

5.3.1.1. Initial requirement list

Three aspect classifications are created in 5.2.3., these are technical, political, and personal. Under technical, the following aspects are identified: space, utilities, logistics/accessibility, and site specificity, for political it is permitting, and finally for personal the aspects management/labour is discovered. In section 4.3.1., it is mentioned how the initial requirement list can be generated. The exact same procedure is followed here. Interview data coming from the stakeholder analysis and aspect identification are used as sources. This resulted in the initial requirement list in Table 19.

Table 19 *Initial requirement list*

Aspect	Requirements
Space	1. Sufficient space to accommodate the standardized refinery modification design in all sites (Appendix 8.4. – Program Delivery Manager). 2. Adequate space to accommodate the facilities for the employees that would be doing the construction (Appendix 8.4. – Program Director). 3. Ample space to enable modularization on site (Appendix 8.4. – Program Director).
Utilities	4. Enough capacity of installed cooling water (Appendix 8.4. – Delivery Lead for Site-Specific Scope). 5. Enough capacity of installed water treatment (Appendix 8.4. – Program Delivery Manager). 6. Enough capacity of installed electrical power (Appendix 8.4. – Requirements and Standardization Manager). 7. Enough capacity of installed steam (Appendix 8.4. – Program Delivery Manager).
Logistics/accessibility	8. Accessibility of site for the equipment to be used (Appendix 8.4. – Appraisal General Manager). 9. Accessibility of site for the construction materials (Appendix 8.4. – Appraisal General Manager). 10. Accessibility of site for the employees (Appendix 8.4. – Appraisal General Manager).
Site specificity	11. Examine the tradeoff between building a new (standalone) property or using an existing facility (Appendix 8.4. – Requirements and Standardization Manager). 12. Consider consequences of moving away from existing site standards (Appendix 8.4. – Requirements and Standardization Manager): a. Human factors b. Contracting 13. Integration with the existing system (Appendix 8.4. – Requirements and Standardization Manager). 14. Active involvement and participation of each site (Appendix 8.4. – Program Director).
Permitting	15. Acquire permit for flora and fauna (Appendix 8.4. – Project Operations Engineer). 16. Acquire permit for nature protection and environmental law (Appendix 8.4. – Appraisal General Manager). 17. Acquire permit for building (Appendix 8.4. – Appraisal General Manager). 18. Acquire permit for noise (Appendix 8.4. – Requirements and Standardization Manager). 19. Acquire permit for air quality and/or emission (Appendix 8.4. – Requirements and Standardization Manager). 20. Acquire permit for waste discharge (Appendix 8.4. – Lead Process Engineer). 21. Acquire permit for water (Appendix 8.4. – Program Delivery Manager).
Management/Labour	22. Ensure a healthy and safe working environment for the employees on-and offsite (Appendix 8.4. – Assistant Professor, Governance expert). 23. Decision on whether to hire local or international employees (Appendix 8.4. – Appraisal General Manager). 24. Retention of existing human capital (Appendix 8.4. – Appraisal General Manager). 25. Provide schooling and workshops to refinery employees to prepare them to upcoming changes (Appendix 8.4. – Engineering Manager). 26. Adequate supervision of each department or division (Appendix 8.4. – Program Delivery Manager). 27. Strive alignment of employees (Appendix 8.4. – Engineering Manager). 28. Facilitate idea and learning sharing (Appendix 8.4. – Appraisal General Manager). 29. Enable transferability of people from site to site (Appendix 8.4. – Appraisal General Manager). 30. Clarify who has decision-making authority and accountability (Appendix 8.4. – Requirements and Standardization Manager).

The requirements that belong to space are all about ensuring that the standardized design, the processes, and the workers, can be accommodated in each site, space-wise. The aspect utilities are focused on auxiliary processing units that support the production process of a refinery. Examples of such utilities are electricity, water, steam, and many more. Logistics/accessibility is about the transportation to and from the refinery sites of everything needed for the refinery modification. The next aspect called site specificity is defined as everything that could be different and hence specific to each refinery site. Plenty of items in other aspects can also fit under site specificity, but only the items that do not belong in any of the other aspects are placed under site specificity. Under the political classification, only the aspect permitting is identified. This aspect is mainly about ensuring that the modification process of the refinery during and after will still meet the expectations of the governing bodies (e.g., emission, water, noise, etc.). Lastly, there is management/labour that pertains to the employees and everything that potentially can have something to do with them and their work. Among these are the working conditions, responsibilities of an employee, decision-making rights, supervision, and so on and so forth.

5.3.1.2. Requirement validation

In section 5.3.2., the requirements seen in Table 19 are validated with the critical stakeholders. Only the stakeholder Permit Approval Authority is not interviewed. There is simply no direct connection to the said organization. However, in creating the requirement list, interviews with policy and governance experts from the Technological University of Delft are done. In general, the critical stakeholders have a consensus with most of the items listed. For some items, different suggestions are given ranging from modification, addition, or removal from the requirement list.

All critical stakeholder's suggestions are implemented directly, and it results in a new requirement list (see Table 20). This direct implementation means that their answers are not present in the interview summaries in Appendix 8.4. Therefore, for some of the requirements in Table 20, like item number three, it is no longer mentioned that it came from Appendix 8.4., but rather the critical stakeholder who mentioned it during the interview. The next step after validating the requirement list will be to make a requirement tree out of it. Not only would it give a better overview, but it would also make the classification of the requirements into functional, behavioural, or structural requirements easier, see section 4.3.1. for extra explanation.

Table 20 *Validated requirement list*

Aspect	Requirements
Space	1. Sufficient space to accommodate the standardized refinery modification design in all sites (Appendix 8.4. – Program Delivery Manager). 2. Adequate space to accommodate the facilities for the employees that would be doing the construction (Appendix 8.4. – Program Director). 3. Adequate space for (supplementary) processes (e.g., maintenance access, equipment, replacement plans, etc.) (Requirements and Standardization Manager).
Utilities	4. Assess which utility is needed and identify what limitations are tied to it like capacity, reuse, uncertainty in sizing of tie in, etc. (Requirements and Standardization Manager): a. Enough capacity of installed cooling water (Appendix 8.4. – Deliver Lead for Site-Specific Scope). b. Enough capacity of installed water treatment (Appendix 8.4. – Program Delivery Manager). c. Enough capacity of installed connection to the electricity grid (Appendix 8.4. – Requirements and Standardization Manager). d. Enough capacity of installed steam (Appendix 8.4. – Program Delivery

	Manager). e. Enough capacity of installed flare (Program Director).
Logistics/accessibility	5. Accessibility and logistic constraints per sites relating to the chosen construction approach (Appendix 8.4. – Appraisal General Manager, Requirements and Standardization Manager). a. How to transport from port/road b. Above ground transportation considerations (bridges, power cables, etc.) c. Underground considerations lie soil loading. 6. Accessibility of site for the employees (Appendix 8.4. – Appraisal General Manager). 7. Determine impact to local traffic system (Requirements and Standardization Manager).
Site specificity	8. Examine the tradeoff between building a new (standalone) property or using an existing facility (Appendix 8.4. – Requirements and Standardization Manager). 9. Gain understanding of the "cultural[3]" differences of each site then looking for the commonality (Appraisal General Manager). 10. Consider consequences of moving away from existing site standards (Appendix 8.4. – Requirements and Standardization Manager): a. Human factors - Provide training and workshops to refinery employees to prepare them to upcoming changes. b. Impact on operations (e.g., sparing philosophy, maintenance procedures) 11. Integration with the existing system (Appendix 8.4. – Requirements and Standardization Manager). 12. Engage local sites to be actively involved – to understand and support the standardization approach treatment (Appendix 8.4. – Program Director). 13. Find out the environmental conditions (e.g., temperature range, humidity, rain fall, but also extremes like earthquakes, cyclones, tropical storms, frost) (Appendix 8.4. – Program Delivery Manager, Requirements and Standardization Manager). 14. Determine local limitation concerning maximum size allowed during transportation (Appendix 8.4. – Program Director). 15. Determine local regulations and requirements' impact on the design (Appendix 8.4. – Requirements and Standardization Manager).
Permitting	16. Understand what permits are needed and how to obtain the permit e.g., nature protection (flora & fauna), building, noise, air quality, emission, water discharge, water, visual impact, and many more (Appendix 8.4. – Project Operations Engineer, Appraisal General Manager, Requirements and Standardization Manager, Lead Process Engineer, Program Delivery Manager).
Management/Labour	17. Availability of qualified project resources (employees) with experience in standardization (Appendix 8.4. – Appraisal General Manager). 18. Resource (employee) continuity per phase and per standardization project (Appendix 8.4. – Appraisal General Manager). 19. Adequate supervision of each department or division (Appendix 8.4. – Program Delivery Manager). 20. Establish a conflict or misunderstanding resolution procedure (Appendix 8.4. – Engineering Manager). 21. Facilitate idea and learning sharing (Appendix 8.4. – Appraisal General Manager). 22. Enable transferability of people from site to site (Appendix 8.4. – Appraisal General Manager). 23. Clarify who has decision-making authority and accountability. (Appendix 8.4. – Requirements and Standardization Manager).

Normally, verification of the requirements will also be done to see if the requirements could be fulfilled by the system or the design. However, the design that is to be created in this study is a framework that will help in the implementation of a standardized refinery modification design. It is not a design that will enable the fulfillment of the requirements. Hence, verifying if the design (i.e., the framework) can meet the requirements is not possible.

[3] The way people do certain things in the refinery, their common practice.

5.3.1.3. Requirement classification

Table 20 in subsection 5.3.1.2. is converted into a requirements tree to give a better overview of all the requirements, as well as to better showcase the difference in functional, behavioural, and structural requirements. The requirements tree generated out of Table 20 can be seen in Figure 12. A larger version of this figure is added in Appendix 8.5. Also, a legend in the bottom-left corner is made, to distinguish the different requirements. At the top of the tree, the mission statement can be found which states: "*To develop a framework that considers local & global effectiveness and heterogeneous stakeholders in the implementation of a standardized refinery modification design*." The mission statement is based on the main research question formulated in this research paper.

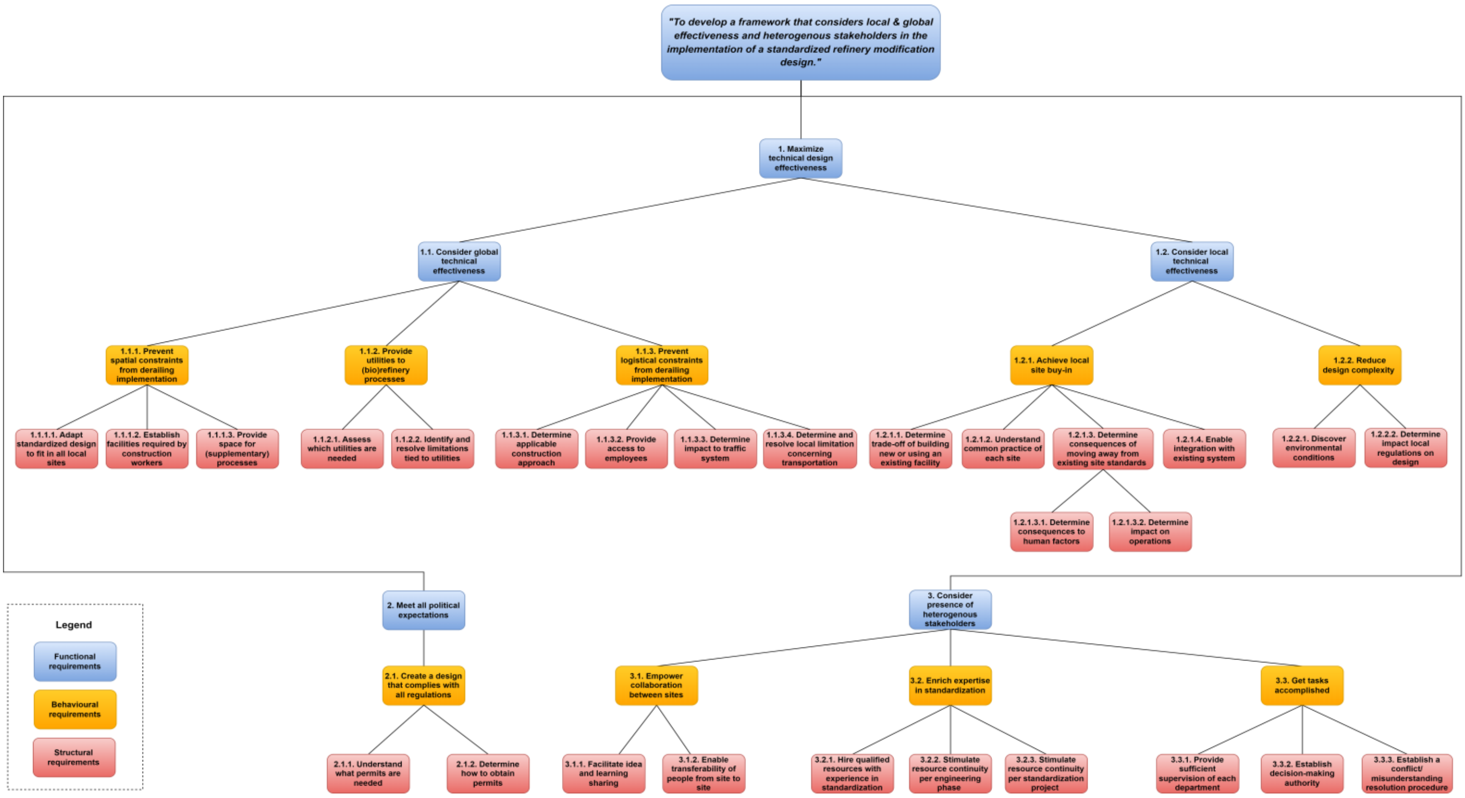

Figure 12 *Requirements tree Worley*

Under the mission statement, functional requirements can be found. The first one is to 1. Maximize the technical design effectiveness by 1.1. Considering global technical effectiveness and 1.2. Local technical effectiveness. Next is to 2. Meet all political expectations and 3. Consider the presence of heterogeneous stakeholders. Under these functional requirements are behavioural requirements and in turn structural requirements are under them. Most of the requirements identified in Table 20 are classified as structural requirements, as these are too concrete or specific and pertained to what should be achieved by the framework. A level above that is a behavioural requirement that tries to answer the how-to question, and on top of it is a functional requirement that focuses on the why. To give an example, the framework shall ("*what*") allow/enable the *1.1.1.1. adapting of a standardized design to fit in all local sites*. Because it will help in ("*how*") 1.1.1. *preventing spatial constraints from derailing the implementation of the standardized design*. That way, it ("*why*") can ultimately contribute to 1. *maximizing the technical effectiveness* of the standardized design. Besides such connections among requirements, sometimes there can also be conflicts. This means that the fulfillment of one can possibly lead to the demise of the other. However, no such conflicting requirements are found.

5.3.2. Artifact design

The next step after requirement design is artifact design. In this part of requirement analysis, means that can fulfill the requirements are thought of, then combined to form an artifact. This artifact is then supposed to meet the requirements altogether. Going back to this research, the focus is not to identify means that will help fulfil the requirements to enable the implementation of a standardized refinery modification design. Rather it is to look for methods on how stakeholders can be aligned to contribute to the implementation of a standardized refinery modification design. The requirements are primarily identified to showcase where, among others, the relevant stakeholders should be aligned. The same thing applies to the means that will be presented in this section. They are mainly identified to highlight the importance of stakeholder alignment, otherwise, conflicting interests and priorities can hinder the appropriate mean selection.

All the requirements shown in the requirements tree in Figure 12 are listed in Table 21. Of all the requirement types, only the structural requirements can be provided with concrete means, as the behavioural- and functional requirements are too general. The same colour coding in the requirements tree is applied here, blue for functional requirements, orange for behavioural, and red for structural. To the right of the structural requirements, the possible means are enumerated.

***Table 21** Morphological Chart for case of Worley*

Function \ Means	A	B	C
1. Maximize technical design effectiveness			
1.1. Consider global technical effectiveness			
1.1.1. Prevent spatial constraints from derailing implementation			
1.1.1.1. Adapt standardized design to fit in all local sites	*Follow most conservative site*	*Strive for global optimum*	*Create space in local sites*
1.1.1.2. Establish facilities required by construction workers	*Build facilities*	*Rent facilities*	*Outsource facility provision*
1.1.1.3. Provide space for (supplementary) processes	*Follow most conservative site*	*Strive for global optimum*	*Create space in local sites*
1.1.2. Provide utilities to (bio)refinery processes			
1.1.2.1. Assess which utilities are needed	*Consult local refinery employees*	*Compare with similar refineries*	*Conduct self-inspections*
1.1.2.2. Identify and resolve limitations tied to utilities	*Outsource utility provision*	*Include utility to design*	
1.1.3. Prevent logistical constraints from derailing implementation			
1.1.3.1. Determine applicable construction approach	*Inspect the accessibility and space in site*	*Consult with local refinery employees*	*Availability of resources (equipment, workforce, materials, etc.)*
1.1.3.2. Provide access to employees	*Shuttle service*	*Transportation allowance*	*Temporary lodging*
1.1.3.3. Determine impact to traffic system	*Conduct empirical study*	*Look at historical data*	*Create simulations*
1.1.3.4. Determine and resolve local limitation concerning transportation	*Work with local government*	*Hire professionals*	*Adapt design to bypass limitation*
1.2. Consider global technical effectiveness			
1.2.1. Achieve local site buy-in			
1.2.1.1. Determine trade-off of building new or using an existing facility	*Cost-benefit analysis*	*Consult with local refinery employees*	*Study similar modification projects*
1.2.1.2. Understand common practice of each site	*Observe*	*Interview a sample group*	*Survey*
1.2.1.3. Determine consequences of	*See 1.2.1.3.1. and 1.2.1.3.2.*		

moving away from existing site standards			
1.2.1.3.1. Determine consequences to human factors	*Observe*	*Interview a sample group*	*Survey*
1.2.1.3.2. Determine impact on operations	*Observe*	*Interview a sample group*	*Survey*
1.2.1.4. Enable integration with existing system	*Adapt design to fit with existing system*	*Adapt existing system to fit with design*	*Adapt both design and existing system*
1.2.2. Reduce design complexity			
1.2.2.1. Discover environmental conditions	*Look at historical data*	*Consult with locals and experts*	*Conduct environmental studies*
1.2.2.2. Determine impact local regulations on design	*Create simulations*	*Make use of scenarios*	*Conduct case study*
2. Meet all political expectations			
2.1. Create a design that complies with all regulations			
2.1.1. Understand what permits are needed	*Consult with local government*	*Consult with permit experts*	*Consult local refinery employees*
2.1.2. Determine how to obtain permits	*Consult with local government*	*Consult with permit experts*	*Consult local refinery employees*
3. Consider presence of heterogenous stakeholders			
3.1. Empower collaboration between sites			
3.1.1. Facilitate idea and learning sharing	*Provide communication workshops*	*Give incentives*	*Standardization of idea sharing procedures*
3.1.2. Enable transferability of people from site to site	*Provide workshops for transferees*	*Give compensation*	*Standardization of equipment, processes, codes, etc.*
3.2. Enrich expertise in standardization			
3.2.1. Hire qualified resources with experience in standardization	*Hire from industries with experience in standardization*	*Provide workshops for standardization*	*Work closely with universities*
3.2.2. Stimulate resource continuity per engineering phase	*Provide workshops to bolster expertise*	*Create a positive working environment*	*Assemble a team with good synergy*
3.2.3. Stimulate resource continuity per standardization project	*Provide workshops to bolster expertise*	*Showcase result of previous standardization project(s)*	*Create opportunities for professional advancement*
3.3. Get tasks accomplished			
3.3.1. Provide sufficient supervision of each department	*Hire enough supervisors*	*Visualize goals with deadlines*	*Regular monitoring (of work)*
3.3.2. Establish decision-making authority	*Develop and appoint credible decision-makers*	*Create absolute deadlines for decisions*	*Encourage and facilitate open discussions*
3.3.3. Establish a conflict/ misunderstanding resolution procedure	*Appoint unbiased mediator*	*Penalize unwelcomed behaviours*	*Conduct regular seminars*

The diverse alternatives or means that can be implemented per requirement are listed in Table 21. A combination of these different means altogether can form an artifact design. Selecting means and forming such a design is not that simple. The plethora of possible combinations and the presence of multiple relevant stakeholders can complicate it even more. Plus, who's to say that all the relevant stakeholders will even agree on the list of means that they can choose from? On top of that, what even precedes this is the question of whether the stakeholders will agree on what needs to be considered before such a design can be implemented (i.e., the list of requirements).

