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A study on Long-Range Business Plan for Turnaround Maintenance Projects.

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Abstract

Turnaround maintenance (TAM) is a periodic shutdown of a plant or facility to perform necessary repairs, overhauls, and inspections. TAM is essential for ensuring the safety, reliability, and efficiency of industrial operations, but it also involves high costs, risks, and uncertainties. Therefore, planning and managing TAM effectively is a critical challenge for plant managers and engineers. This study proposes a long-range business plan (LRBP) for TAM that integrates strategic, tactical, and operational decisions in a holistic framework. The LRBP aims to optimize the trade-off between the benefits and costs of TAM over a long-term horizon, considering various factors such as market demand, production capacity, equipment condition, maintenance resources, and risk mitigation. The study develops a mixed-integer linear programming (MILP) model to formulate the LRBP problem and applies it to a case study of a petrochemical plant. The results show that the LRBP can provide significant savings in TAM costs and improve the performance indicators of the plant. The study also conducts a sensitivity analysis to examine the effects of different parameters and scenarios on the optimal LRBP. The study contributes to the literature on TAM planning by proposing a comprehensive and practical approach that can support decision-makers in the complex and dynamic environment of industrial plants.

Key Words: Turnaround Management; Long-Range Business plan; Turnaround; Constraints Modelling.

1. INTRODUCTION

Turnaround (TAR) maintenance is one of the enormous cost maintenance management strategies in Oil and Gas industries to advance the availability and reliability of critical equipment. It is vital for an organization to perform TAR projects to support the asset integrity, reliability and safety of production facilities while curtailing interruption and amplifying productivity. Since cost involvement is exceedingly high, the Turnaround project must be a part of the overall company business plan, to ensure that it reflects the current needs of the constantly changing business environment. The present-day business environment, where raw material costs, product prices, demand can change rapidly and pandemic, makes it inevitable, affects corporate plans. Turnaround long range business plan shall be flexible to respond to these changes.

Continuous Planning is a stage of the TAR business process that happens all the time. The main output is a long-term TAR business plan for 5 years (updated every year) that is made after careful and complete alignment with all stakeholders. Each process plant depends on upstream and downstream stakeholders, so TAR in any facility is not an isolated event. Also, a 2-year fixed TAR plan is derived from the above flexible 5-year plan to help TAR teams get ready for action. So, starting actions for TAR Planning are also done in Continuous Planning stage. There are two important business outcomes in the long-range business plan. First, (Oliver, 2001) A five-year rolling turnaround schedule and Second, Expected turnaround budget for the next five years. During business plan, organization should look at and review the data and activities such as, Marketing strategy, Plant, or unit performance data (both current and expected), Inventory capacities, required inspection compliance, Benchmarking results and findings, Market conditions, downstream and upstream coordination, Capital or investment planning, equipment mechanical performance, Regulatory and legal requirements.

Many best practices from different industries are established and used widely in construction industries. These best practices cover project risk assessment, quality management, and front-end planning developed by the Construction Industry Institute, 2014 (CII, 2014). Some researchers have also developed improvement plans for TAR maintenance project, such as (Nikmatul et al., 2023) Improvement of Turnaround Maintenance Project Execution Through Long-Term Specific Contracting Strategy, (Raoufi et al., 2014) Process Improvement for Power Plant Turnaround Planning and Management. However, there is a lack of industry best practices that focus on the long-term business plan phase in turnaround maintenance project, even though many relevant best practices exist for other phases of Turnaround projects in published research literature. Experts want to use best practices to enhance their organization's performance of turnaround projects. This paper provides a review of such best practices.

This article has two sections. The first section reviews previous studies that relate to constraints and their corresponding best practices for the business plan phase of Turnaround Maintenance projects. The literature review gives a collection of TAR business plans related to best practices from various companies involved in turnaround projects. The literature review also provides recommendations for the TAR management team. The second section of this paper presents a collection of best practices obtained from the industrial experts, managers, engineers, and contractors, who participate in TAR projects planning and management. The problem here is that the constraints described here are an essential part of TAR projects Business plan. However, the list of constraints is not complete here. Every year the TAR project will face new constraints during the business plan stage based on business conditions. To deal with the challenge of new constraints in the business plan phase of TAR project, the project management team needs to be careful to identify, manage and monitor those new risks with the help of existing or newly learned from industrial practices. The suggested industrial best practices will assist the companies involved in turnaround projects to solve their constraints in the business plan phase of TAR project.