The stakeholders' answers during the stakeholder analysis point to the existence of some form of alignment because everyone is all for the implementation of a standardized refinery modification design. Thus, one can easily assume that the stakeholders will find a consensus on every aspect of such a project. However, interviews with the various critical stakeholders suggest otherwise (see Appendix 8.4. – Program Delivery Manager & Engineering Manager). The stakeholders may have alignment when it comes to the significance of successfully implementing a standardized refinery modification design, but probably not on how to do it. Therefore, alignment is seen to be a crucial missing part. This research aims to contribute to this alignment matter by designing a framework that will enable the alignment of the stakeholders on what needs to be considered by the implementation of a standardized refinery modification design. Once the stakeholders can agree on this, only then will they be able to decide on the appropriate means to be implemented. In the following subchapter, the relevant stakeholders that must be aligned are identified.

5.4. Relevant Stakeholder Identification

As explained in subchapter 4.4., the target is to identify relevant stakeholders per requirement via interviews with the critical stakeholders. For most of the critical stakeholders, providing the list of relevant stakeholders per requirement is not possible, due to time constraints during the interview. Therefore, most of them named the relevant stakeholders per group of requirements. In this case, the naming of the stakeholders is done per behavioural requirements. The critical stakeholders' answers are combined right away in Table 22. The number of stakeholders per behavioural requirement in Table 22 looks few at first glance. However, a lot of the stakeholders mentioned in the table are stakeholder groups. For example, a design team of an engineering contractor is usually made up of multiple stakeholders. Consider the different disciplines of engineering (e.g., electrical, process, civil, etc.) and their supporting staff. Depending on the project, the number of these people could greatly vary. This meant that the number of stakeholders is not readily countable. The more stakeholders involved, the higher the chance for conflicting interests and priorities, which in turn leads to a more complex system.

***Table 22** Relevant stakeholders for the requirements*

Aspect	Behavioural Requirement	Relevant stakeholders per aspect
Space	1.1.1. Prevent spatial constraints from derailing implementation	• Design team engineering contractor • Local refinery site management • Operations management • Construction management • Engineering management • Maintenance management
Utilities	1.1.2. Provide utilities to (bio)refinery processes	• Design team engineering contractor • Local refinery site management • Operations management • Commercial management • Suppliers
Logistics/ Accessibility	1.1.3. Prevent logistical constraints from derailing implementation	• Construction team • Local refinery site management • Maintenance management • Turn around management • Procurement and logistics team • Community liaison with authorities
Site specificity	1.2.1. Achieve local site buy-in and 1.2.2. Reduce design complexity	• Local refinery site engineering team • Design team engineering contractor • Global project management • Operations management • Safety Team

		• Maintenance management • Project leadership • Economical actors
Permitting	2.1. Create a design that complies with all regulations	• Governing bodies • Environmental Department • Regulatory Compliance Department • Project leadership
Management/ Labour	3.1. Empower collaboration between sites, 3.2. Enrich expertise in standardization, and 3.3. Get tasks accomplished	• Construction team/management • HR • Global project management • Maintenance management • Project Leadership • Site-based engineering team • Engineering management • Controls management • Procurement management • Local refinery site management • Operations management • Maintenance management • Economical actors

There are some similarities in the answers of the critical stakeholders, for example, both the Project Delivery Lead Manager and the Appraisal General Manager have the local refinery side management as a relevant stakeholder for the aspect Utilities. However, there are more dissimilarities in their answers, than there are similarities. This can be due to different reasons, but this is not seen as a problem in this research. Earlier in section 3.2.4., it is already mentioned that this can happen. Therefore, it has been decided beforehand that if the critical stakeholders will name varying relevant stakeholders per (group of) requirements, then all will be considered relevant and shall be included in the list.

From Table 22 it can be seen that some stakeholders are recognized as relevant in multiple requirements. The top spot belongs to maintenance management with five appearances. Next was a tie between the local refinery site management and the operations management with four mentions. Then, on the third spot both the design team engineering contractor and the project leadership garnered three selections. Of the five most relevant stakeholders, the top three come from the stakeholder classification refinery operation group (see Table 12). The remaining two are from the design responsible and project management classifications (see Table 12). This result illustrates the importance of the stakeholders coming from the refinery operation group when it comes to implementing a standardized refinery modification design. In Table 23 it can be seen by which aspects the top relevant stakeholders are selected as relevant. Another important result that can be seen from Table 22 is the number of stakeholders relevant per group of requirements. Looking carefully at what is listed in the table, it can be seen that the group of requirements under the aspect of Management/Labour has the highest number of relevant stakeholders. This is followed by Site specificity, then Space & Logistics/Accessibility are tied. After that is Utilities and in the last place is Permitting.

Table 23 *Top relevant stakeholders*

Stakeholder	Aspect
Maintenance management	Space, Utilities, Logistics/Accessibility, Site specificity & Management/Labour
Local refinery site management	Space, Utilities, Logistics/Accessibility & Site specificity
Operations management	Space, Utilities, Site specificity & Management/Labour
Design team engineering contractor	Space, Utilities & Site specificity
Project leadership	Site specificity, Permitting & Management/Labour

5.5. Stakeholder Alignment

In subchapter 4.4., the various stakeholder alignment methods discovered in the literature have been presented. Here in this subchapter, the alignment methods being implemented by the engineering company Worley and their client will be explained in section 5.5.1. Afterward, these alignment methods will be compared with that in subchapter 4.4. in section 5.5.2.

5.5.1. Stakeholder alignment methods of Worley and their client

To discover what is currently being implemented in the project of Worley when it comes to stakeholder alignment, the critical stakeholders are asked. This took place during the interview for requirement design, and they are inquired as to what alignment methods they typically use. At the same time, they are also asked what other alignment methods they potentially thought will work. One stakeholder interviewed during the stakeholder analysis step also mentions alignment methods. His/her answer shares similarities with what's already in Table 24, so it was no longer included in the list.

Table 24 *Stakeholder alignment methods identified from critical stakeholders*

Stakeholder	Alignment methods being implemented	Does it work?	Other suggestions
Engineering Manager	• Frequent alignment sessions • Proper kick-off meeting • Face to face interaction		• Kick-off meeting can be improved by alignment in structure of decision-making and instructions.
Project Delivery Lead Manager	• Show benefits for the sites (predictability, cost, and schedule). • Recognize the disadvantages for the sites.	• Generally, it works if the advantages are big enough. • People are inclined to work along if they are listened to, and their concerns are taken.	• Inform people of the essence of standardization -> contribute to energy transition and in saving the world.
Appraisal General Manager	• Understand their issues, limitations, and concerns. • Look for areas of common interest and priority. • Look for compromise and mutual respect.	• Success is variable.	
Project Director	• Involve all stakeholders at the beginning of the project. You need them to commit when the project starts.	• It always worked.	• Create a path forward, so everybody can be aligned with your principle. • Create a good teamwork and motivate them.
Requirements and Standardization Manager	• Early engagement • Communicate the why of what we're trying to do and what its impact is to their area? Does it add value, or does it enable value in the future?		• Understand the current situation and the reasons behind it.

The alignment methods being implemented in this project of Worley can be summarized in two ways. The first is (1a) to involve everyone early in the project – let them (especially those from the refinery sites) know of the projects benefits (value) and potential drawbacks. Second, is (2a) to understand their limitations, issues, and concerns before looking for an area of common interest. When it comes to potential alternative alignment methods, the following have been suggested: (1b) show the project's impact on energy transition, (2b) clarify the structure in decision-making and instructions, (3b) create principles whereby everyone can be aligned, (4b) teamwork and motivation, and finally (5b) understand the current situation and the reason behind it.

5.5.2. Comparison alignment methods of Worley and in literature

Table 8 from section 4.5.4., is taken and modified here in section 5.5.2. to make the comparison of the alignment methods applied in the project of Worley with that from the literature possible. The alignment mechanisms under cooperation, control, coordination, and collaboration are not exhaustive. However, these are discovered to be extensive compared to the others uncovered in the literature (see 4.5.4) and hence these are selected to be used for comparison.

Table 25 *Stakeholder alignment mechanisms applied by Worley and their client*

Cooperation	Control	Coordination	Collaboration
1. Conduct a stakeholder analysis.	1. Outcome control (Goal setting, Incentive system, Performance monitoring/rewarding)	1. Departmentalization	1. Operational Awareness
2. Assess influence of stakeholders.	2. Behaviour control (Planning, Procedures, Rules & Regulation, Behaviour monitoring/rewarding	2. (De)Centralization	2. Knowledge
3. Understand stakeholder expectations.	3. Social control (Partner selection, Trust build-up, Joint decision-making, Joint problem solving	3. Formalization and Standardization	3. Internal Assessment
4. Define what is (project) success for a stakeholder.		4. Planning	4. Partner Selection
5. Keep stakeholders involved and consider their input.		5. Output and Behaviour Control	5. Working Together
6. Keep stakeholders updated.		6. Lateral or Cross-Department Relations	6. Value Creation
		7. Informal Communication	7. Staying Together
		8. Organizational Culture	8. Exit Strategy

The alignment methods implemented by Worley and their client: (1a) I*nvolve everyone early in the project – let them (especially those from the refinery sites) know of the projects benefits (value) and potential drawbacks* and 2a U*nderstand their limitations, issues, and concerns before looking for an area of common interest*, share similarities with the mechanisms from cooperation, control, and collaboration in Table 8. From cooperation, 1a and 2a have overlap with conducting a stakeholder analysis, understanding stakeholder expectations, defining project success, keeping stakeholders involved, and considering their input. Under control, the similarity is with goal setting under outcome control, and operational awareness & internal assessment in collaboration. All the alignment mechanisms in Table 8 that share a resemblance with 1a and 2a are coloured orange.

On the other hand, regarding the potential alternative alignment methods that the critical stakeholders mentioned: 1b relates to the point defining what is project success for a stakeholder under cooperation, 2b with behaviour - and social control, plus the coordination mechanism decentralization which determines the level that has decision-making authority.

Next, 3b has a connection with social control, 4b with social control as well and working together (point 5 under collaboration). Finally, 5b about understanding the current situation and the reason behind it is in a way like trying to understand the stakeholders influence and expectations (points 2 and 3 under cooperation). All the alignment mechanisms in Table 8 that share resemblance with 1b – 2b are coloured yellow. The remaining uncoloured mechanisms are those that Worley and their client do not implement.

The result of this comparison shows that the alignment methods identified by Worley (and their client) share similarities with what is in the literature, primarily with cooperation and control mechanisms. However, from this result, it cannot be concluded that coordination and collaboration mechanisms are not used or implemented in their project. It can be that the critical stakeholders have not considered coordination and collaboration to be elements of stakeholder alignment. This means that for this project of Worley, stakeholder alignment is solely focused on cooperation and control mechanisms. This, therefore, signifies the importance of clearly establishing coordination and collaboration as a part of stakeholder alignment.

5.6. Synthesis

The last step in implementing the framework in the case of Worley will be to synthesize the results of the various steps that are conducted. The most important results are the list of requirements that need to be considered before implementing a standardized refinery modification design, the list of relevant stakeholders for the implementation of the said requirements, and finally the alignment methods that can be applied. In section 5.3.2., it is mentioned that the stakeholders in the project of Worley seem to be aligned based on their answers during the stakeholder analysis. However, interviews with the critical stakeholders will tell you otherwise. As the problem owner mentioned during the interview, the project level interest is similar among the stakeholders, but not on the operation level (see Appendix 8.4. – Program Delivery Manager). Therefore, to achieve successful implementation of a standardized refinery modification design, alignment of stakeholder interest/priority must take place at the project and operation level. However, achieving full alignment in terms of interest/priority at the operation level is unlikely to happen. This is due to everyone being wired differently (i.e., varying experience, expertise, thinking process, and so on). As an example, on a project level, both a refinery manager and a process engineer might agree that safety should be the number one priority, so their interest is aligned. Going down into operations, their heterogeneity may prevent them from fully agreeing on how to guarantee safety, so their interest becomes misaligned. Thus, achieving a complete alignment of interest/priority is not that probable, and relying only on cooperation mechanisms is not enough. Hence, other mechanisms are needed as a workaround, this is where control, coordination, and collaboration mechanisms come into play. In 5.6.1., the gaps or the mechanisms that are not being implemented by Worley will be identified and then consolidated. In the last section (5.6.2.), the consolidated alignment mechanism will be formulated into some form of advice for Worley. Finally, in 5.6.3., the result of the framework implementation will be validated.

5.6.1. Alignment mechanisms consolidation

Before consolidating the remaining mechanisms in Table 8, a short definition of each stage will once more be shown. Cooperation can simply be defined as the stage where interest alignment occurs (Ali & Haapasalo, 2023). Control is where decision-making capacity can be assigned and control mechanisms selected (Marcum et al., 2012). Next is coordination and here the alignment of the stakeholders' actions can happen (Castaner and Oliveira, 2020).

Finally, there's collaboration and it's defined as the process through which actors work together interdependently to reach their desired common goals (Bedwell et al., 2012). Coordination and collaboration share a great resemblance. In both coordination and collaboration, stakeholders will strive to achieve a goal. But their difference is that in coordination stakeholders work separately, while in collaboration stakeholders work together according to Calbucci (2022).

In the previous subchapter (5.5.), the alignment mechanisms currently in place in the project of Worley, the suggestion for alternative alignment methods, and their respective overlap with that from the literature are explained. In this section, the gaps will be identified, and the impact thereof. Once all the gaps have been determined, then these can be consolidated to be given as advice or recommendation for Worley. Take note that the alignment mechanisms that will be mentioned here are no longer what the critical stakeholders identified during the interviews. Rather these will be the alignment mechanisms' counterparts, discovered in section 5.5.2 (orange- and yellow-coloured items in Table 25).

Starting with cooperation, Worley currently implements (or implemented) *stakeholder analysis*, *understanding of stakeholder expectations*, *defining of project success*, *keeping stakeholders involved & considering their input*. The critical stakeholders identified the *assessment of the influence of the stakeholders* as an alternative alignment method that can also be implemented. The only mechanism unimplemented in the cooperation stage is the *keeping of the stakeholders updated*. This can result in stakeholders being less supportive or engaged to participate in the project (Bennett, 2022). It is highly possible that the keeping of the stakeholders updated is already being conducted by Worley, however, none of the critical stakeholders identified it as an alignment mechanism during the interviews. Hence, it is not included.

Moving on to control, only *outcome control* is mentioned to be used as an alignment mechanism by Worley. On the other hand, both *behaviour*- and *social control* are suggested to be implemented. Lack of controls will result in difficulty to track performances, outputs, progress, and even open the room for misconduct (Duggan, 2023).

The third stage is coordination and here it seems that Worley is really lacking as most of the items are uncoloured (see Table 25). Even *(de)centralization* is only being suggested and not really implemented. The impact of not having these coordination mechanisms (or maybe having them in place but not utilizing them as an alignment mechanism) is that stakeholders will not be able to (effectively) align their actions. As an example, consider that there is a misalignment of stakeholders under the coordination stage in item number four or *planning* with regard to the deadlines. Imagine that employee A is dependent on the work of employee B, and they have a misaligned understanding of the deadline. Employee B thinks it's in one week, while employee A believes it's tomorrow already. Such misalignment of information will negatively impact the work of employee A. This simple scenario showcases the importance of stakeholder alignment in the coordination stage. To reiterate, even if a mechanism is being implemented by Worley but not mentioned during the interview then this remains uncoloured in Table 25. Therefore, the information in Table 25 should be taken with a grain of salt. The important conclusion that can be made here is that the critical stakeholders do not consider the coordination stage to be a part of the alignment mechanism.

Moving on to the last stage or collaboration two items namely *operational awareness* and *internal assessment* are implemented by Worley, while *working together* is suggested to also be executed. This leaves *knowledge*, *partner selection*, *value creation*, *staying together*, and *exist strategy* as the gaps in this stage. Each of these gaps have different impacts, for example, the lack of alignment of the stakeholders in partner selection can result in the creation of partners not fitting or complementary to each other's capability/weakness.

Now that all the gaps have been identified from the different stages, the next step is to combine them all as shown in Table 26. Even the alignment mechanisms suggested by the critical stakeholders to be implemented (yellow-coloured items in Table 25) are added here as well because they are not being implemented by Worley yet. In the following section, a recommendation or advice is given to Worley in terms of how to apply the items in Table 26.

Table 26 *Unapplied stakeholder alignment mechanisms by Worley*

Cooperation	Control	Coordination	Collaboration
• Assess influence of stakeholders. • Keep stakeholders updated.	• Behaviour control (Planning, Procedures, Rules & Regulation, Behaviour monitoring/rewarding • Social control (Partner selection, Trust build-up, Joint decision-making, Joint problem solving	• Departmentalization • (De)Centralization • Formalization and Standardization • Planning • Output and Behaviour Control • Lateral or Cross-Department Relations • Informal Communication • Organizational Culture	• Knowledge • Partner Selection • Working Together • Value Creation • Staying Together • Exit Strategy

5.6.2. Implementation of alignment mechanisms to the case of Worley

Before formulating the advice for Worley, a crucial assumption is made here and that is Worley correctly implements all their alignment mechanisms currently in place (orange-coloured in Table 25). This assumption is made to limit the scope of the advice to be given to Worley, and to point them directly where to focus. Otherwise, the process of identifying commonalities with the literature and gap identification in the previous sections becomes superfluous. Having said that, the first step is to start with the cooperation stage. On top of the list is *assessing the influence of stakeholders*. It is not too late to conduct this, even if their project already has begun. Assessing the influence or power of a stakeholder is important for Worley as the stakeholders with high influence can affect the project's progress. In this research, this step has been done (see section 5.1.3.) as a part of the framework development, unbeknownst to the author that it will also be relevant for this part of the paper. Therefore, Worley can take advantage of this by just taking the result of 5.1.3. and expanding it where necessary. The last item under cooperation is the *keeping of the stakeholders updated*. Surely, this step is present in Worley, as plenty of the stakeholders are interdependent with each other's work. The advice for Worley is to see this step not just as a means to let each other know of their progress, but also as a means to keep everyone engaged and supportive of each other and the project. This can easily be implemented by creating a list of stakeholders that need to be updated on the progress of the different aspects of the project.

Going to the next stage or control both *behaviour-* and *social control* are missing. Alignment here among the stakeholders is necessary to get the desired behaviour and social interaction. Both have similarities in terms of what they try to achieve, and their biggest difference is that behaviour control is formal and social control is informal. Hence, both controls will be combined to simplify. These control mechanisms can be achieved in different ways such as the use of planning and rules & regulation, trust build-up and joint decision-making (see Table 26 for complete list). Out of these methods one is considered to be a big challenge in Worley's project and that is concerning decision-making. According to one of the critical stakeholders, structure in decision-making in their project is missing (Appendix 8.5. – Engineering Manager). This makes alignment in top processes difficult according to him/her. Therefore, as advice Worley is suggested to establish mechanisms that will enable or even expedite decision-making, to put behaviour- and social control in place. Questions like who the decision-maker(s) are and when decisions should be made must be communicated to the stakeholders upfront and everyone should be aligned in this.