2. CONSTRAINS AND BEST PRACTICES IN LONG-RANGE BUSINESS PLAN (Literature Reviews).

This section summarizes and documents previous research on the challenges and best practices in business planning for TAR projects. Long range business planning is the process of creating a strategic plan for all turnarounds in a business unit or company. Strategic planning involves the creation of both a long-term schedule, usually 5 years, and a budget for all turnarounds in the business unit/company. Industries that have developed TAR management processes based on plant turnaround management philosophy and long-term strategy to achieve a higher level of budget and schedule accuracy (McLay, 2012). End to End Turnaround project is composed of various stages. Each stage of the project manages different data, deliverables, timing, and milestones. (Oliver, 2002) Turnaround stages include the business plan, conceptual development, work development, detailed planning, pre-turnaround work, turnaround execution, and post-turnaround stages.

2.1 Deliverables

Business plans are the first stage of any Turnaround/Shutdown projects which have many deliverables as per industry standards. Such as, long term plan (Cost and Schedule), Premises and Strategy formation, Key performance measures are agreed, and project risk registers are captured. (Oliver, 2002) Declaring that purpose of business plan is to show the long-range schedule and budgets for turnarounds and to integrate them into the overall corporate plan. Confirming the deliverables which are Forecast turnaround budget and A five-year rolling turnaround schedule. (Hariyanto et al., 2020) Considers long range schedule plan is one of major deliverables in business plan phase of TAR project. (Hey, 2019) Also listing the results same as above mentioned other authors such as, forecasted budget and Schedule.

Box 2.6: Five-year look-ahead example

5 year refinery turnaround schedule		2018-2023	
	Major Turnarounds	*Cat Changes*	*Comments*
No 1 CDU	Feb-22		4 year interval for refinery area 1
No 1VDU	Feb-22		4 year interval for refinery area 1
No 1 FCCU	Feb-22		4 year interval for refinery area 1
No 2 CDU	Feb-20		4 year interval for refinery area 2
No 2 VDU	Feb-20		4 year interval for refinery area 2
No 2 FCCU	Feb-20		4 year interval for refinery area 2
Visbreaker	Feb-20		Furnace tube cleaning every 2 years depending on severity
Kero Hydrotreater	Feb-22	Feb 18/Feb 20/ Feb 22	KHT cat changes every 2 years
Diesel Hydrotreater	Feb-22	Feb 18/Feb 20/ Feb 22	DHT cat changes every 2 years
Naphtha Hydrotreater	Feb-22	Feb 18/Feb 21/ Feb 24	NHT cat changes every 3 years
Platformer (CCR)	Feb-22	Feb 18/	Cat changes - as required
ISOM Plant	Feb-22		4 year interval for complete refinery turnaround
LPG Merox Unit	Feb-22		4 year interval for complete refinery turnaround
Cat Poly Plant	Feb-22		4 year interval for complete refinery turnaround
Amine DEA	Feb-22		4 year interval for complete refinery turnaround
Amine MEA	Feb-20		4 year interval for complete refinery turnaround
No1 Sulphur Recovery Unit	Feb-22		4 year interval for complete refinery turnaround
No 2 Sulphur Recovery Unit	Feb-20		4 year interval for complete refinery turnaround
Tankage area 1	Feb-22		4 year interval for refinery area 1
Tankage area 2	Feb-20		4 year interval for refinery area 2
Flare Facilities 1	Feb-22		4 year interval for refinery area 1
Flare Facilities 2	Feb-20		4 year interval for refinery area 2
Steam Power Plant and Utilities 1	Feb-22		4 year interval for refinery area 1
Steam Power Plant and Utilities 2	Feb-20		4 year interval for refinery area 2
Cooling Water System 1	Feb-22		4 year interval for refinery area 1
Cooling Water System 2	Feb-20		4 year interval for refinery area 2

Figure 1: Five-year Look Ahead Sample from Literature (Hey, 2019)

Box 2.7: Two-year look-ahead example

2 year refinery turnaround schedule	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
	2019												2020												2021	
No 1 CDU																										
No 1VDU																										
No 1 FCCU																										
No 2 CDU														XX	28 days											
No 2 VDU														XX	28 days (benchmark target)											
No 2 FCCU														XXX	42 days (benchmark target)											
Visbreaker												X	7 days													
Kero Hydrotreater														X	27 days (benchmark target)											
Diesel Hydrotreater														X	30 days (benchmark target)											
Naphtha Hydrotreater																								31 days		X
Platformer																										
ISOM Plant																										
LPG Merox Unit																										
Cat Poly Plant																										
Amine DEA																										
Amine MEA														X	35 days											
No1 Sulphur Recovery Unit																										
No 2 Sulphur Recovery Unit														X	35 days (benchmark target)											
Tankage area 1																										
Tankage area 2														X	21 days											
Flare Facilities 1																										
Flare Facilities 2														X	14 days											
Steam Power Plant and Utilities 1																										
Steam Power Plant and Utilities 2														X	21 days											
Cooling Water System 1																										
Cooling Water System 2														X	21 days											

Figure 2: Two-year Look Ahead Sample from Literature (Hey, 2019).

2.2 Constraints and Best practices

From section 3.1 it is clinched that there are two main outcomes of long-range business plans of TAR project. However, to achieve these goals, organizations face various issues, or many factors influence the decisions. TAR project team is responsible for understanding and controlling these influences to achieve goals. This section focuses on some of earlier studies found influences and their solutions.

The main challenges of the business plan stage of Turnaround/Shutdown maintenance projects are displayed in Figure 3 below.

Figure 3 List of Constraints

Based on literature reviews, the feasible solutions for Turnaround/Shutdown maintenance project business plan stage constraints are shown in Figure 6 below.

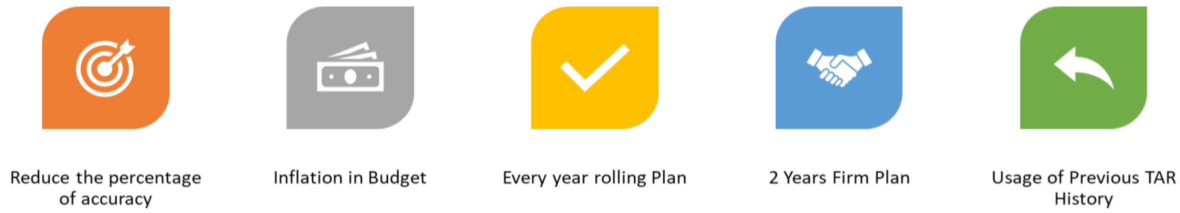

Figure 4 List of Possible Solutions

I. Changes in Business Environment

Business environment is the factors which are affecting the business operations and Decisions. Factors can be further divided into two categories. One is External, which are coming from external sources such as government rules and regulations. Another is Internal, coming from internal organization sources such as changes in procedures and policies. Since business plan occurs five years before the Turnaround start date, there is a high chance that these factors will impact the decision made on the business plan. (Oliver, 2002) Declaring that forecasted budget and schedule inevitable from the change due to present day business environment, where raw material costs, product prices and demand can change rapidly. (Hey, 2019) Suggesting considering the factors such as market conditions, Operating plant performance in the decision-making process of business plan. (Al-Marri et al., 2020) Identified external factors are Economic condition of organization affects overall performance of the Turnaround projects.

To overcome the business environmental issues in business plan industries should consider more contingency in their budget and schedule. (Oliver, 2002) suggesting that forecasted budget and schedule should be more flexible to oversee this constraint. Extending their suggestion to use process assets such as manuals, and procedures of maintenance and inspection. (Lawrence, 2012) In a survey of conference participants at the Turnaround Industry Networking Conference (TINC) — Europe, held in March 2011 in Amsterdam, The Netherlands,2 83% of respondents said that their turnaround control budget was intended to be a ±10% estimate (see Figure 4). 3 The remaining 17% said that their estimate was supposed to include sufficient contingency/reserve that it was a “not to exceed” number. (Lawrence, 2012) Concluded that business plan stage results in a ±50% accuracy estimate, the following conceptual design stage results in a ±30% estimate, and the final basic design stage results in a ±10% estimate.