Once all the stakeholders are fully cooperating, so aligned in interest & priority and at the same time control mechanisms are in place (to check if everyone indeed is aligned). Then the next stage is to try to coordinate everyone's work. In Table 26, the different coordination mechanisms can be seen. Plenty of these are present and being implemented in the company of Worley. However, the company does not recognize coordination as a means that can help to align stakeholders. Some of the mechanisms identified under coordination are also present under different stages. As an example, output – and behaviour control are present in both control and coordination stages. Going back to the explanation of behaviour control in the previous paragraph, then one can understand its relevance for stakeholder alignment. Following the transitivity rule, then this makes coordination to be relevant for stakeholder alignment as well. For Worley, the suggestion is to determine which coordination mechanisms are present in their project and to see if alignment of stakeholders is present in those. For example, consider *departmentalization* or the division of labour based on a stakeholder's task. In an engineering company like Worley, departmentalization is strongly in play. Just consider the different engineering disciplines departmentalized to work on their part of a design. If the stakeholders are not aligned in information with regards to who is responsible for what, then that will affect the progress of the entire project. Another example is in *(de)centralization* or the level of decision-making authority. If alignment in terms of who should have the authority for decision-making is not clearly established, then conflicts can arise. This like the previous example given can also affect the progress of the entire project or worse even jeopardize it. These are just two minor examples and there can be a lot of other issues that may arise if alignment in coordination is not in place.
As a suggestion, Worley is asked to identify which coordination mechanisms are in place in their project. Then, it must be discovered where exactly alignment of stakeholders is needed (e.g., alignment in procedures, communication, interface, etc.).

Looking at the last stage or collaboration, the first mechanism unimplemented is *knowledge*. This mechanism looks at the viability of a project (see 4.5.4.), so it is irrelevant for Worley, but more so for the client. Next is *partner selection* and this mechanism is also present under social control in Table 26. This is about the selection of potential partners for a project. *Working together* is the step under collaboration where the governance & management structure, conflict resolution methods, and key performance indicators among others are selected. Surely this is present in Worley, but again it is probably not considered to be an alignment mechanism. Alignment in these steps is needed to ensure that the stakeholders can work harmoniously together. The step working together is kind of similar if not the same to coordination which is about the alignment of the stakeholders' work. The following step is *value creation* which translates to continuous improvement of the processes or the taking advantage of lessons learned. This is not an alignment mechanism per se, but the lessons learned can be used to better align the stakeholders in the next opportunity. The second to the last step is *staying together* and this looks at the measure of performance of collaboration among the stakeholders. Basically, it evaluates how effective the collaboration is and hereby also how aligned the stakeholders are. The last one is *exit strategy* which focuses on when the collaboration can end.

When it comes to giving advice to Worley, the focus will be on value creation and staying together, because the others are either covered already in the previous stages (partner selection and working together) or precede/succeeds (knowledge and exit strategy) the project of Worley. Going back to value creation, Worley should capitalize on all lessons learned and that includes stakeholder alignment. Finally, the collaboration must be evaluated regularly so that issues or problems can be fixed immediately and not when it is too late.

Besides the steps that Worley can implement to improve stakeholder alignment in general, an additional step has also been formulated in this paragraph. This step stems from the other essential information acquired from this study. This step has a little bit less to do with stakeholder alignment but more so with the implementation of a standardized refinery modification design. The first essential information is the list of aspects and thereby requirements that must be considered before a standardized refinery modification design can be implemented. These lists are focussed on the technical and political differences of each site, while still aiming for a global effective design. Lastly, there is also the record of relevant stakeholders that must be aligned for the implementation of the requirements. To unite the relevant stakeholders in the requirements to be considered, alignment in their interests and priority must be achieved at the project and operational levels. However, as mentioned before, full alignment is not entirely possible. Hence, alignment in other aspects than interest and priority must also take place. This is where the other alignment methods that have been identified come into play. Alignment in cooperation, control, coordination, and collaboration will help to achieve this. In the company of Worley and particularly in their project used as a case in this thesis, alignment in cooperation, control, and collaboration is present, albeit not complete (see Table 26). On the other hand, alignment in coordination is lacking and needs a lot of work. A crucial assumption made earlier is that the alignment methods in place in cooperation, control, and collaboration are all successful. Whether this is the case in real life remains to be seen. Hence, this requires a checking from Worley so that actions can be taken if necessary. A summarized list of the advice given to Worley is listed below.

Advice for Worley:

1. Align relevant stakeholders in requirements that must be considered for the implementation of a standardized refinery design. Consider the cooperation stage first (i.e., alignment of interest and priority), and if that is not enough incorporate control, coordination, and collaboration mechanisms.
2. Enrich cooperation stage through:
    a. Utilization of the power-interest grid to identify the influence of the stakeholders and expand where necessary.
    b. Creation of a list of stakeholders that need to be updated accordingly and update them whenever necessary.
3. Improve control mechanism by establishing a decision-making structure.
4. Develop coordination stage by identifying coordination mechanisms implemented in the project. Then, find out per mechanism if there is any aspect of it that requires stakeholder alignment.
5. Supplement collaboration mechanisms by a matter of:
    a. Capitalizing on the lessons learned from stakeholder alignment.
    b. Evaluating where collaboration of stakeholders is going wrongly/greatly and implement changes where needed.

5.6.3. Validation

Throughout the creation of the framework in Chapter 4, validation has constantly been happening, whether it be through interviews or casual conversations with the interview participants. The selected interview participants are kept as diverse as possible (i.e., different roles in the project) to capture the difference in opinions and ideas. Also, whenever possible, a literature review has been conducted to verify the information given by interview participants. During those moments, the interview participants are informed of the aim of the study and the processes being planned to reach it. What's more the problem owner is fully aware of the contents of the framework and what it is aimed to be used for. The summarized list of advice that ultimately came out of the framework is something that the problem owner recognizes as useful for their project. With that, the result is partially validated as it meets the expectation of those who will use it. More validation can be applied to the results as will be explicated in the discussion subchapter.

6. Discussion & Conclusion

This portion of the paper is composed of two subchapters, the discussion in 6.1., and the conclusion in 6.2. In 6.1., the key findings along with their significance and limitation are explained. Then, in the final subchapter, the conclusion summarizes the origin of the topic along with the main research question. This is followed by the framework development procedure to be used to tackle the main research question. After that, is the result of framework implementation to a case and the relevance of the study. Finally, it ends with the suggestions for future work.

6.1. Discussion

Two important results came out of this research. The first one is the framework that has been developed to align stakeholders in the most relevant requirements to be considered for a particular design. The framework contains a step-by-step process as to how this can be achieved. The framework is this paper's biggest contribution to science. It has been made to be quite general, so that it can be applied to different cases/systems were a design needs to be created. The framework has been validated through application in an engineering company's project. For this project, an engineering company has been contracted to create a standardized refinery modification design (fossil fuel → biofuel) that can be implemented in multiple refineries worldwide. This type of project is very complicated due to all the different elements that need to be considered (local vs. global elements), and it's made complex by the presence of heterogenous stakeholders. The framework that has been developed can reduce this complexity by aligning the relevant stakeholders in the requirements to be considered for the standardized refinery modification design.

Given more time, the framework can further be validated by applying it to multiple other cases, thus, not only in a refinery modification system. Also, it can be validated by showing it to experts in stakeholder management and system engineers. As they have expertise in stakeholder alignment and design creation. But even without getting the opportunity to do so, as mentioned earlier, the framework has been kept general. There are no concepts or parts of it specific only to refinery modification design. Hence, the framework is seen to be applicable not just in refinery modification projects, but essentially in any system where a design needs to be implemented to bring change in the said system. The developed framework is therefore considered to be generalizable.

Besides its scientific significance, this paper also has social relevance which is tied to it being implemented in a case. This is the second important result of this research, which is the outcome of the application of the developed framework to a standardized refinery modification project of an engineering company. After applying the framework to the case, the ultimate outcome that came out of it is a list of steps that the engineering company can follow. The significance of the research finding for the company is that it contributes to the implementation of a standardized refinery modification design, by enabling alignment of the heterogeneous stakeholders. Once the stakeholders reach alignment, then they can collaborate better – work together interdependently to achieve their desired mutual goals. Furthermore, the discovery of these steps can help in the stimulation of standardization in the construction industry. For any organization, such steps can be beneficial as they can help to lessen the complexity of a project once stakeholder alignment is achieved. Simultaneously it contributes to the maximization of the effectiveness of the design to be implemented because both local and global requirements are being considered. To be clear it is not being mentioned here that the steps created for the engineering company are applicable for every organization. Rather, the formulation of such steps specifically for an organization by following the framework can be beneficial for them.

Just as how the framework needs more validation by applying it to other cases, the same thing can be said about the steps that have been formulated for the engineering company. There simply isn't enough time to test it in the project of the engineering company. That is why throughout the development of the framework, regular consultation with the problem owner has been done to check if the framework being developed is still in line with what is expected. However, if time wasn't a limitation, then the steps that have been formulated can be tested in the engineering company (Worley). First, a workshop with the critical stakeholders will be done to illustrate and show the results (i.e., the steps to be followed). Then, it will be checked which alignment mechanism is indeed present/absent in the different stages of cooperation, control, coordination, and collaboration in their project. That way it can be controlled if the answers given by the critical stakeholders regarding the alignment mechanisms being implemented in the project are accurate. Afterward, adjustments shall be made accordingly to the steps that the company must follow to align the respective stakeholders. Without knowing what the actual data is and basing it only on the answers given during the interviews, changes are deemed to be necessary for Worley. This type of change should enable the stakeholders to understand and realize that complete alignment of interest and priority is not possible, hence, other alignment mechanisms are needed. Worley is not being advised to entirely change the way they work, however, certain aspects of it do require improvement should they wish to become more successful in conducting their projects. As discovered in the case study, stakeholder alignment in Worley still has lots of room to grow.

The last part of the discussion to be explicated here is the presence of an unexpected result. The unexpected result is the unity of all stakeholders concerning their interests (see Table 14). All the stakeholders that participated in the interview for the stakeholder analysis have the same interest with regard to the project, which surprised the problem owner. "*How is it that the implementation of a standardized refinery modification design is so difficult, if everyone has the same interest?*". Then, it's discovered that there is indeed an alignment of interest when it comes to the project level, but non on the operational level (Appendix 8.4. – Project Delivery Manager). This explains where the difficulty of such a project lies. This, therefore, causes reflection of sub-question number five. "*How can the interest and priority of the relevant stakeholders be aligned to achieve maximum repeatability of the standard design?".* As can be seen from the sub-question, the target is to find out how the interest and priorities of the relevant stakeholders can be aligned. After going through this sub-question, it has been discovered that the alignment of the stakeholders goes beyond the alignment of interest and priority alone. There are other stages where relationships of stakeholders can be developed as well namely in Cooperation, Control, Coordination, and Collaboration. Alignment of interest and priority only takes place in the cooperation stage. Furthermore, complete alignment of stakeholders in interest and priority in every aspect of the cooperation stage is highly unlikely due to the uniqueness of everyone. This matches what the problem owner mentions that alignment at the project level may be present but not on the operational level. Therefore, alignment of the stakeholders in other stages is also necessary.

6.2. Conclusion

Throughout this research, the design science cycle of Hevner (2007) has been followed (relevance cycle, design cycle, and rigor cycle). It starts with the rigor cycle where the theories present in the literature related to the topic have been studied. Initial research on standardization of a refinery modification design delivered little to no results, which led to a sparked interest in this study. Even after conducting a state of the art, still, no results were found. Not only that, but also the lack of papers that look at multiple aspects (technical, political, and personal) simultaneously during the implementation of a standardized refinery modification design is discovered as a gap in the literature. This became the knowledge gap upon which the main research question is based which is: ***"How can a standardized refinery design be implemented keeping local and global effectiveness in mind and considering different stakeholders?"***. This main research question is what this paper has tried to solve, by first answering the sub-research questions. Going through all the sub-research questions enabled the development of a framework that can be utilized to tackle the main research question.

The first three sub-questions are part of the relevance cycle. Answering the first sub-research question led to the discovery of the critical and auxiliary stakeholders (from the perspective of the problem owner, the Project Delivery Manager) along with their problem perceptions. From this sub-question, a novel classification of stakeholders in a refinery modification system has also been formulated. Then, the second and third sub-questions gave way to finding out the aspects and the requirements that must be considered when implementing a standardized refinery modification design. The requirements from the relevance cycle are seen as an important input for the creation of the framework in the design cycle. It is through these requirements that the local and global effectiveness of the design come into play. The stakeholders prioritizing global effectiveness will push for requirements that do so, while potentially giving less importance to local effectiveness. The opposite applies to the stakeholders from the local refineries who surely value local requirements more than the global ones. It is not that simple to just say that global effectiveness takes precedence over local effectiveness in all aspects of the design. Otherwise, the local stakeholders might become less cooperative in the project as their inputs or concerns are not being considered at all. Finding this balance between local and global effectiveness signifies how challenging the problem is. To discover this balance, the fourth sub-research question comes to play. In the fourth sub-research question the relevant stakeholders to be considered when implementing the requirements are revealed. Finally, the various alignment methods that can be used to align the relevant stakeholders to maximize global and local effectiveness are researched in the last sub-research question. Synthesizing all these results in a framework that can also be utilized in other industries/sectors or even systems where stakeholder alignment is missing. Throughout the entire process of the design cycle, the framework has been constantly verified and validated as part of the design cycle.

Once the framework is done being evaluated (see design cycle in Figure 1), then it can be tested in the field or applied to a case as part of the relevance cycle. Applying it to the case of Worley, the critical stakeholders for the problem owner are the: Engineering Manager, Appraisal General Manager, Project Director, and Requirements and Standardization Manager. The rest of the stakeholders are then auxiliary to the problem owner. The relevant aspects along with the requirements and the list of relevant stakeholders are too many to mention, but they can be viewed in Tables 18, 21, and 22 respectively. When it comes to alignment methods, various means exist, but the ones selected for the case study can be seen in Table 8. Four stages must not be neglected when aligning the relevant stakeholders namely Cooperation, Control, Coordination, and Collaboration. Then, advice has been formulated for the engineering company Worley on how it can align its stakeholders so that effective implementation of a standardized refinery modification design in different sites globally can be brought closer to reality. To answer the main research question, a standardized refinery modification design can be implemented by aligning the relevant stakeholders with the requirements that need to be considered for the modification of a refinery. The requirements that have been identified in the case study consider both global and local effectiveness. However, the alignment of stakeholders in these requirements is not that simple and so the relationship of the stakeholders must be built/strengthened in different stages namely cooperation, control, coordination, and collaboration. Alignment of stakeholders in these stages will help in ensuring the success of the implementation of the standardized refinery modification design.

After going through all parts of the design science cycle, the only step remaining is the addition to the knowledge base in the rigor cycle. This basically illustrates the scientific relevance of the thesis or the framework to be exact. From this study, it has been discovered that no paper out there looks at a (standardized) refinery modification design while considering multiple aspects at once and especially involving stakeholders. The papers are mostly focussed on technical, economical, or political aspects, while stakeholders or personal aspects are not seen to be relevant. This paper contributes to this by creating a thesis that looks at technical, political, and personal aspects simultaneously for the implementation of a standardized refinery modification design. This paper has laid the foundation for other researchers to consider the significance of personal aspects in such systems. Furthermore, no paper out there looks at multiple aspects simultaneously. This thesis does that by considering technical, political, and personal aspects. This contribution to the knowledge base is something that has been developed meticulously by going through the design science cycle of Hevner (2007).

From a societal relevance, this study helps in advancing standardization in the construction industry, specifically in the modification of refineries. As mentioned in the introduction standardization in the construction industry is very limited, compared to the other industries. Successful standardization in the construction industry can entice other organizations to consider it as well. More standardization in the sense of reusable design means a reduction of resources needed in terms of workforce. This means that there will be more available for other projects. Also, if the project of Worley is to be successful and if the alignment of stakeholders plays a crucial role in it, then, other mega projects might start to give importance to stakeholder alignment as well. The more aligned the stakeholders are, the higher the chance of project success.

For future steps, it is highly suggested to consider aspects that are intentionally excluded in this research due to time constraints (economic and societal factors). These can potentially play a significant role in such a system since we are talking about a project that is easily worth millions if not billions of euros. Additionally, because (bio)refinery is being discussed here, then there is still the chance for some issues to arise (e.g., emission, feedstock, etc.). Hence, the list of aspects that need to be considered and thereby the requirements should be expanded. Moreover, the other validation suggestions mentioned previously in the discussion about testing the framework to other systems and the checking of the steps formulated for Worley are also highly suggested.

7. Bibliography

Alalwan, H. A., Alminshid, A. H., & Aljaafari, H. A. S. (2019). Promising evolution of biofuel Generations. *Renewable Energy Focus*, *28*, 127-139. https://doi.org/10.1016/j.ref.2018.12.006

Alfano, S., Berutti, F., Denis, N., & Santagostino, A. (2016). The future of second-generation biomass. *McKinsey & Company. https*://www.mckinsey.com/capabilities/sustainability/our-insights/the-future-of-second-generation-biomass

Ali, F. & Haapasalo, H. (2023). Development levels of stakeholder relationships in collaborative projects: challenges and preconditions. *International Journal of Managing Projects in Business*, *16*(8), 58-76. DOI:10.1108/IJMPB-03-2022-0066

Amigun, B., & Musango, J. K. (2011). An analysis of potential feedstock and location for biodiesel production in Southern Africa. *International Journal of Sustainable Energy*, *30*(1), 35-58. DOI: 10.1080/1478646X.2011.579611

Anderson, C., Greig, C., & Ebert, P. (2022). From Ambition to Reality 2: Measuring change in the race to deliver net zero. *Worley.* https://www.worley.com/~/media/Files/W/Worley-V3/documents/our-thinking/from-ambition-to-reality/from-ambition-to-reality-2.pdf

Antoniolli, I., Guariente, P., Pereira, T., Pinto Ferreira, L., & Silva, F.J.G. (2017). Standardization and optimization of an automotive components production line. *Procedia Manufacturing*, *13*, 1120-1127. https://doi.org/10.1016/j.promfg.2017.09.173

Bailey, M. (2022). ExxonMobil announces new SAF production technology. *Chemical Engineering*. https://www.chemengonline.com/exxonmobil-announces-new-saf-production-technology/?printmode=1

Bedwell, W. L., Wildman, J. L., DiazGranados, D., Salazar, M., Kramer, W. S. & Salas, E. (2012). Collaboration at work: an integrative multilevel conceptualization, *Human Resource Management Review*, *22*(2), 128-145. DOI: 10.1016/j.hrmr.2011.11.007

Bennett, C. (2022). Your Simple Guide to Keeping Stakeholders Informed. *Consultation Manager*. https://www.consultationmanager.com/your-simple-guide-to-keeping-stakeholders-informed

Betts, P. (2016). Cultural, Political and Social Factors Influence the Meaning of Translations. *Globalization Partners International. https://www.globalizationpartners.com/2016/06/09/cultural-political-and-social-factors-influence-the-meaning-of-translations/*

Bioenergy Career Grid. (2017). *Office of Energy Effiiency & Renewable Energy.* https://www.energy.gov/eere/bioenergy/bioenergy-career-grid

BP (2022). *What is sustainable aviation fuel?.* https://www.bp.com/en/global/air-bp/news-and-views/views/what-is-sustainable-aviation-fuel-saf-and-why-is-it-important.html

Brand, C. (2021). 7 reasons why global transport is so hard to decarbonize. *World Economic Forum*. https://www.weforum.org/agenda/2021/11/global-transport-carbon-emissions-decarbonise

Brazier, F., van Langen, P., Ruttkay, Z. & Treur, J. (1994). *On Formal Specification of Design Tasks*. Conference: Artificial Intelligence in Design 1994, Lausanne, Switzerland. DOI: 10.1007/978-94-011-0928-4_31

Brazier, F. M., van Langen, P. H. G., & Treur, J. (1996). A logical theory of design. In J. S. Gero (Ed.), *Advances in Formal Design Methods for CAD, Proceedings of the Second International Workshop on Formal Methods in Design* (pp. 243-266). Chapman Hall. https://doi.org/10.1007/978-0-387-34925-1_14

Brazier, F., van Langen, P., Lukosch, S., & Vingerhoeds, R. (2018). Complex Systems: Design, engineering, governance. In H. L. M. Bakker, & J. P. de Kleijn (Eds.), *Projects and People: Mastering Success* (pp. 35-60). NAP.

Bridgewater, A. V. (2007). The production of biofuels and renewable chemicals by fast pyrolysis of biomass. *International Journal Global Energy Issues*, *27*(2), 160-203. DOI: 10.1504/IJGEI.2007.013654

Brinsmead, T. S., Herr, A., & O'Connell, D. A. (2015). Quantifying spatial dependencies, trade-offs and uncertainty in bioenergy costs: An Australian case study (1) - least cost production scale. *Biofuels, Bioproducts and Biorefining*, *9*(1), 21-34. DOI: 10.1002/bbb.1502

Calbucci, M. (2022). Collaboration vs. Coordination: Why aren't you achieving as much as you could?. *Linkedin*. https://www.linkedin.com/pulse/collaboration-vs-coordination-why-arent-you-achieving-calbucci

Casey, M. (2017). The Secrets to Stakeholder Alignment. *Brain Traffic*. https://www.braintraffic.com/insights/the-secrets-to-stakeholder-alignment

Castaner, X. & Oliveira, N. (2020). Collaboration, coordination, and cooperation among organizations: establishing the distinctive meanings of these terms through a systematic literature review. *Journal of Management*, *46*(6), 965-1001. DOI: 10.1177/0149206320901565.

Chandrasekaran, S., Kalidas, S., Mir, M., Nel, G., Parbhoo, P., Rao, A., & Srikanthan, S. (2021). Capital Projects 5.0: Reimagining capital-project delivery. *McKinsey & Company*. https://www.mckinsey.com/capabilities/operations/our-insights/capital-projects-50-reimagining-capital-project-delivery

CFI Team. (2023). *Streamlining*. https://corporatefinanceinstitute.com/resources/management/streamlining/

Dekker, H. C. (2004). Control of inter-organizational relationships: evidence on appropriation concerns and coordination requirements. *Accounting, Organizations and Society*, *29*, 27-49. https://doi.org/10.1016/S0361-3682(02)00056-9

Duggan, T. (2023). *Signs & Symptoms of a Lack of Internal Control of a Business.* https://smallbusiness.chron.com/signs-symptoms-lack-internal-control-business-51658.html

Dutch Emission Authority. (2018). Organisatie. *Emissieautoriteit* https://www.emissieautoriteit.nl/organisatie-en-klimaatbeleid

van Dyk, S., Su, J., Ebadian, M., & Saddler, J. (2022). Production of lower carbon-intensity fuels by co-processing biogenic feedstocks: Potential and challenges for refineries. *Fuel*, *324*. https://doi.org/10.1016/j.fuel.2022.124636

Ekman, A., Wallberg, O., Joelsson, E., & Börjesson, P. (2013). Possibilities for sustainable biorefineries based on agricultural residues – A case study of potential straw-based ethanol production in Sweden. *Applied Energy*, *102*, 299-308. DOI: 10.1016/j.apenergy.2012.07.016

Engebø, A., Klakegg, O. J., Lohne, J. & Lædre, O. (2020). A collaborative project delivery method for design of a high-performance building. *International Journal of Managing Projects in Business*, *13*(6), 1141-1165. DOI: 10.1108/IJMPB-01-2020-0014.

Enserink, B., Hermans, L., Kwakkel, J., Thissen, W., Koppenjan, J., & Bots, P. (2010). *Policy Analysis of Multi-Actor Systems*. LEMMA.

EPA. (2022). *Economics of Biofuels*. https://www.epa.gov/environmental-economics/economics-biofuels

European Commission. (2022). *Biofuels*. https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/biofuels_en

Fawzy, S., Osman, A. I., Doran, J., & Rooney, D. W. (2020). Strategies for mitigation of climate change: a review. *Environmental Chemistry Letters*, *18*(6), 2069–2094. https://doi.org/10.1007/s10311-020-01059-w

Ferrer, P. S. S., Galvao, G. D. A. & de Carvalho, M. M. (2020). Tensions between compliance, internal controls and ethics in the domain of project governance, *International Journal of Managing Projects in Business*, 13(4), 845-865. DOI: 10.1108/IJMPB-07-2019-0171.

Gasparatos, A., Stromberg, P., & Takeuchi, K. (2013). Sustainability impacts of first-generation biofuels. *Animal Frontiers, 3*(2), 12–26, https://doi.org/10.2527/af.2013-0011

Grant, M. (2021). Standardization. *Investopedia*. https://www.investopedia.com/terms/s/standardization.asp

Grant, M. J. & Booth, A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Information & Libraries Journal*, *26*(1), 91-108. https://doi.org/10.1111/j.1471-1842.2009.00848.x

Gulati, R., Wohlgezogen, F., & Zhelyazkov, P. (2012). The Two Facets of Collaboration: Cooperation and Coordination in Strategic Alliances. *Academy of Management Annals*, *6*(1), 531-583. https://journals.aom.org/doi/abs/10.5465/19416520.2012.691646

Hevner, A. R. (2007). A Three Cycle View of Design Science Research*. Scandinavian Journal of Information Systems*, *19*(2). https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1017&context=sjis

Hirschmann, W. B. (2014). Profit from the Learning Curve. Harvard Business Review. https://hbr.org/1964/01/profit-from-the-learning-curve

IEA. (2019). *The Future of Hydrogen*. https://www.iea.org/reports/the-future-of-hydrogen

IEA. (2022). *Transport*. https://www.iea.org/topics/transport

Indeed. (2022). *Standardization in Business: What It Is and Examples.* https://www.indeed.com/career-advice/career-development/examples-of-standardization-in-business

International Organization for Standardization. (2017). *Collaborative business relationship management systems — Requirements and framework* (ISO Standard No. 44001:2017). https://www.iso.org/standard/72798.html

Jergeas, G. F., Williamson, E., Skulmoski, G. J., & Thomas, J. L. (2000). Stakeholder management on construction projects. *AACE International Transactions*, P12.1-P12.6 https://www.proquest.com/scholarly-journals/stakeholder-management-on-construction-projects/docview/208199241/se-2

Jeswani, H. K., Chilvers, A. & Azapagic, A. (2020). Environmental sustainability of biofuels: a review. *Proceedings of the royal society A*, 476. https://doi.org/10.1098/rspa.2020.0351

Joni, S.-N. & Beyer, D. (2009). How to Pick a Good Fight. *Harvard Business Review. https://hbr.org/2009/12/how-to-pick-a-good-fight*

Klessova, S., Thomas, C. & Engell, S. (2020). Structuring inter-organizational R&D projects: towards a better understanding of the project architecture as an interplay between activity coordination and knowledge integration. *International Journal of Project Management*, 38(5), 291-306. DOI: 10.1016/j.*ijproman.2020.06.008*

Lambert, D. M., Knemeyer, A. M., & Gardner, J. T. (2010). *Building high performance business relationships. Sarasota*, FL: Supply Chain Management Institute.

Laude, A., Ricci, O., Bureau, G., Royer-Adnot, J., & Fabbri, A. (2011). CO_2 capture and storage from a bioethanol plant: Carbon and energy footprint and economic assessment. *International Journal of Greenhouse Gas Control*, *5*(5), 1220-1231. DOI: 10.1016/j.ijggc.2011.06.004

Lavoie, A. (2014). How To Get Rid Of Toxic Office Politics. *Fast Company*. https://www.fastcompany.com/3028856/how-to-make-office-politicking-a-lame-duck

Leung, M.-Y., Olomolaiye, P., & Chinyio, Ezekiel, BSc (Hons), MSc, PhD. (2010). Construction stakeholder management. In *Risk and construction stakeholder management* (pp. 75–98). essay, Wiley-Blackwell: Oxford, UK. https://doi.org/10.1002/9781444315349.ch6

Li, Y., Zhao, C., Chen, L., Zhang, X., Zhang, Q., Wang, T., Qiu, S., Tan, J., Li, K., Wang, C., & Ma, L. (2018). Production of bio-jet fuel from corncob by hydrothermal decomposition and catalytic hydrogenation: Lab analysis of process and techno-economics of a pilot-scale facility. *Applied Energy*, *227*, 128-136. https://doi.org/10.1016/j.apenergy.2017.07.133

Mannan, R. (2021). Overcoming the Shortage of Engineers. *New Engineer*. https://newengineer.com/blog/overcoming-the-shortage-of-engineers-1509925

Marcum, C. S., Bevc, C. A., & Butts, C. T. (2012). Mechanisms of Control in Emergent Interorganizational Networks. *Policy Studies Journal*, *40*(3), 516-546. https://doi.org/10.1111/j.1541-0072.2012.00463.x

Martinez, J. I., & Jarillo, J. C. (1989). The Evolution of Research on Coordination Mechanisms in Multinational Corporations. *Journal of International Business Studies*, *20*(3), 489–514. http://www.jstor.org/stable/155188

McCormick, J. (1998). *Carrots, Sticks and Sermons: Policy Instruments and Their Evaluation* (1st ed.). Routledge. https://doi.org/10.4324/9781315081748

Meade, P. H. (2007). *A guide to benchmarking*. University of Otago. https://planning.curtin.edu.au/local/docs/Guide_to_Benchmarking_Oct2007.pdf

Memişoğlu, G., & Üster, H. (2016). Integrated bioenergy supply chain network planning problem. *Transportation Science*, *50*(1), 35-56. DOI: 10.1287/trsc.2015.0598

Mintzberg, H. (1980). Structure in 5's: A Synthesis of the Research on Organization Design. *Management Science*, *26*(3), 322-341. https://www.ics.uci.edu/~corps/phaseii/Mintzberg-StructureIn5s-MgmtSci.pdf

Molwus, J. J. (2014). *Stakeholder management in construction projects: A life cycle based framework* [Doctoral dissertation, Heriot Watt University]. Heriot-Watt University Library. https://core.ac.uk/download/pdf/77035943.pdf

Moran, S. (2017). Planning of Layout Activities. *Process Plant Layout* (2nd ed., pp. 65-74). https://doi.org/10.1016/B978-0-12-803355-5.00005-6

Moseman, A. (2021). Which is more likely: electric airplanes or hydrogen-powered airplanes?. Climate Portal. https://climate.mit.edu/ask-mit/which-more-likely-electric-airplanes-or-hydrogen-powered-airplanes

Mupondwa, E., Li, X., & Tabil, L. (2017). Large-scale commercial production of cellulosic ethanol from agricultural residues: A case study of wheat straw in the Canadian Prairies. *Biofuels, Bioproducts and Biorefining*, *11*(6), 955-970. DOI: 10.1002/bbb.1800

NASA. (2023). *Is it too late to prevent climate change?.*https://climate.nasa.gov/faq/16/is-it-too-late-to-prevent-climate-change/

Oliveira, C., & Schure, K. M. (2020). Decarbonisation options for the Dutch refinery sector. *PBL Netherlands Environmental Assessment Agency and TNO Energy Transition*. https://www.pbl.nl/sites/default/files/downloads/pbl-2020-decarbonisation-options-for-the-dutch-refinery-sector-3659_0.pdf

Organisation for Economic Co-operation and Development. (2019). "Glossary of Industrial Organisation Economics and Competition Law," 39-40. https://www.oecd.org/regreform/sectors/2376087.pdf

Palmeros Parada, M. (2020*). Biorefinery Design in Context: Integrating Stakeholder Considerations in the Design of Biorefineries*. https://doi.org/10.4233/uuid:72e0c6e1-9c17-4b8c-b5ce-fb6a8e2abf20

Parsons, J. A. (Ed.) (2008). *Encyclopedia of Survey Research Methods*. Sage Publications. https://doi.org/10.4135/9781412963947

Peffers , K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, C. (2007). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, *24*(3), 45-77, DOI: 10.2753/MIS0742-1222240302

Prasetyo, W. D., Putra, Z. A., Bilad, M. R., Mahlia, T. M. I., Wibisono, Y., Nordin, N. A. H., & Wirzal, M. D. H. (2020). Insight into the Sustainable Integration of Bio- and Petroleum Refineries for the Production of Fuels and Chemicals. *Polymers (Basel)*, *12*(5). https://doi.org/10.3390%2Fpolym12051091

Qazi U. Y. (2022). Future of Hydrogen as an Alternative Fuel for Next-Generation Industrial Applications; Challenges and Expected Opportunities. *Energies*, *15*(13). https://doi.org/10.3390/en1513474

Rijksoverhid. (2010). Organisatie van ministerie van Sociale Zaken en Werkgelegenheid.. https://www.rijksoverheid.nl/ministeries/ministerie-van-sociale-zaken-en-werkgelegenheid/organisatie

Rijksoverheid. (2013). *Provincie voert landelijk en eigen beleid uit*. https://www.rijksoverheid.nl/onderwerpen/provincies/taken-provincie

Robertson, S. (2001). Requirements trawling: techniques for discovering requirements. *International Jpurnal of Huamn-Computer Studies*, *55*(4), 405-421. https://doi.org/10.1006/ijhc.2001.0481

Santibañez-Aguilar, J. E., González-Campos, J. B., Ponce-Ortega, J. M., Serna-González, M., & El-Halwagi M. M. (2014). Optimal planning and site selection for distributed multiproduct biorefineries involving economic, environmental and social objectives. *Journal of Cleaner Production*, *65*, 270-294. DOI: 10.1016/j.jclepro.2013.08.004

Schooley, S. (2023). Are Workplace Politics Destroying Your Business? Here's How to Fix It. *Business News Daily*. https://www.businessnewsdaily.com/6374-fix-workplace-politics.html

Shell. (2009). *Working together to scale saf production*. https://www.shell.com/business-customers/aviation/100years/flying-together/scale-saf.html

Shell. (2020). *Thriving in the new reality: Refinery revamp projects FAQ.* https://www.shell.com/business-customers/catalysts-technologies/resources-library/refinery-revamp-faq.html#1

Slaney, M. (2022). Essential skills for aligning stakeholders every time. *Medium*. https://martinslaney.medium.com/essential-skills-for-aligning-stakeholders-every-time-8d1f25680b61

Spekman, R. E., Kamauff, J. W., & Myhr, N. (1998). "An empirical investigation into supply chain management: a perspective on partnerships". *Supply Chain Management*, *3* (2), 53-67. DOI: 10.1108/13598549810215379.

Srivastav, A. K. (2019). Economic Factors. *WallStreetMojo*. https://www.wallstreetmojo.com/economic-factors/

Stanier, J. (2018). Workplace politics. *The Engineering Manager*. https://www.theengineeringmanager.com/growth/workplace-politics/

Stephen, J. D., Mabee, W. E., & Saddler, J. N. (2010). Biomass logistics as a determinant of second-generation biofuel facility scale, location and technology selection. *Biofuels, Bioproducts and Biorefining*, *4*(5), 503-518. DOI: 10.1002/bbb.239

Su, J., van Dyk, S., & Saddler, J. (2022). Repurposing oil refineries to "stand-alone units" that refine lipids/oleochemicals to produce low-carbon intensive, drop-in biofuels. *Journal of Cleaner Production*, *376*. https://doi.org/10.1016/j.jclepro.2022.134335

Thomas, C. E. (2009). Fuel cell and battery electric vehicles compared. International *Journal of Hydrogen Energy, 34*(15), 6005-6020. https://doi.org/10.1016/j.ijhydene.2009.06.003

Thompson, K. (2016). Interviews in Social Research: Advantages and Disadvantages. *Revise Sociology*. https://revisesociology.com/2016/01/23/interviews-in-social-research-advantages-and-disadvantages/

Varvasovszky, Z., & Brugha, R. (2000). A stakeholder analysis. *Health Policy and Planning, 15*(3), 338–345. http://www.jstor.org/stable/45089636

Waisi, G. R., Demir, M., Humble, J. E., & Lev, B. (2015). Automation of strategy using IDEF0 — A proof of concept. *Operations Research Perspectives*, *2*, 106-113. https://doi.org/10.1016/j.orp.2015.05.001

Watt, A. (2014). *Project management*. BCcampus. https://opentextbc.ca/projectmanagement/

Winch, G. M. (2010). *Managing Construction Projects: An Information Processing Approach*. (2 ed.) John Wiley & Sons Ltd.

Zeltwanger, H. (2015). A short history of standardization and CAN. *Control Engineering*. https://www.controleng.com/articles/a-short-history-of-standardization-and-can/

Zhao, C., Yan, Y., Wang, C., Tang, M., Wu, G., Ding, D., & Song, Y. (2018). Adaptation and mitigation for combating climate change – from single to joint, *Ecosystem Health and Sustainability*, *4*(4), 85-94. DOI: 10.1080/20964129.2018.1466632

8. Appendix

8.1. Stakeholder List

Here below is an extensive but not all-inclusive list of stakeholders. This list has been generated through interviews conducted during the stakeholder analysis.

- **Engineering Contractor**
  - Program Management
    - Program Director
    - Program Delivery Manager
    - Engineering Manager
    - Area Manager
    - Program Support
  - (Lead) Engineers
    - Civil Structural Engineers
    - Electrical Engineers
    - Environment, Health, and Safety Engineers
    - Instrumentation Engineers
    - Mechanical Engineers
    - Piping Engineers
    - Process Engineers
    - Subject Matter Experts
  - Procurement
  - Assurance
  - Cost
  - Tools & Development

- **Client**
  - Executive group
    - CEO
    - VP Fuel Production
    - VP Fuel Marketing
    - VP Aviation
    - VP New Energy Developments
    - VP Global Refining
    - VP Refinery Operations
  - Projects group
    - Appraisal General Manager
    - Project Manager
    - Project Delivery Lead Site-specific scope
    - Project Delivery Lead Common scope
  - Counterparts from engineering contractor
    - Site-specific scope
    - Common scope
  - Operation & Management of refinery
    - Refinery Manager
    - Operations Manager
    - Site Operation Representatives
    - Oil movement responsible
    - (Senior) Operators
    - Process person for utilities
  - Maintenance of refinery
  - HSSE
- **Construction**
- **Commissioning**
- **Logistics**
- **Equipment suppliers/manufacturers/ designers**
- **Government**
  - Regulating Bodies[4]
    - ILT (Human Environment and Transport Inspectorate)

[4] *Dutch Regulating Bodies*

- SZW (Netherlands Labor Authority)
- NVWA (Netherlands Food and Consumer Product Safety Authority)
- Regional Protection Agency
- Dutch Emission Authority
- DCMR (Environmental Protection Agency)
- Etc.

  - Supranational Government
  - National Government
  - Provincial Government
  - Local Government
- **Environmental Non-Governmental Organizations**
- **Standard Committees**
- **Citizens**

8.2. Aspect List

This subchapter of the appendix presents the complete list of aspects discovered through interviews with all the stakeholders. The aspects have been divided into three kinds, technical, political and techno political.