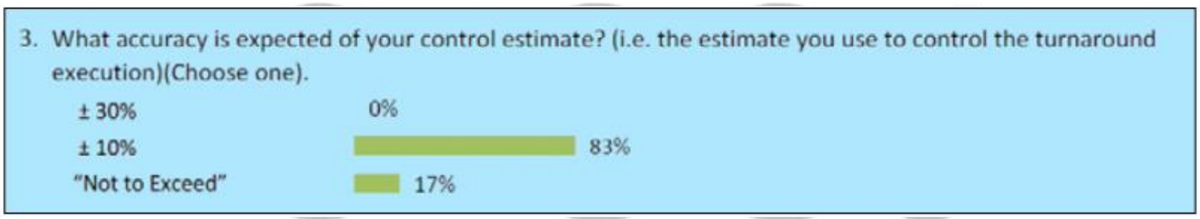

Figure 5 Expectation of Accuracy from Literature (Lawrence, 2012).

II. Unconfirmed Scope of works

The work scope for the turnaround is crucial for achieving satisfactory results, since it affects the cost, schedule, and reliability of the plant. The main way to be competitive is to keep the scope and its growth as low as possible during the turnaround execution window. However, business plan decision must made (Hariyanto et al., 2020) 5 years before the Turnaround execution starts, where project team will not be aware of any scope. Unconfirmed scope is another major factor which will affect budget and schedule in the following way. If scopes are considered less, budget and Schedule should be lower. Later stage increased scope will require more money and Time to complete such a scope of work. Vice versa, If any reason, more scopes considered, will end up with increased forecasted budget and duration. This scenario increases the challenges in management approval for forecasted budget and duration. (Al-Marri et al., 2020) acknowledging that scope of works is one of the technical factors affecting overall Turnaround project performance. (Lawrence, 2012) Concluding that There are no guidelines on how to calculate uncertainty allowances for emerging work, discovery work and contingency.

(Hariyanto et al., 2020) Suggesting, using earlier TAR scope of works to estimate cost and Time duration for the turnaround with accuracy of 70%. (Jackson, 2022) A Long-Range Plan (LRP) budget has been established based on the 80% (repeatable) scope basis. (Hey ,2017) suggested using Risk-based inspection to increase the accuracy of scope at business plan stage. (Lawrence, 2012) Suggesting capturing actual data from previous Turnaround projects to estimate cost of the turnaround projects. Various literatures are confirming that Turnaround project should consider previous TAR scopes including, major equipment list based on risk-based inspection, periodic preventive maintenance, and long lead materials which are required to perform the maintenance activities, for their initial estimation and schedule confirmation.

III. Plant Operational Performance

After the Business plan decision concluded on budget and schedule, production must be in operation to meet their goals. Which is increased production. This needs equipment to run continuously, which will result in higher wear and tear of equipment parts. Which forces us to increase maintenance activities. (Hey ,2017) Confirmed that operational process factors which are deciding next Turnaround schedule such as, fouling, corrosion, and coking. Operational performance issues will result in increasing the scope of work and lead to budget and Schedule overrun. (Lawrence, 2012) In turnaround/shutdown maintenance projects, the “known unknowns” are Additional work due equipment failure between the completion of the estimate and the start of the turnaround and Discovery work that is discovered during the turnaround execution, once equipment is opened for detailed inspection. Both are occurring due to plant operational performance which is affecting decisions made during the business plan stage.

(Hey ,2017) Suggesting solutions for the plant operational performance is Reliability-cantered maintenance and Risk-based inspection. (Hariyanto et al., 2020) proposing contingency in the budget plan, which will eventually help cover the additional scopes which are raised due to plant operational issues. (Hey, 2019) explaining that proper scope change control process will help organization to only include turnaround relevant critical works which results to complete Turnaround maintenance project within budget and schedule.