- Technical
  - Space
  - Utilities
    - Steam
    - Cooling water
    - Water treatment
    - Power
  - Units of measurement
  - Site specifics
  - Climate
  - Soil type and earthquake resilience
  - Feed properties and composition
  - Integration with existing site systems
  - Consequences of moving away from existing site standards
  - Existing – vs new material specifications
  - Existing – vs new process conditions
- Political
  - Inflation Reduction Act (IRA)
  - Operating and environmental regulations
  - Permits (noise, emission, water treatment, and power)
  - Standards
  - Unions vs subcontracting
  - Management style
  - Incentive
  - Contractual obligations
- Techno Political
  - Safety
  - Transportation of equipment and infrastructure or accessibility
  - Emission/Waste/Pollution
  - Sustainability
  - Externalities
  - Labour/Staffing

8.3. Interview Questions

Appendix subchapter 8.3 presents the interview questions asked unto the interview participants. The interviews took place in two phases, phase one for stakeholder analysis and phase two for requirement identification. Only the critical stakeholders identified during the stakeholder analysis were interviewed in phase two. All interviews had been conducted in a semi-structured way and so the interview questions were not always followed chronologically. Also, sometimes, follow-up questions were asked to elicit more explanation. Such questions are not included in the list below. The interview questions asked to the interview participants were:

1. What is your name, expertise, current position, and affiliation with the research topic?
2. Who would you consider as stakeholders when it comes to implementation of standardized refinery modification design from the perspective of:
    a. Technical (Design or Operation)
    b. Political
3. Who are the stakeholders that you work closely with?
4. What are your most important resources with regards to implementing a standardized refinery modification design (e.g., information, knowledge, technology, authority, money, position in network, etc.)?
5. Would you consider your task as something that only you can do?
6. What would you say is the current situation when it comes to implementing a standardized refinery modification design? Is there a specific reason that is the case?
7. Do you think that the current situation should be changed?
8. How can your proposed change in the situation be achieved?
9. Would a successful implementation of the standardized refinery modification design influence your work positively/negatively and in what way?
10. Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?
11. In addition to identifying the aspects, a guideline has also been developed. Please look at the guidelines included in this document and pay close attention to the ones that you have an affinity with. Are there important processes, procedures or requirements that are not listed in the said guideline that should be included, if so, can you name them?
12. Sticking to the items or aspects as a whole in the guidelines that you have an affinity with or knowledge of who are the relevant stakeholders for its implementation (see last page for an extensive but not all-inclusive list of stakeholders)?
13. To successfully implement the guidelines, stakeholder alignment is seen as a crucial element. Which of the item(s) listed above is most challenging in terms of trying to align the relevant stakeholders?
14. What would you normally do so these stakeholders can be aligned? And did it work?
15. Do you have another idea as to how the stakeholders can be aligned in the item(s) you mentioned in question 3?

8.4. Interview Summaries

This subchapter of the Appendix presents the interview summary. In total, 15 people were interviewed. These interview participants are experts from the engineering contractor Worley, the client of Worley, and the Technological University of Delft.

Worley – Program Delivery Manager

What is your name, expertise, current position, and affiliation with the research topic?

I am ____, experienced in realizing projects for customers and is currently working on standardization for a client where one refinery modification design will have to be implemented in multiple locations. When it comes to prior experience with standardization projects, it is present but on a much smaller scale.

Who would you consider as stakeholders when it comes to implementation of standardized refinery modification design from the perspective of:

- Technical (Design or Operation)
- Political

I see the following as stakeholders when it comes to implementation of a standardized refinery modification design:

1. *Project execution group like Worley*
    a. *Engineering disciplines that focus on optimizing (plus lead engineers)*
    b. *Project management that is interested in standardization*
    c. *Tools & development*
2. *Customer or client*
    a. *Projects group*
    b. *Operation & maintenance group working in refinery*
3. *Contractors*
4. *Regulatory bodies that provide permits*

Who are the stakeholders that you work closely with?

When it comes to direct working relations, I work closely with the client's project organization (project group). On the other hand, the engineers work with the operation & management group of the customer. This is difficult because on the project level the interest is similar, but on the operation level it is different. This is because an operation guy wants it in a way that he is used to. He knows that other solutions would work too but prefers to do what he is used to. The engineers, however, need approval on their design from local operations people. And so common ground needs to be found.

What are your most important resources with regards to implementing a standardized refinery modification design (e.g., information, knowledge, technology, authority, money, position in network, etc.)?

In terms of important resources, it's the understanding of how processes work, where you can influence these and why they work the way they work. Then, try to explain the intent behind it. The execution strategy of the project can be developed by a few people, but having everyone understand and follow is something different.

What would you say is the current situation when it comes to implementing a standardized refinery modification design?

Applying a standardized design does not happen often, usually we do very repetitive projects with a standardized approach.

Is there a specific reason that is the case? Do you think that the current situation should be changed?

I am not quite sure why this has been the approach used ever since, but it has to change. Looking at our project as the case, there is no way that it can be finished in time if it was seen as individual projects. It would require more people, more guidance and hence too big. Ultimately if the project were to be successful, it would help in fighting climate change.

How can your proposed change in the situation be achieved?

The approach that will work is by developing a blueprint design that can be copied and implemented in other sites to the maximum extent possible. The rest would then be site specific. This is seen as a difficult task as there is no experience yet.

Would a successful implementation of the standardized refinery modification design influence your work positively/negatively and in what way?

Successful implementation would be positive as it will drastically reduce the effort needed for the current and future projects.

Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?

The technical and political restrains (aspects) that must be considered are:

1. *Available space*
2. *Utilities like steam, cooling water, water treatment, and power are important. They can be a very significant cost adder. If the current capacity and system can be accommodated, with minor modifications, then it has a major positive cost impact. Especially that these are all site specific and there are differences within these sites.*

3. *From the political side, there could be challenges like laws. For example, the Inflation Reduction Act in the USA.*
4. *Also permitting requirements around noise, emission, water emission, etc. Refineries are designed to meet local requirements and not to the best possible techniques if not required. One may suggest taking the most stringent requirement and making a standardized design out of it, which is fine but if can add costs and operators will not do it*
5. *Standards of the client that need to be met like difference between the EU (European Union) and USA.*

In addition to identifying the aspects, a guideline has also been developed. Please look at the guidelines included in this document and pay close attention to the ones that you have an affinity with. Are there important processes, procedures or requirements that are not listed in the said guideline that should be included, if so, can you name them?
See table 20
Sticking to the items in the guidelines that you have an affinity with or knowledge of who are the relevant stakeholders for its implementation? or requirements that are not listed in the said guideline that should be included, if so, can you name them?

Guideline Item	**Relevant stakeholders for implementation**
1-2 (Space)	*Design team engineering contractor and local refinery side management*
3-6 (Utilities)	*Design team engineering and local refinery side management*
7-9 (Logistics/accessibility)	*Construction team*
10-16 (Labour/staffing)	*Local refinery side management, (global) project management, operations/maintenance management*
17 (Site specificity)	*Economical actors*
18 (Site specificity)	*Site actors*
19 (Site specificity)	*Engineers*
20 (Site specificity)	
21 (Site specificity)	*Engineers*
22-27 (Permitting)	*Governing bodies*

To successfully implement the guidelines, stakeholder alignment is seen as a crucial element. Which of the item(s) listed above is most challenging in terms of trying to align the relevant stakeholders?
To me it's dealing with people, so probably labour/staffing and site specificity. Most of the permitting we need to comply anyways and most of the (items) are solvable.
What would you normally do so these stakeholders can be aligned? And did it work?
Not really sure if it works, but usually you show the benefit for the specific site of being able to standardize, which is predictability and schedule. Because there are less things you need to discover and it's probably a bit more efficient in time and cost. You also show that you recognize the disadvantages that the site will be struggling with. Just brushing them aside, like the example of maintenance/knowing the equipment is something they need to address and a potential cause for error. Therefore, it must be taken seriously. -> Communication, listening and showing why bother to change.
Generally, it works if the advantages are big enough, you show people they are listened to and take their concerns seriously, then most people are inclined to work along.
Do you have another idea as to how the stakeholders can be aligned in the item(s) you mentioned?
Inform people that keeping things simple and standard (so not bespoke or custom made) will contribute to speeding up realizing things that will contribute to energy transition and hence save the world.

Worley – Engineering Manager

What is your name, expertise, current position, and affiliation with the research topic?
My name is _____, an expert in engineering that is currently looking at the standardization of refineries.
Who are the stakeholders that you work closely with?
I work closely with counterparts from the client's company, my boss (project manager and his counterpart) the engineering leads (process, mechanical, piping, civil, safety, structural, electrical, instrumentation), and with the people from the refineries for site specific scope.
What are your most important resources with regards to implementing a standardized refinery modification design (e.g., information, knowledge, technology, authority, money, position in network, etc.)?
My most important resource is knowledge, hence we conducted knowledge management workshops with the subject matter experts to investigate what can be standardized from an engineering point of view and by capturing the commonalities from the sites. This can also be considered as the position in the network as without this network then it would not have been possible.
Would you consider your task as something that only you can do?
I consider my task as something that not only I can do. Anybody else can do it, as it is an easy task.
Would a successful implementation of the standardized refinery modification design influence your work positively/negatively and in what way?
Successful implementation of a standardized design will be definitely be positive as this has never been done before. Successful achievement will be rewarding for everybody.

What would you say is the current situation when it comes to implementing a standardized refinery modification design? Is there a specific reason that is the case?

In the current situation, there normally isn't standardization. There is standardization on site but considering it in multiple sites around the globe is challenging. The approach for such projects (individual projects instead of standardized) is probably due to the client organization structures. Before, the refineries were asked to operate on their own, compete and report their profit, so they are developed per refinery. Now the client wants to achieve global optimality.

Do you think that the current situation should be changed?

I think standardization is a good approach, although it has some downsides like complexity. Doing one mega project is already a challenge and a lot of them fail. Now it's made even more complex, but if we can succeed then it is pivoting in the industry.

How can your proposed change in the situation be achieved?

Standardization can be achieved if each phase of engineering is successful as it will show a good track record. Repeatability and standardization have happened in other industries but not really in downstream refining work. To achieve success in standardization, I suggest that the organizational structure must change. There are too many parties involved across the globe and this makes decision-making and alignment difficult in top processes. The preference would be having it in one location with one core team so centralized. Too many parties make it complex as there is a difference in time and working methods.

Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?

The technical and political aspects that must be considered are:

1. *Units of measurement (metric vs. imperial)*
2. *Site specifics that you need to accommodate*
3. *Unions in USA and subcontracting in EU have different legislations this can affect the design*
4. *Union) and USA.*

In addition to identifying the aspects, a guideline has also been developed. Please look at the guidelines included in this document and pay close attention to the ones that you have an affinity with. Are there important processes, procedures or requirements that are not listed in the said guideline that should be included, if so, can you name them?

Looking at the relevant aspects, I am not sure if decision-making is captured well enough in these. It would kind of belong in a management (governance) aspect. Consider the complexity and size of such a project. Getting the information flow and all the communication in the teams, but also the right level of decision-making I think is one of the biggest challenge here in respect of standardization.

Sticking to the items in the guidelines that you have an affinity with or knowledge of who are the relevant stakeholders for its implementation? or requirements that are not listed in the said guideline that should be included, if so, can you name them?

Space aspect: Construction management with engineering management

For the items mentioned in the next interview question these are the relevant stakeholders: Construction management, procurement management, engineering management, controls management on the engineering company and client side (all with different goals). This is mainly for the project level; on the site level you have the site management.

Labour/staffing aspects like retention of existing human capital then you would need management again plus HR

Site specificity: Important is the site based engineering team

To successfully implement the guidelines, stakeholder alignment is seen as a crucial element. Which of the item(s) listed above is most challenging in terms of trying to align the relevant stakeholders?

It's the items about establishing a conflict or misunderstanding resolution procedure, striving for alignment of employees, and clarifying who has decision-making authority and accountability.

What would you normally do so these stakeholders can be aligned? And did it work?

Frequent alignment sessions

Proper kickoff meeting

Face to face interaction because body language is essential in communication.

Do you have another idea as to how the stakeholders can be aligned in the item(s) you mentioned?

With regards to kickoff meeting -> it can be improved by alignment in the structure of decision-making and instructions. The structure of decision-making, and instructions have been tried but it's hard.

Structure in decision-making- who can make decisions and how can we make them. Considering standardization, you need to look at every topic with different lenses (fabrication, construction, controls, cost, schedule, etc.).

Doing it in a structured way means you agree upfront who are the decision makers. When a decision needs to be made and you have a structure in place, then you can consider different glances at the same topic. You have a framework for easy decision-making.

Instructions - this is how we are going to do the work, if you cannot follow it, then this is the escalating mechanism/proper support on the right decision-making

Client – Appraisal General Manager

What is your name, expertise, current position, and affiliation with the research topic?

My name is ______, accountable for the front-end development of the program. I have been working on project development or delivery for quite some time, 40% in refining, 40 % in chemicals and 10% in upstream. I basically defined the expectations to Worley for standardization in the current program, keeping the aspirations of the executives of their company in mind.

Who would you consider as stakeholders when it comes to implementation of standardized refinery modification design from the perspective of:

- Technical (Design or Operation)
- Political

For me, the stakeholders are the executive leaders (VP fuel production, VP fuel marketing, VP aviation, VP new energy developments, VP global refining, VP refinery operations), people who run the refineries, engineering that provide expertise and guidance (so not design like those from Worley). I work closely with these stakeholders as well, especially refinery operations and representatives. To ensure that they have input in the entire design process. Getting them onboard in terms of agreeing to the concept of standardization is critical for the potential success of the program. As much as they might be part of a global organization, their job is to look after their own site. I tend to think that those actively involved in the project as project team members and less as stakeholders in the outcome. In the process they can be considered as stakeholders though.

Who are the stakeholders that you work closely with?

Those that I mentioned earlier.

What would you say is the current situation when it comes to implementing a standardized refinery modification design? Is there a specific reason that is the case?

The current project is built on the experience learned from attempted projects and the way they were developed. Every site had their own team that initiated projects based on their view or local business unit view, on what would deliver value for that business unit. For example, for our refinery in X, we know that the legislation in the state of Y would give us a lot of credits for low-carbon fuel. So, we would want to build a plant that can make renewable diesel fuel from bio feedstocks so we can make tons of money. But the project did not get approved. Projects are always led at the local level and only regional considerations, so the solutions are very different. The approach is like this because of the way the company is organized, historically the company was organized with independent business units. But before that it was centralized, however, it was seen as a waste as you create a lot of overhead costs. As a result, undeserving businesses continue to operate, the book Reengineering the Corporation says that you should rather break that up and make every business its own business unit, given its own profit and loss statement. This led to every business competing for resources within and outside the company. Every refinery therefore came up with their own idea as to how it can improve its profit. A few years ago, the company decided to restructure and did away with those individual business units, so back to more centralized operations. The restructuring is still ongoing as it cannot happen overnight. The challenge (of standardization) here is trying to get people who have worked in an independent way to all of a sudden do it the way someone else tells you to.

Do you think that the current situation should be changed?

There are plusses and minuses to this change, standardization can bring a certain level of value. The degree of standardization can determine how much value it will bring. We are not standardizing for the sake of standardizing. We are standardizing to create value. It is not simple to say that you should standardize everything, it is not a one size fits all. Consider airplanes (standardized) and airports (not). More standardization can be achieved by more education and stakeholder engagement.

How can your proposed change in the situation be achieved?

To make it easier to standardize we must come up with a design envelope. It is much easier on a common design envelope. Once we agreed what a reasonable common envelope would be, that enabled us to decide what is conducive to be standardized. But it should deliver value.

What are your most important resources with regards to implementing a standardized refinery modification design (e.g., information, knowledge, technology, authority, money, position in network, etc.)?

The most important thing (resource) required for a refinery modification project is human knowledge of the operation. Having experienced people in refinery operation and knowledgeable of this specific sight. This was their company's biggest bottleneck to get things started. People that also know the new technology are needed through technology providers and people from our side who know enough about that technology (not to design it), but to be certain about what we are getting from them will work in our facility. This is just for the foundation of the project, to get it working you will need engineers and construction craftsman, however there isn't an infinite resource pool available (human capital constraint). Usually in such projects money is critical, but not in this case as there is a real corporate strategy to invest.

Would you consider your task as something that only you can do?

My task is not something only I can do, nobody is indispensable. But there are not many people in the company with combination of experience that I have. I do a great job of stakeholder management with those above me, I have worked in refinery, I have done major project works, I have familiarity with the local issues, and I am familiar with engineering.

Would a successful implementation of the standardized refinery modification design influence your work positively/negatively and in what way?

If the entire program is implemented successfully, then you would have multiple units all implemented in the same way. The people running the units can talk to eachother and share learnings. The start of the first one is going to be challenging, but there will be a lot of learning. We should be able to take people from that site to the second site and that should get to a stable operation a lot easier and so on until the last site. What's more when they are operating and you run into a problem somewhere, then they wouldn't need to figure it out on their own. With regards to implementation of the design, it would also require less human capital. From a supply chain perspective, buying multiple units of an item would also be beneficial to the supplier. Potentially less cost and time as well for them in making one standardized item than buying multiple different items. A disbenefit however is that the local refineries will not produce optimally due to the standardized design. There is the potential to over-and under design depending on the area. The optimal totality will however be greater, by optimizing the design from a program perspective.

Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?

The aspect that needs to be considered is the ability to get the equipment/construction resource there. Getting massive pieces of a refinery can be too restricted. Also, getting capable human resources is no longer economic. Getting a thousand people from somewhere far to work on a project is less attractive than hiring a contractor locally. To sum up, you should look at space and supporting infrastructure. You have to look at what benefit you would have if you were going to build it in an existing facility as opposed to a new property? On a political note, internally, it would be better to use existing assets as investments have already been made before (not just money, so like human capital).

In addition to identifying the aspects, a guideline has also been developed. Please look at the guidelines included in this document and pay close attention to the ones that you have an affinity with. Are there important processes, procedures or requirements that are not listed in the said guideline that should be included, if so, can you name them?

See table 20

Sticking to the items in the guidelines that you have an affinity with or knowledge of who are the relevant stakeholders for its implementation? or requirements that are not listed in the said guideline that should be included, if so, can you name them?

Space: Asset (or refinery) manager, operations manager
Utilities: Refinery Manager, Operations Manager, Commercial Manager (for purchasing of utility if possible)
Logistics/accessibility: Maintenance Manager, Turn Around Manager
Labour/staffing: Project Leadership, Refinery Leadership,
Site specificity: Operations and Maintenance Managers, Business Leadership, Project Leadership
Permitting: Environmental Department/Regulatory Compliance Department, Project Leadership

To successfully implement the guidelines, stakeholder alignment is seen as a crucial element. Which of the item(s) listed above is most challenging in terms of trying to align the relevant stakeholders?

Labour/staffing is the most difficult for alignment because we are in a resource short market. So agreeing priorities for the qualified people jus takes quite a bit of stakeholder alignment. The people working in the refinery (typically) prioritizes safe (day-to-day) operation of the refinery and projects are secondary. → Labour/staffing then site specificity because the others boil down to physics (and calculations). But dealing with humans can't be solved with a mathematical calculation.

What would you normally do so these stakeholders can be aligned? And did it work?

Success is variable, the way to align the stakeholders is to spend time in gaining understanding of their issues, limitations, and concerns. And looking for areas of common interest and priority. -> Looking for compromise and mutual respect. The approach we tried to use was seeking for the area where I can get a yes. If I can't get a yes to a 100% of my desire, what can I get a yes to (70% or 60%)? It's not about looking at it as a negative, but as a positive. What can we agree on and what can we say yes to?

Do you have another idea as to how the stakeholders can be aligned in the item(s) you mentioned?

Nope, I have a lot of tools in the toolbox. I tried to use them all but mostly it comes down to establishing mutual respect.

TU Delft – Assistant Professor, Governance expert

What is your name, expertise, and current position?

I am ___, an associate professor in the section organization & governance. My background is public administration and director of studies of Engineering and Policy Analysis in The Hague. My research topic is more on regulation & enforcement in the digital age on the public side. But I also have a general knowledge on organizational studies in the private side.

Who would you consider as stakeholders when it comes to implementation of standardized refinery modification design from the political perspective?

It depends on the size of the project and hazards around it. Especially if it touches public values like sustainability, safety, security, public health and health for employees. The government involved depends on the size of the project, the smaller the project the lower the governance and always the municipality is involved. If space and planning is important then province will also be involved. They will all relate to the EU level so supranational level. The different public values result in Worley getting confronted by specialized public officials of multiple layers. In Netherlands these regulators are ILT (Human Environment and Transport Inspectorate), SZW (Netherlands Labor Authority), NVWA (Netherlands Food and Consumer Product Safety Authority), Regional Protection Agency, etc.

Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering political differences?

It's good to think about decision-making on this matter. Consider safety, there are plenty of stakeholders involved but they have different time spans of intervention like the government. Within Worley as a company, there are also departments within the company that mind public values. The people from these might have extrinsic and intrinsic motivation and they make tradeoffs. They kind of act as internal regulators.

Do you have idea on alignment methods that can be implemented?

Now we are talking about instruments to influence others' behavior. The broader definition for public organization like instruments being financial, regulatory and communicative and the multiple sources: nodality, money, etc. These by and large apply to private engineering companies as well. However, the legal basis of intervention is different. For public values there is law, for companies there are procedures and quality/safety standards. So for a company it's their own standard and the translation of the standard from outside (governmental/ public rules, interoperation of what the client wants).

Worley – Civil Engineer

What is your name, expertise, current position, and affiliation with the research topic?

My name is ____, and I have more than 13 years of experience as a civil structural engineer in oil and gas industry. I am working as a senior engineer in the project.

Who are the stakeholders that you work closely with?

We (civil engineers) normally work with the lead engineer, the people from different disciplines of engineering and our site-specific counterpart.

What are your most important resources with regards to implementing a standardized refinery modification design (e.g., information, knowledge, technology, authority, money, position in network, etc.)?

Knowledge or experience in modularization.

Would you consider your task as something that only you can do?

It depends on the project, in civil engineering there are different expertise. In a very big project that I worked on, there are certain dedicated teams working with multiple engineers.

What would you say is the current situation when it comes to implementing a standardized refinery modification design? Is there a specific reason that is the case?

Normally the projects are approached individually.

Do you think that the current situation should be changed?

The current approach should change to reduce the engineering effort and be cost effective.

How can your proposed change in the situation be achieved?

Using modular approach in terms of construction approach. So, fabricate everything in one location and transport in specific sites. There would then be one engineering done in one place and everything will be arranged there.

Would a successful implementation of the standardized refinery modification design influence your work positively/negatively and in what way?

If everything will go smooth, then it will be good. But it's not possible.

Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?

Decision on construction approach should be made early.

TU Delft– Assistant Professor. Policy Innovation expert

What is your name, expertise, and current position?

My name is ____, I'm an assistant professor of policy innovation at Department of Multi Actor Systems at Technology Policy and Management at TU Delft. In terms of my research I'm interested in understanding, explaining, and promoting policy innovation so innovative policymaking. Primarily focusing on sustainable energy transition.

Who would you consider as stakeholders when it comes to implementation of standardized refinery modification design from the political perspective?

- *Landowner*
- *Regulators, standard committees, ministries, government agencies, etc.*
- *Advocacy organizations, environmental NGOs, environmental agencies, or pollution control board*

Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?

Technical: Climate, Soil type
Political: Permits, Labor, Externalities, Safety
Techno/Political: Waste/Pollution, Land, Infrastructure, Water

Worley – Lead Piping Engineer

What is your name, expertise, current position, and affiliation with the research topic?

My name is ____, current position is lead engineer piping and layout. My background is aeronautical engineer. I work on the current project, and we are designing multiple sites from day one as a drive to make one design that fits all.

Who would you consider as stakeholders when it comes to implementation of standardized refinery modification design from the perspective of:

a. Technical (Design or Operation): *local site representatives (technical and refinery management), Worley stakeholders our department and the office, client counterpart working on common scope*

b. Political: *local government and regulators for permits and to comply with conditions from an insurance point of view*

Who are the stakeholders that you work closely with?

That's the technical representatives of different (local) sites, so there are the engineering managers. We are also the contractor for the local scope of ____ so we are in touch with them.

What are your most important resources with regards to implementing a standardized refinery modification design (e.g., information, knowledge, technology, authority, money, position in network, etc.)?

90% of my work is technical so I am not really involved in any politics or management. Really just collecting all the necessary information from the different disciplines. Make sure it is reliable so I can distribute to my team so people can use it to make the design. From my end to make sure that quality is met and that we comply on all standards.

Would you consider your task as something that only you can do?

No one is irreplaceable right. I don't say that everyone that I have in the team can do my job, but the job I do there is plenty of capable people in this office that can also take it. The type of work we are doing is not rocket science, there is a step-by-step process that you normally use from a sheet of paper to a refinery design which we just follow.

What would you say is the current situation when it comes to implementing a standardized refinery modification design? Is there a specific reason that is the case?

It's not the first that something like this comes along, but it is the first time on this scale. It is very common that if you do a design where you have three different trains, you design one train then you copy it three times. That is what we have been doing time and again. The scale is different, but the approach is the same. You want to get the best result for the least effort and least time, in this case if you can design it once and replicate it three times then that is the most efficient. If you need to tinker it later, and if it is still the most efficient thing to do then you do it.

Do you think that the current situation should be changed?

In this phase where we are now (not yet in detail), a big portion looks standardizable. But next phase, we go into detail, more studies are done and all the details from the sites will be considered and that is where there will be divergence. 100% cookie cutter design is not possible. It's a good starting point, but I don't think that in the end the units will be completely identical. You will recognize their base similarity, but they have specifics per site.

How can your proposed change in the situation be achieved?

The approach is fine, but there are issues that need to be tackled:

- *Legislation*
- *Standards*
- *Units*
- *Site condition*
- *Size of module is different per location due to accessibility*

Make refinery (workers) accept the changes or to change their point of view is not easy but is needed to prevent everything from falling apart. Forcing them is not ideal as the relationship will go bad, people will get offended.

Would a successful implementation of the standardized refinery modification design influence your work positively/negatively and in what way?

It is positive, it is good if you can prove that it works. We are talking about sites that are far apart with so much different site conditions. If you can prove that even with these conditions, we can still make it work then that's a win-win situation. But it is not an easy task, the further you go into details, the discipline will face more issues. For example, difference between steel from US and EU. There will be a work around all of these things, but it takes time to find the solution. At a certain point you need to be aware that diving in and solution seeking is going to take more time than just to design it uniquely, so there must be a tipping point to be vigilant about.

Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?

- *Existing material specifications vs. new material specification*
  - *Existing specs could be based on out-dated codes and standards*
  - *Existing systems could be at end-of-life due to corrosion, and require replacement*
- *Existing spacing/layout principles, vs. latest principles.*
  - *General observation is that over the years, the plants have become more spaced out, using a larger footprint. Due to increased spacing between equipment and facilities*
- *Existing process conditions vs. new process conditions*

- *Pressure, temperature, corrosion rate, metallurgy could be different, exceeding existing allowables*

From 'political' point of view, what you notice sometimes is that site operations/maintenance have been operating a plant for many years. They are found to be more reluctant to accept new technologies or designs. As in their experience these are "new" (although it could be that those technologies have been around for a long time). Political is more the agenda of the local refinery considering this project. Countries have different management style. In some places it's always the higher top who decides regardless of what the specialist says. Unlike in a country like the Netherlands where it is more transparent.

Worley – Workstream Coordinator

What is your name, expertise, current position, and affiliation with the research topic?

_____, from a background I am a chemical and industrial engineer, during my masters it was operations management and logistics. After that I worked as cost estimator, afterward I went into assurance. Then I went into project engineering, and I ended up here. Now working as workstream coordinator, basically I look at the processes and how these can be made smoother. I am not involved in the technical aspect of the project but more so on how to make sure it is going to work.

Who are the stakeholders that you work closely with?

I work closely with the program director and the program delivery manager.

What are your most important resources with regards to implementing a standardized refinery modification design (e.g., information, knowledge, technology, authority, money, position in network, etc.)?

I think that the most important thing I bring is indeed network and a different view. I have a very large network in comparison to most of the people here.

Would you consider your task as something that only you can do?

No, I believe there is no single job that only one person can do. There's no second ____, but there are who definitely can. It depends on the market, currently we have another stress market, so not enough people. I think that if I would quit now then they would not replace me and just do it themselves.

What would you say is the current situation when it comes to implementing a standardized refinery modification design? Is there a specific reason that is the case?

I think that for sustainable aviation fuel it doesn't exist, but I think for hydrogen it does exist. Cause every refinery is like their own island, everybody wants their own thing and I think that this has worked for a long period of time. Now with the eye on climate change, the whole world needs to be more sustainable quicker. Companies are getting smarter and instead of building a refinery locally, they wonder how to do it optimally. It reduces cost and we get to net zero more quickly.

Do you think that the current situation should be changed?

Yes

How can your proposed change in the situation be achieved?

Work together more, the government and the companies. Especially since the companies are the ones that must execute it. Otherwise, companies will just do it to comply. Companies want to change but they don't want to do something that won't be of good years later. It's all about risk spreading and how to make money. To do more standardization we also need to share our findings.

Would a successful implementation of the standardized refinery modification design influence your work positively/negatively and in what way?

I think it's positive in multiple ways, if we talk about work in a standardized format, we can multiply it multiple times. We can get projects done quick so we could get more of those projects. Another reason is we don't need as many people for it as we should usually. Positive effect is also more of sustainable aviation fuel, so we fly greener.

Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?

Technical - Site (specific) differences, Contractual obligations, Difference in units (metric and imperial), and Emission like Nitrogen here in the Netherlands
Political - IRA in America

Client – Delivery Lead for Site-Specific Scope

What is your name, expertise, current position, and affiliation with the research topic?

I've been working since 2004 for _____, my background is chemical engineering and I've been working in several roles within the refinery. I started out as optimization engineer and did that for a few years. Then, I had various positions that I acquired. I went later on to production and planning and became a refinery planner, but I didn't like it. After some projects, I worked under a very experienced process engineer and learned a lot about the engineering projects. Ultimately, I am now the delivery lead of this stage for the local engineering contractor (LEC) so site specific to the refinery in ____. This means all the stuff outside the common scope. The way it is set up, the LEC and the optimized engineering contractor (OEC) are the same (Worley).

Who would you consider as stakeolders when it comes to implementation of standardized refinery modification design from the perspective of:

Technical (Design or Operation)

- *Design: All (local) discipline (leads) especially the subject matter experts, engineering manager, process leads, HSE*
- *Operational: Oil movement responsible, process person for utilities, (senior) operators,*

Who are the stakeholders that you work closely with?
The engineering and process leads
What are your most important resources with regards to implementing a standardized refinery modification design (e.g., information, knowledge, technology, authority, money, position in network, etc.)?
This question is better asked to somebody working in the common scope, I'm focusing on the site-specific scope. But I can tell you what I think about this question. I believe that the design philosophies are important when it comes to common scope. It needs to be shared with the different sites and the different sites need all to be in agreement. The site, technical practices (STP) we have in the company that lead to the codes and standards that have been proposed for the project. These are couple of sources where information can be gathered.
Would you consider your task as something that only you can do?
No, everybody is expendable. But I do believe that my past working experience (technical knowledge of refinery and production planning) allow me to quickly identify bottlenecks and raise questions when needed and solve problems. In this stage people can easily add more scope and hence complexity, but you should protect yourself against that and be able to challenge assumptions.
What would you say is the current situation when it comes to implementing a standardized refinery modification design? Is there a specific reason that is the case?
It's difficult to judge for me what's in the market. But like what you said the refineries were like individual companies within a company and they were also by the higher management. So, you were compared with your colleagues from another refinery. The fundamental change is that you're not in a competition. It's just a high-level plan of the company in the best locations in the world. When you start developing this project you need to keep in mind that it's not a competition, don't try to be better or outsmart the other refinery.
Do you think that the current situation should be changed?
In this case because the plans are all the same and we want to build a certain amount of sustainable aviation fuel, knowing that you can't build one big plant and you have to divide it over your sites then it makes sense to identify the common scope elements. Because if you make x or y individual projects and you're going to encounter similar issues and you will solve them in different way, then that will cost a lot of energy and money. If you encounter an issue and solve it in x number of sites in one go, then that's more efficient.
Another important gain is that with a common scope, you can go out to one vendor for equipment according to the same standard instead of doing everything x times.
How can your proposed change in the situation be achieved?
Yes, so on a high level the approach chosen was the right one. Ideally, I think you would want to have one LEC and OEC contractor. At the moment we are dealing with different contractors and that is not always easy because they have different ideas and they're dealing with NDAs between the two different contractors. But you never live in an ideal world and not always the same contractors available. Even for the same contractor as Worley, even though they're under the same name they have other ways of working. I think because historically, like the refineries in our case they almost were (now I'm speculating) in competition with each other. Instead of having the same views, that in itself doesn't help the efficiency.
Would a successful implementation of the standardized refinery modification design influence your work positively/negatively and in what way?
I think it would be a remarkable accomplishment of the whole team. On paper it sounds easy to come up with common scope and a common design. But for the reason mentioned, take the codes and standards, you always have to deal with site specific technical practices that are different from one side to the other and therefore also philosophies.
Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?
Technical: Design should fit all locations, so the most conservative site is chosen to base the design on. To ensure that the chosen option is feasible at the site which is most stringent. Therefore, it will lead to over designing or too stringent for another site (considering the likes of ambient temperature, plot plan, cooling water, etc.)
Political: Incentive difference in countries impact the economic evaluation of the project. Even if the total investment cost is the same, you would still get difference in incentives. This means that one refinery will get a higher profit than the other due to the legislation, because the incentives are larger there compared to another country.

Worley – Program Director

What is your name, expertise, current position, and affiliation with the research topic?
My name is______, I am the project director. I have 30 years of experience working in an engineering company and another business. I am a mechanical engineer.
Who would you consider as stakeholders when it comes to implementation of standardized refinery modification design from the perspective of:
It's a complex project, the number of stakeholders is significant. You have Worley, the client, the sites. Each site has a technical team and it's important to align them. You also have engineering possible in each site. In Worley that's our group. From the client another important stakeholder is their engineering office in ____. From the

operation side, each site needs to be involved because they will operate the plant. For the political we develop all documents that the local administration will require for the permits. Each site has different regulations. So, the local laws are important.

Who are the stakeholders that you work closely with?

With the client's team and a person appointed by the client with regards to the standardization point of view.

What are your most important resources with regards to implementing a standardized refinery modification design (e.g., information, knowledge, technology, authority, money, position in network, etc.)?

My engineering team is my most important resource, so the people. Obviously also my engineering manager who is in charge of all these processes.

Would you consider your task as something that only you can do?

It's not my philosophy. I always try that all my team will be involved in all activities. So no, first I don't like to be the focal point, what happened if I will be sick or will move to another company, so no, definitely no.

What would you say is the current situation when it comes to implementing a standardized refinery modification design? Is there a specific reason that is the case?

This is an extraordinary opportunity to standardize. We are going to standardize X sites at the same time so as much as we can standardize, we will reduce cost, number of work hours, reduced price for equipment. The biggest challenge that we are facing at the moment is modularization - to create a modular design. Fabricate all the modules in one yard and move all these modules to the sites and facilitate construction.

The problem here is that each site has different conditions. We cannot define a unique model, for example in XXX there is a limited access, so we need to cope with all these circumstances. So, we are preparing a modularization procedure.

You cannot talk about standardization without modularization, and vice versa. Modularization will in theory give you more quality, safety, cost, avoid social problems (e.g., lack of resources in the sites).

How can your proposed change in the situation be achieved?

Modularization can be made more successful, if we standardize a lot, because they are linked. Next is to have available yards that can develop the project. Then, the client must see that the idea will reduce time (so schedule), cost, improve quality, safety

Would a successful implementation of the standardized refinery modification design influence your work positively/negatively and in what way?

If we can standardize and demonstrate to the client that we reduce the cost, schedule (it's the key to the success of this project, each month that it's delayed, then money will be lost) quality, safety, then we can have (more) work.

Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?

From the standardization point of view permit is not important. Technical wise, we need to do a study about the logistics. We are going to use modular design, so you need to check accessibility. I think this is the main difference with the existing facilities. Another important factor when you use a modularized design is you will require a smaller number of employees. So, staff people, you don't need to implement temporary facilities e.g., canteen, shops, toilets or you would require less space.

In addition to identifying the aspects, a guideline has also been developed. Please look at the guidelines included in this document and pay close attention to the ones that you have an affinity with. Are there important processes, procedures or requirements that are not listed in the said guideline that should be included, if so, can you name them?

See table 20

Sticking to the items in the guidelines that you have an affinity with or knowledge of who are the relevant stakeholders for its implementation? or requirements that are not listed in the said guideline that should be included, if so, can you name them?

For the aspect space, if it's brownfield work then the people from refinery need to give you space. On the other hand, for green field, the engineering disciplines (design team and safety) are more important. For new utilities it's the process engineers, for old utilities it's the site management.

Logistics/accessibility is for construction and site. Labour and staffing involve a lot, human resources, project manager, project leads, discipline leads, refinery teams, site teams. For site specificity the relevant stakeholders are safety and design, refinery people team. Finally for permitting the client is responsible for all items.

To successfully implement the guidelines, stakeholder alignment is seen as a crucial element. Which of the item(s) listed above is most challenging in terms of trying to align the relevant stakeholders?

The most challenging is site specificity in terms of getting people together to agree.

What would you normally do so these stakeholders can be aligned? And did it work?

It's easy, to involve all the stakeholders at the beginning of the project, and it always worked. We need to involve the site people/team when we start the project. They need to feel like this is a project, so you need collaboration. You need to involve (them) to commit when the project is going to start.

Do you have another idea as to how the stakeholders can be aligned in the item(s) you mentioned?

Create a path forward, so that everybody will be aligned with your principle. First that people must understand the project, so define the principles and everybody must be aligned with these principles. Create a team, good teamwork, motivate the team,

Worley – Lead Process Engineer

What is your name, expertise, current position, and affiliation with the research topic?

My name is ____, I'm the lead process engineer. My background is chemical engineering and I have been working in this industry for about 20 years. I don't have technical expertise in the current specific technology to be honest, but I do have in process engineering in general. In terms of affiliation with standardized projects, I have worked in licensed technology and there is a high degree of standardization in that. I have already seen that you can win a lot of time and the know-how of standardizing certain technologies, so I have a good basis to start from.

Who would you consider as stakeholders when it comes to implementation of standardized refinery modification design from the perspective of:

Typically, we see the refineries themselves (the owner of the ultimate equipment). In this case the owner is the client ____. The manager of those sites as well as they may have different opinions. Financially, I think typically the same refinery managers. Politically, regulators are not really that important. They set the boundary limits for the project which we have to work with. Usually, they don't have a direct stake in it. There are some interesting interfaces there. In one of our project sites, the client initiated together with a geopolitical stakeholder a project to process one of the waste streams, which will be win-win for both.

Who are the stakeholders that you work closely with?

I work closely with the client side, specifically the people who will be operating the plant.

What are your most important resources with regards to implementing a standardized refinery modification design (e.g., information, knowledge, technology, authority, money, position in network, etc.)?

I think that my most important resource is the information that we have. The technology information from the licenser or from the know how that we developed ourselves.

Would you consider your task as something that only you can do?

No, I think in Worley the whole principle is that if I get sick, the next say my colleague should be able to take it over. Doesn't always work like that, but that is the intention. We are trying to capture that in the way we design equipment in Worley quality systems.

What would you say is the current situation when it comes to implementing a standardized refinery modification design? Is there a specific reason that is the case?

I have not heard that we have replicated designs for ____. I think that's the first. This wasn't done before because typically the timing of the projects is not the same with the different sites in different locations. For example, there was a turn around in XXX and that's typically the window when you want to have new facilities to be brought online. They probably don't match the same sequences in other countries.

But now there is a common driver. I think the common driver is the legislation. We have to go towards these certain percentage of renewable feedstock in the output. So now every company is desperately working towards the same deadline and that is the common driver now.

Do you think that the current situation should be changed?

I think there is a lot to gain by building a best practice. By setting a standard by developing a basis that you can replicate from and when it is rolled out in other sites, then the client can win a lot more time and money.

The biggest challenge we face is the ambient condition, so the weather. It affects the normal cooling water supply temperature that you have. And in turn that drives the design of the cooler that we on a specific surface to cool a stream down. BY just changing one parameter, all the equipment changes. And we also have differences within the sites, internal electric power systems (different voltage levels and frequency).

So, these are going to be site specific, and the local standards will be driving them.

How can your proposed change in the situation be achieved?

What I would say is capturing the know how is already the first step. How to design a unit and how you have actually designed pieces of that unit. If you work with a company like Worley and you have already captured how you designed those pieces of equipment, the next time you design it, it would be ideal if you could open your predecessors' files. What's the basis, is there anything special, you should be able to read it in the files.

What is done now is that information is not deliverable We only end up giving the refinery an equipment/product that we bought plus its documentation, but you won't know why. This is not capture in the deliverables. It would be good for refineries to actually capture that.

Within Worley we do it as long as there is no confidentiality issue. But we have to be careful if it was done from different companies, then we cannot directly use it.

Would a successful implementation of the standardized refinery modification design influence your work positively/negatively and in what way?

I think so yes, the better job we do with standardization, the better potential of building another one in different location. If we can really capture what we have done: the design, know how, engineering and replicate it as fast as possible then it will save the client a lot of time. But also it will impact our Worley business, it will position as really good for more projects/work with the client and other companies.

Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?

I'm not sure if I can answer that that easily. For sure all the boundary conditions are important like ambient conditions (weather), earthquake resistance, difference between continent/country. This will change the design of a certain equipment and the size of the structure, etc.

Politically, what we see is that the difference in the situation does not help in standardization. Thinking about wastewater treatment, in a certain site cooperation with other companies is possible and economically favorable *due to the incentives. For another site it might not be the case and so contacting a wastewater treatment company is the option, which is less favorable.*

Client – Project Operations Engineer

What is your name, expertise, current position, and affiliation with the research topic?
My name is ____, I am a chemical engineer. I've been working in refinery design, operation, and management for the last for about 30 years now. I'm currently a project operations engineer working on a project of __ biofuels at __ different sites.
Who would you consider as stakeholders when it comes to implementation of standardized refinery modification design from the perspective of technical (Design or Operation)
Refinery managers, operations manager, site operations representatives
Who are the stakeholders that you work closely with?
Sites operations representatives, so those people involved from each site. Process design team of an engineering contractor like Worley.
Would you consider your task as something that only you can do?
I think no, it's not something that only I can do. I think it's a matter of being able to take an open mind to it and be able to accept that there may be differences and how do we work through it and how are we able to compromise and capture what's the best for the individual sites.
What would you say is the current situation when it comes to implementing a standardized refinery modification design? Is there a specific reason that is the case?
Our refineries are different heritage of the original owners and the original design philosophies for those were all different. It took several years but now there is a ____ philosophy. Still a lot of those sites adhere to the original philosophy. The sites still work individually towards a lot of those individual philosophies. From an operations perspective, the sites fulfill the requirements of the company's standard, but they may have a slightly different interpretation of the standard. So we're dealing with __ different interpretations and we have to make sure to standardize this and meet the original intent
Do you think that the current situation should be changed?
In a perfect world every site would do it, every site would be exactly the same and implement all of the policies and procedures exactly the same. But there are slight differences in those implementations that come up as part of our work for standardizing our standard design.
How can your proposed change in the situation be achieved?
It would have to come from the top – down. Everybody is going to have to do it this way and this is how it's going to be done. There's not going to be an individual or a site customization to how these polices are implemented. The sites have been given the freedom to interpret it their own way and they've done that.
Would a successful implementation of the standardized refinery modification design influence your work positively/negatively and in what way?
I think it can be very positive, by doing a standard design, I think we're able to compromise and come to a design that that is acceptable to all the sites, but I think there's a lot of things that in the development of that design will be needed in the next stages – training simulator and operating procedures that can be developed as well with a standard process. So instead of doing each site, developing it five times, we can develop it once and get the 80/90% case and then provide it to each of the sites to slightly customize it to their liking.
Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?
Political – operating and environmental regulations. You have to adapt to the worst case, the strictest policies.
The local rules and regulation.
Technical- feed properties/composition, safety

Client – Requirements and Standardization Manager

What is your name, expertise, current position, and affiliation with the research topic?
_________.
20 Years engineering and project management in major and moderate projects.
Currently requirements and standardisation manager for a programme of projects so how we leverage standardization for value, how we apply our design, how we design our standardized processes.
Previously held roles of engineering manager, project manager, interface manager, central engineering requirements specification lead.
Worked with IOGP in developing standardised procurement specifications (JIP33) and outlining standardised rules for digital engineering requirements.
Who would you consider as stakeholders when it comes to implementation of standardized refinery modification design from the perspective of:
a. Technical (Design or Operation)
- *Design*
  - *Company central engineering*
  - *Site engineering*
  - *Equipment suppliers/manufactures/designers*
  - *EPCs*

- *Construction*
- *Commissioning*
- *Operations*
- *Local authorities/governance/local and national regulations*
- *Logistics*
- *Procurement*
- *HSSE*

- *Operation*
  - *Logistics & supply chain*
  - *Site operations*
  - *Local community*
  - *HSSE*

b. Political

- *Local governments – incentives, grants, regulations, policy setting*
- *Operator companies*

Who are the stakeholders that you work closely with?
Company central engineering, Site engineering, Equipment suppliers/manufactures/designers, EPCs, Standards Development Organizations (SDOs), Technology license holders, Construction, Commissioning, Operations

What are your most important resources with regards to implementing a standardized refinery modification design (e.g., information, knowledge, technology, authority, money, position in network, etc.)?
Two things

- *Standardizing the workflow and process -> how are we gonna do something?*
- *Information needs within that (workflow/processes)*

Understanding the information that needs to be managed by the standardized processes, the stakeholder inputs, looking at where you got similarities, where to aggregate, challenging the need of some of them, knowing what information everybody's gonna need at each stage are principles that need to be understand.
Would you consider your task as something that only you can do?
No, but there are fundamental principles you need to understand
What would you say is the current situation when it comes to implementing a standardized refinery modification design? Is there a specific reason that is the case?
Standardize design exists but not consistently in a global sense. There is a large degree of local standardization but not necessarily international standardization. For many refineries, they have been specifically set up as individual entities accountable for their own application of codes and standards and have differing regional requirements and regulations to comply with.
In upstream organization we have a major project common process, so if you're doing a project, there's a mandatory framework of requirements that sits over that, not around the technical detail, but how you set up the program, who's accountable for what, how it's delivered, outlines which individual subset processes need to be followed, how they could be set up, who needs to be involved when you do what. So that standardization for delivery is there.
Downstream, by the refineries, they don't have the same project delivery organization. You will find standardization within individual locations (e.g., ways of working systems).
Do you think that the current situation should be changed?
Yes,
There are two sides to it:

- *Technical design*
  - *Custom and practice as how things have been done historically, so people have over time come to do a particular way of doing something different (per site). There are also regional and regulatory requirement differences. Internationally there are also different standards (ISO, API)*
  - *There are things where you cannot standardize (e.g., electrical frequency)*
- *Standardizing process of delivery*
  - *Doable at high level but going into detail is hard.*

How can your proposed change in the situation be achieved?

- *Improved standardisation at the international codes and standards level with SDOs. Improved standardisation in harmonising regional requirements (primarily driven by the harmonisation of the SDOs)*
- *Understanding data need – people want to standardize tools, but it doesn't matter if you use a different tool as long as you know how to take the relevant information and use it the same way.*
- *Decision making- understand tradeoffs. Are you making the decision on the lightest, cheapest, best, etc. Who is the decision maker?*
- *Agreement on sequencing – how you're gonna deliver and who has accountability.*

Would a successful implementation of the standardized refinery modification design influence your work positively/negatively and in what way?
Only positive if it's done for value or reduce risk, not standardizing for the sake of standardization. → Reduced engineering effort, leveraging supply chain economies of scale, simplifying verification and inspection, efficiency, familiarity with standardises tools, systems, and processes.
Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?
Understand scope boundaries if you are building a completely standalone unit or integrated to existing. Because it would lead to different approach.

- *Integration with existing site systems (utility, power) receiving from it is simple but if you need to modify then it will be complicated.*
- *Unintended consequences of moving away from site existing standard - operator knowledge, human factors, contracting, spares, etc.*
    - *Say you want to use a specific new motor, then you need a new maintenance contract, new spares, servicing, train technicians, etc.*
- *Regulatory permitting – wildlife, noise, air quality, etc.*

In addition to identifying the aspects, a guideline has also been developed. Please look at the guidelines included in this document and pay close attention to the ones that you have an affinity with. Are there important processes, procedures or requirements that are not listed in the said guideline that should be included, if so, can you name them?
See table 20
Sticking to the items in the guidelines that you have an affinity with or knowledge of who are the relevant stakeholders for its implementation? or requirements that are not listed in the said guideline that should be included, if so, can you name them?

- *For space the input needs to come from operation and the maintenance crews. Also, suppliers and vendors, but this is becoming les of an issue now. The people that will be doing it (the design) are the engineering.*
- *The project engineering team from a design standpoint will be setting the project needs for the process. That also ties into suppliers because you've got interfaces with them to get the information of what they need (maximums, minimum, flow rates, pressures, etc.). For the site, it will be people that are accountable for the existing systems and the team. You also need people who are accountable and have oversight for concurrent engineering in the site.*
- *Under logistics and accessibility, the relevant stakeholders are the procurement and logistics team. Project team (engineers, community liaison with authorities) and the site*
- *Then, for labor and staffing these people will be the teams managing individuals on site (but this is primarily for construction) so construction team, commissioning team, labor resourcing (like HR)*
- *Stakeholder wise, site specificity goes across everything. A large aspect comes to engineering, but tying with site team is important.*
- *For permitting, engineering will give the inputs, but then it will go through the environmental and corporate responsibility type teams that altogether have relationship with local authorities for obtaining permits.*

To successfully implement the guidelines, stakeholder alignment is seen as a crucial element. Which of the item(s) listed above is most challenging in terms of trying to align the relevant stakeholders?
I think if you're trying to implement some standardized guidelines. The hardest thing I think is actually the change of the existing tools, processes, procedures, code standards and requirements. So it's the moving away from what people are currently doing or always done is probably the hardest thing and explaining why I'm moving on -> site specificity and labour/staffing

What would you normally do so these stakeholders can be aligned? And did it work?
Early engagement and the opportunity to modify plans slightly based on the feedback that you've had. You need to communicate the why of what we're trying to do, not just the what, so people can understand. Why that change is wanting to be made and how it will make a difference to their area? Communicate why the change adds value or enables value in the future.

Do you have another idea as to how the stakeholders can be aligned in the item(s) you mentioned?
Understand the current situation (local systems, local requirements, etc.), and the reasons behind it.

Client – Refinery Shift Team Leader Oil Movement

What is your name, expertise, current position, and affiliation with the research topic?
So my name is ______, I started as a junior operator and climbed may way as a shift team leader from oil team movement. We make sure that the crude is good enough to put in the unit. I've been working in the production and planning for a year. I've also done two turnarounds.

Who are the stakeholders that you work closely with?
Colleagues in oil team movement, Delivery Lead Site-Specific Scope, Project Manager from the site,
What are your most important resources with regards to implementing a standardized refinery modification design (e.g., information, knowledge, technology, authority, money, position in network, etc.)?
The knowledge about the materials in site, how the refineries work, what we do in several assets, the information that operators need to learn (from books). I think we need to spend more time at the content part so we can find all information and also for maintenance. Then we can capture all the requirements and easier to search if you have questions.
Would you consider your task as something that only you can do?
No, because I've been working for ___ for 20 years now, and we have a complete development plan. Basically you do several tasks to get to a different level, we grow as a person but also in our current roles. So if they ask a different team leader from oil movement, he/she maybe have the same/more/less knowledge as me. If you are not replaceable then you haven't done a good job. Every role needs to be replaceable by someone beneath them.
What would you say is the current situation when it comes to implementing a standardized refinery modification design? Is there a specific reason that is the case?
I think this is the first standardized project we are doing in our refinery. We are not good at standardizing to be honest. The difficulty is that every refinery is different, the layout. We want to be the same as the standardized design, but every refinery has its own layout structure, that makes it difficult to implement a standardized project. I am not saying it's impossible but it's challenging.
Do you think that the current situation should be changed?
Yes, because if it works it makes life easier and we would reinvent/change completely as a company. We have a standardized design that we want to have on all refineries. The difficulty is that the people who work for the companies, but also the land specific regulations. I like the idea of having a complete project which is thought about by many people and then implemented on different sites. But I always thing that you need a little bit site specific changes to implement a project.
How can your proposed change in the situation be achieved?
When we want to do a project, the problem is we always want to have an influence on what needs to be changed in the project, because we think it can be done better. But I am a person who wants to stick to the plan, because it is well thought and interfering with it will cause delays and even more difficulties. Have a confidence that it will work. The problem is that we want to micromanage, say change the design and if it didn't work then we regret it.
Would a successful implementation of the standardized refinery modification design influence your work positively/negatively and in what way?
Very positive, if you look at what we ware doing, we are doing an enormous project. We've never done such. If this is to be successful, then we are able to contribute to the net zero project of the company. Second, it creates a good future for us (secure, cause we will have a competitive advantage in the refinery market).
Looking at implementation of a standardized refinery design, what aspects of an existent refinery must be considered when replacing it with a new design, considering technical and political differences?
Technically – it needs to be in the vision and philosophy of the company, in the next X years.

- *Licenses*
- *Environmental*

Politically – it needs to fit the agenda of the country.

8.5. Supplementary figures

This subchapter of the appendix presents all supplementary figures.

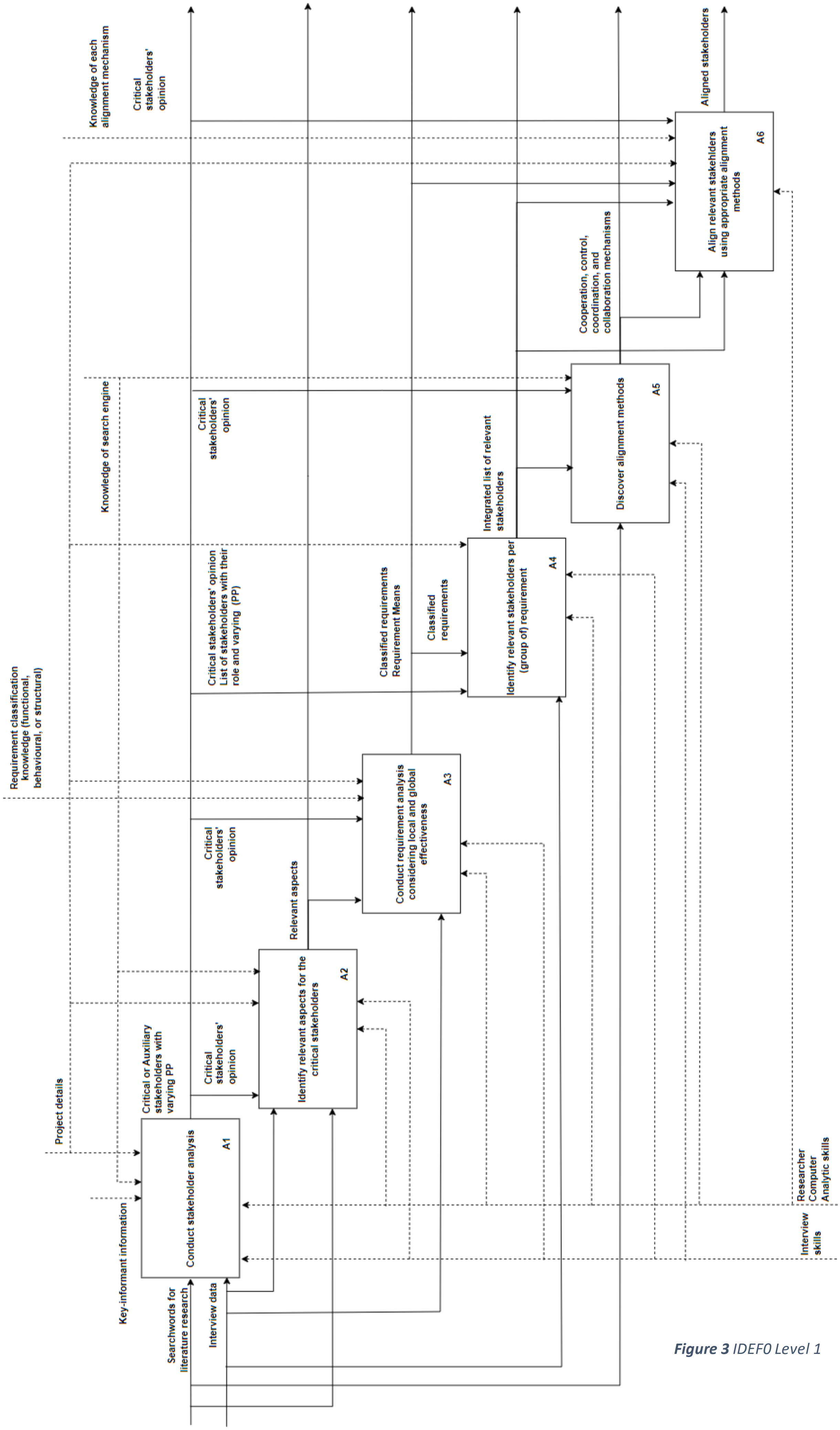

Figure 3 *IDEF0 Level 1*

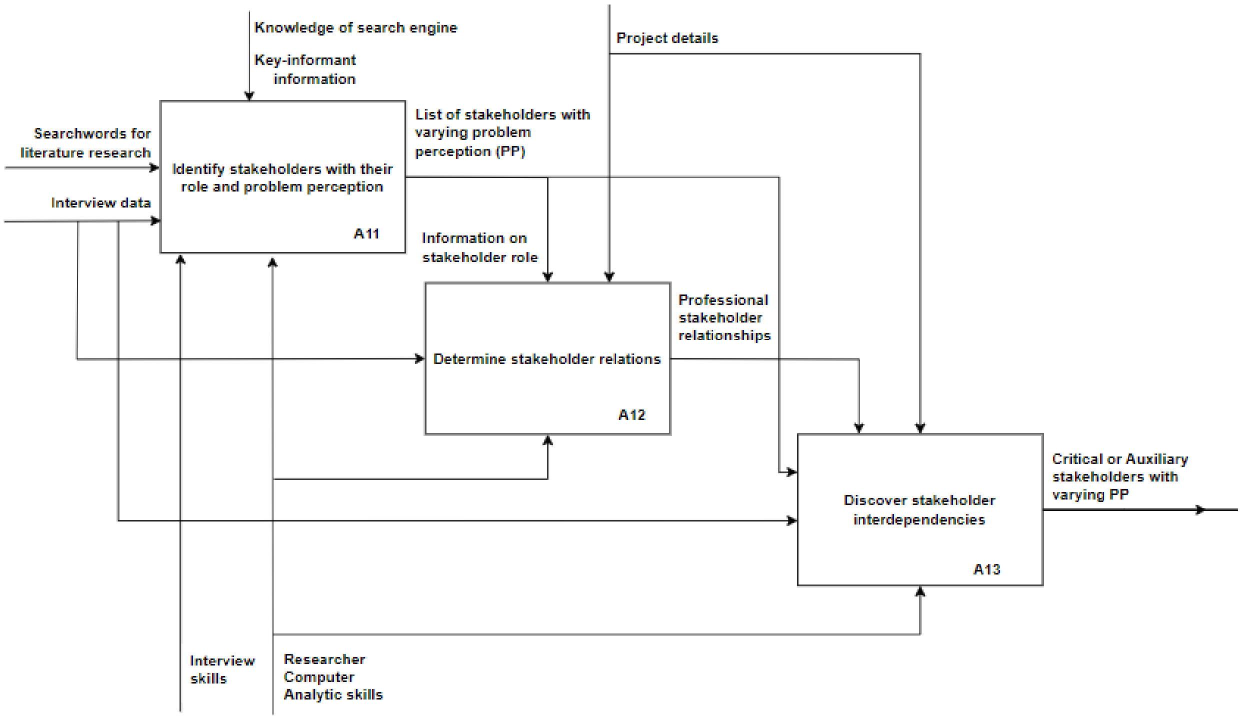

Figure 13 *IDEF0 A1 Level 2*

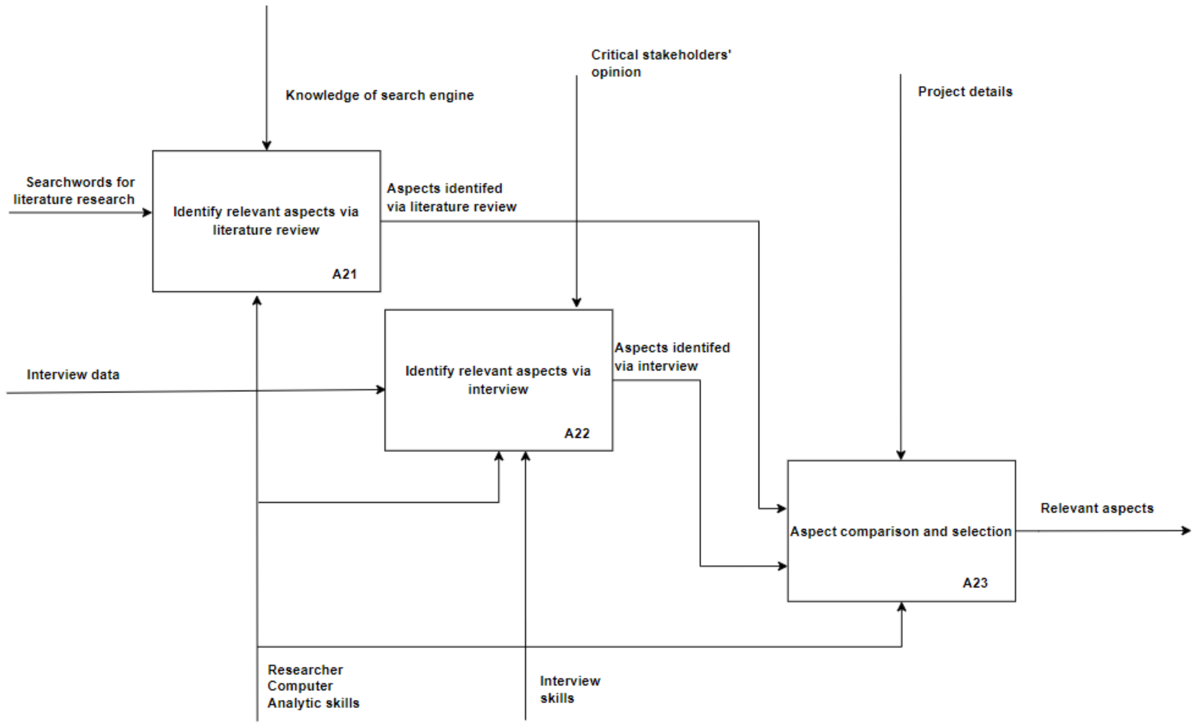

Figure 14 *IDEF0 A2 Level 2*

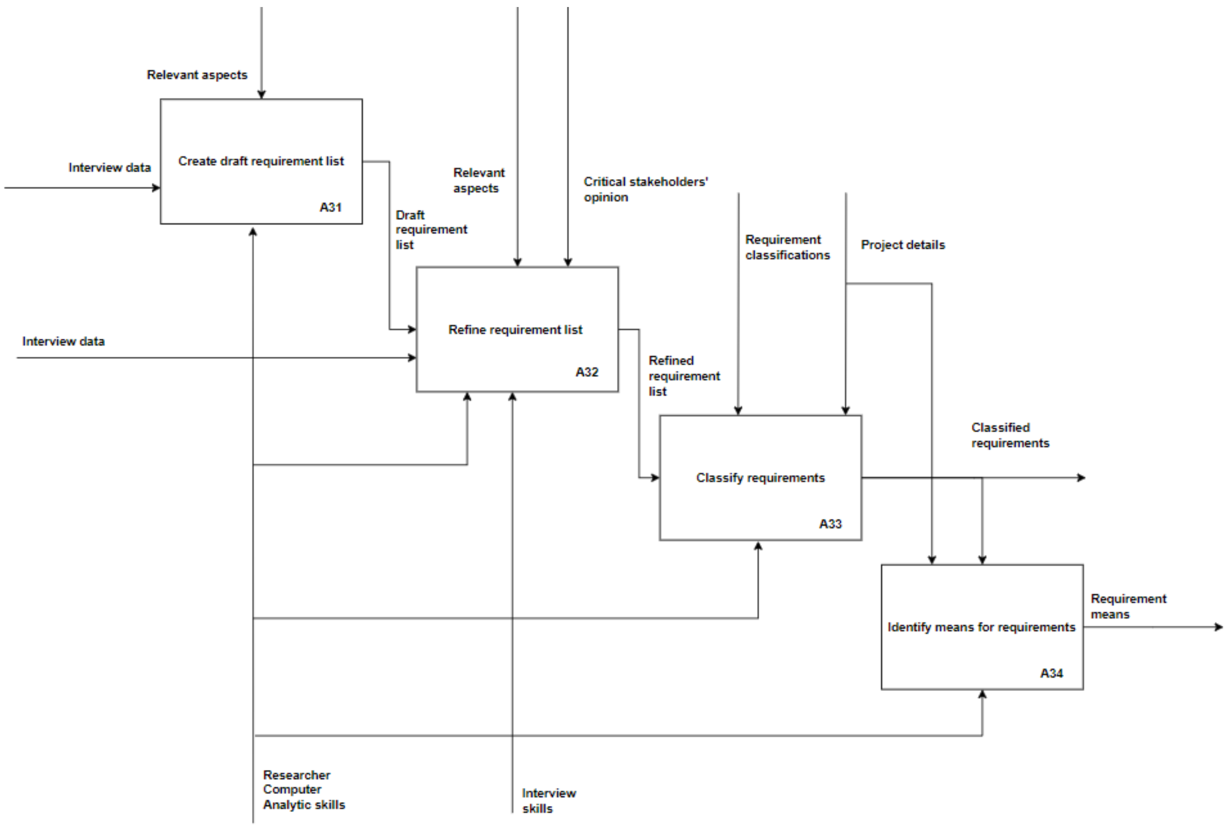

Figure 15 *IDEF0 A3 Level 2*

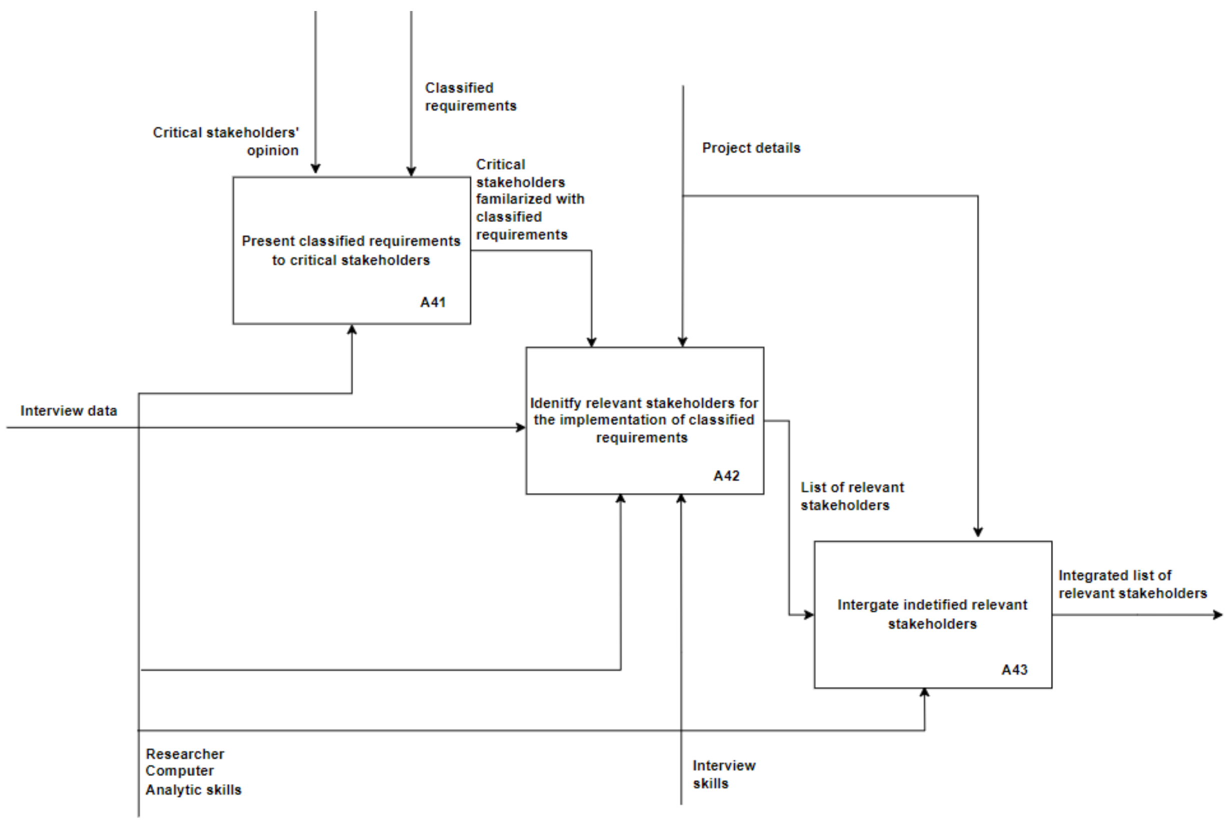

Figure 16 *IDEF0 A4 Level 2*

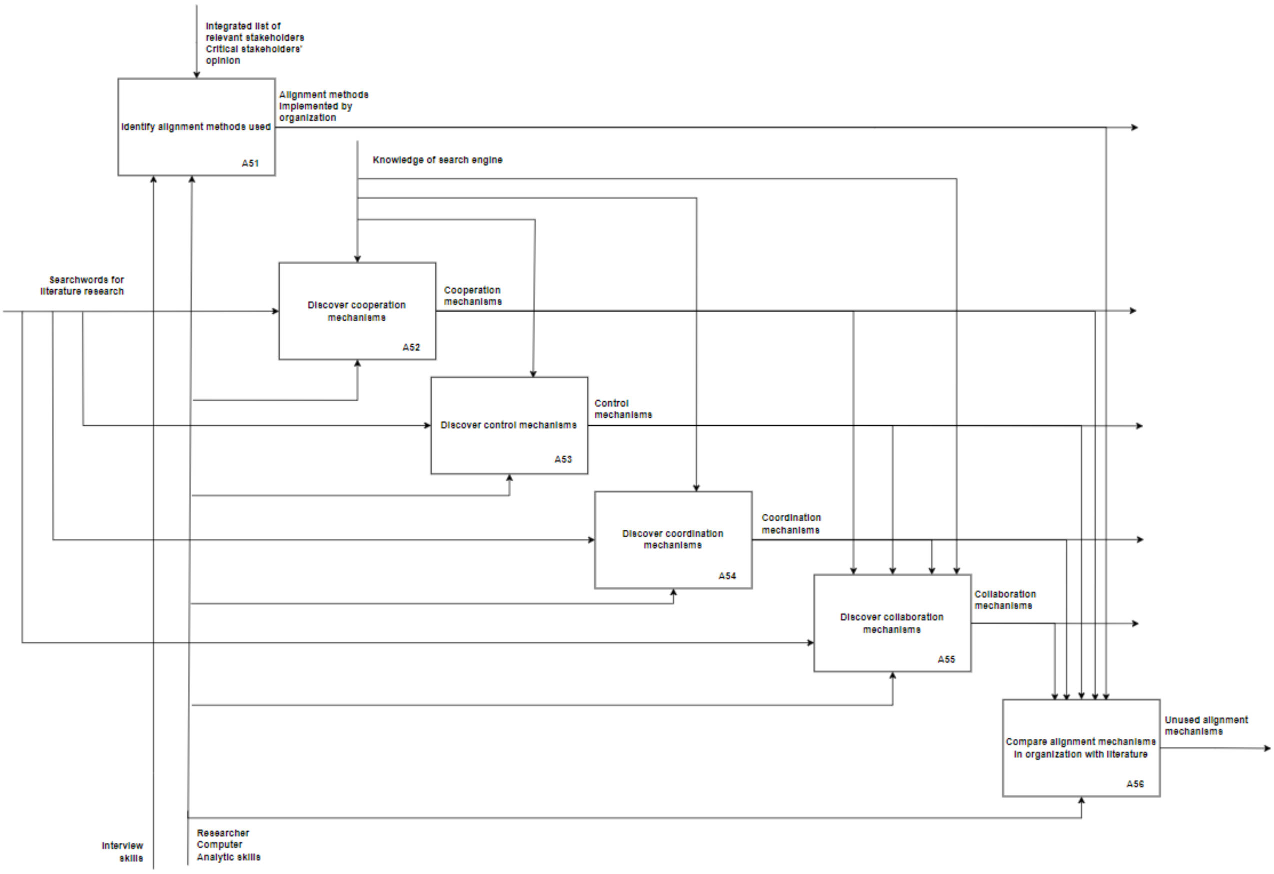

Figure 17 *IDEF0 A5 Level 2*

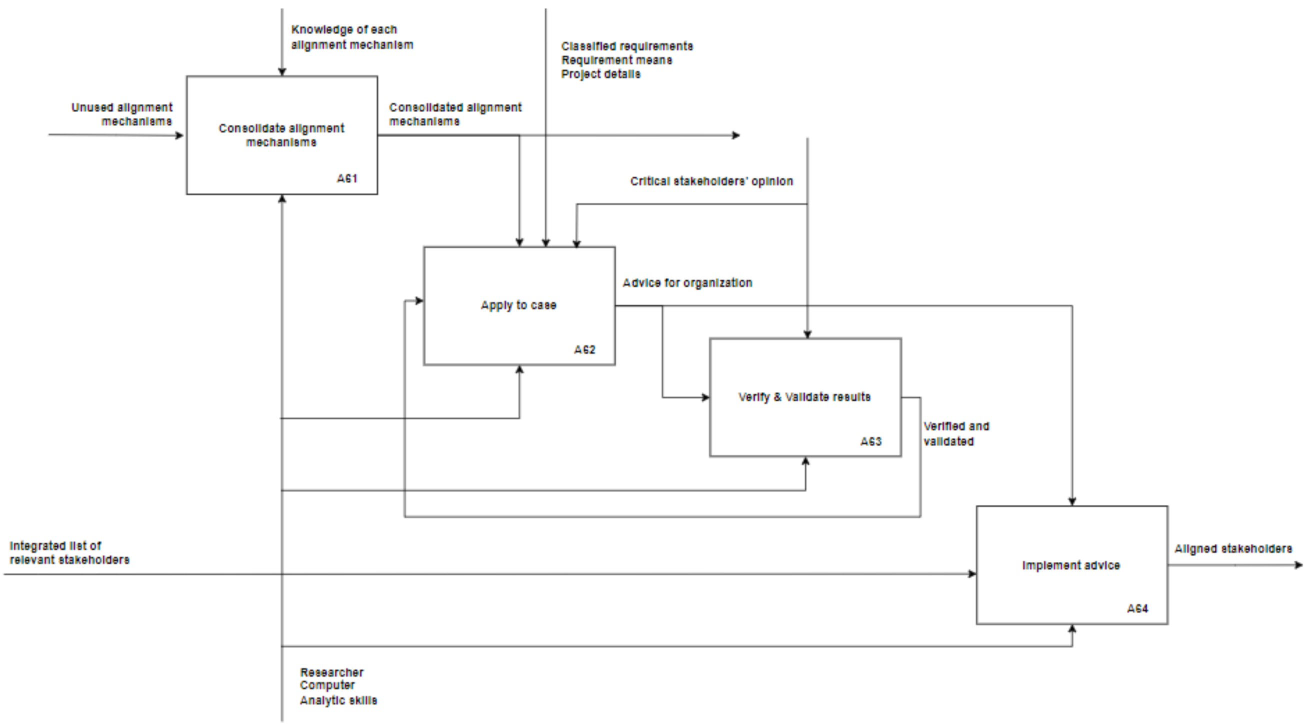

Figure 18 *IDEF0 A6 Level 2*

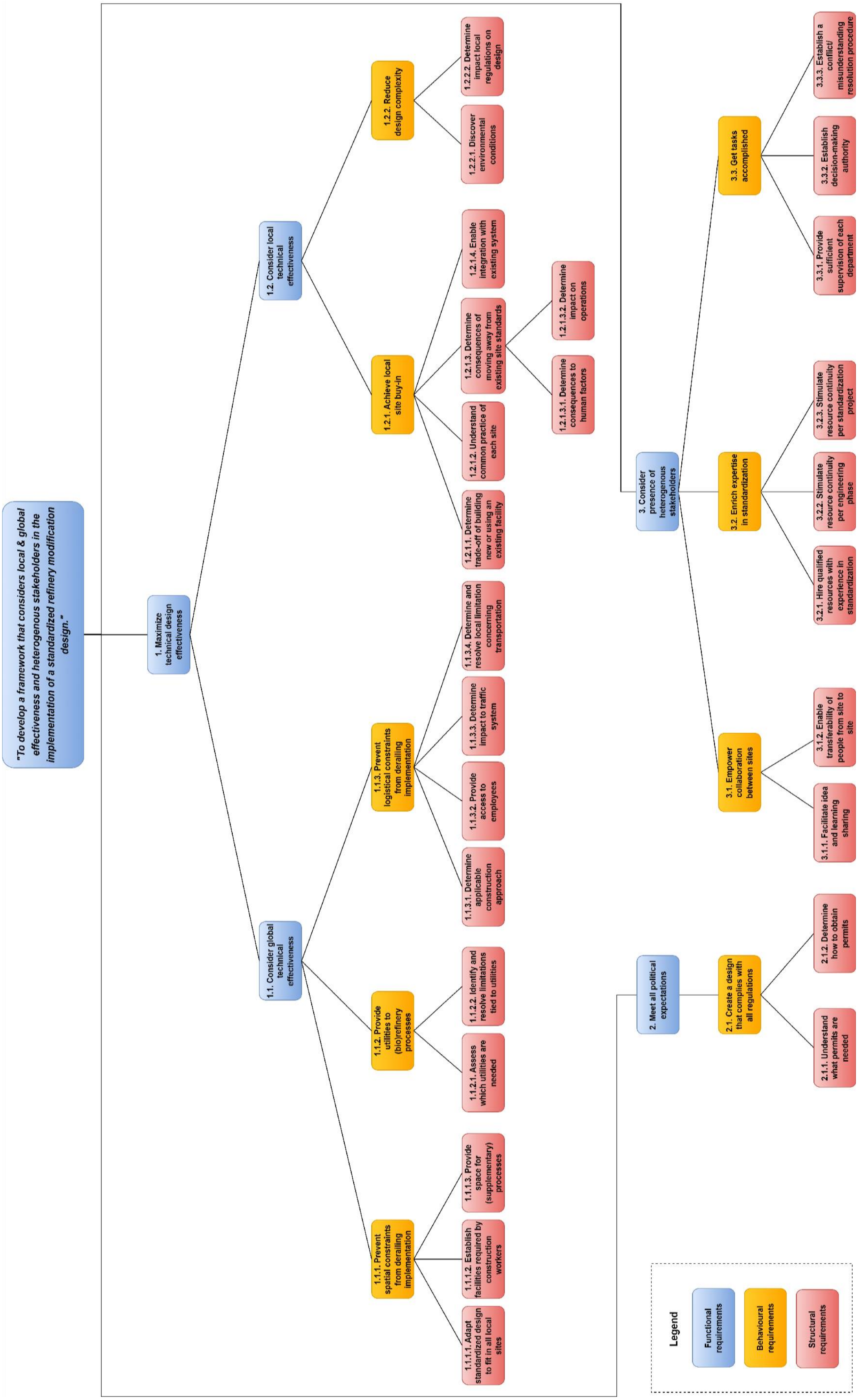

Figure 12 *Requirements tree Worley*