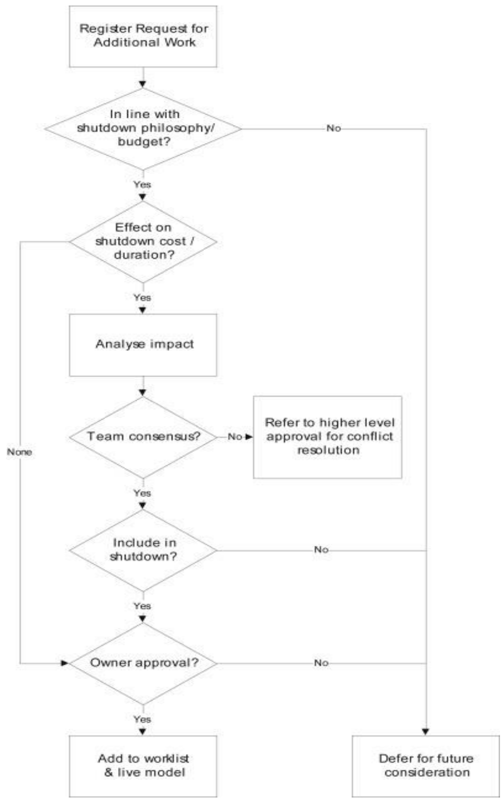

Figure 6 Scope control process from Literature (Hey, 2019).

IV. Regulatory and Legal Requirements

The aim of business is to increase profit and to achieve this target plant operation is particularly important. Therefore, decision makers will try to operate the assets as extended as possible. All the management decisions should ensure plant operations. However, these are restrictions from legal authorities and regulatory boards to inspect and maintain the equipment periodically to ensure the safety of people and environment. Which forces management to take decision on shutting down the operating plants periodically to confirms plants are operated with specific parameters which expected by regulations. American petroleum institute (API) is one of the regulated bodies for pressure vessels to ensure standards and safety compliance of those equipment. Another standard is safety critical equipment performance standards (SCEPS), meant for emergency shutdown equipment. Function of this equipment is mandatory during emergencies. Failure to these standards lead to catastrophe. Therefore, business selection must shut down the plants for a while. However, management tries to optimize duration of plant shutdown and encourage Turnaround Management (TAM) team to complete the mandatory activities as soon as possible to restore the production with aim of minimum business opportunity loss. (Hey, 2019) Traditionally, constitutional inspections of pressure having equipment such as boilers, furnaces, pressure vessels, and heat exchangers, decide the run length of the plants.

Since its, Mandatory for business to shutdown to meet regulations, earlier literatures are suggesting way to reduce optimize the durations. (Elfeituri et al., 2019) suggesting moving maintenance and inspection activities from a traditionally reactive or time-based approach to initiative-taking maintenance. The proactive methodologies for risk-based inspection provide guidelines for identifying and quantifying degradation mechanisms and risk to help prioritize inspection and care actions. Based on their study in five Libyan refineries, they were implementing turnarounds every two years then decided to move the turnaround cycle to three years interval based on historical experience and after analysing the probability and consequences of failures.

V. Bench Marking Results

Bench marking is the process of comparing one's own performance, processes, and practices with those of other organizations in the same or similar industry. (Bruce et al., 2021) The frequency of turnaround maintenance may vary from 4 to 6 years, depending on the plant equipment installation and operating models. Business plan stage occurs 4 to 6 years before actual turnaround starts, Industries encourage bench marking studies in between to target the overall objectives of increased profit by understanding their current position and performance relative to their peers and best practices, to Identify areas for improvement and innovation, as well as potential pitfalls and threats, and to establish realistic and attainable targets and action plans. These results change in business plan activities such as budget and schedule agreed during business plan stage. (Hey, 2019) Based on Benchmarking outcomes, A Middle East oil refinery changed their run length to 6 years. This is the longer duration between one TAR event to the next TAR event. Increased interval between turnaround affects reliability and increase the maintenance scope, results increased cost and Time to complete, increased scope.

(Solomon Associates, 2023) To manage this constraint, Solomon Associates suggest mini short shutdown in between to improve reliability and extend run length up to six years. According to financial standards, Industries should account for inflation for a year. If the Turnaround interval changes, they should also adjust the financial inflation for the extra year, which will help the Turnaround project team meet their goals such as finishing on time and within budget.

2.3 Synopses from literatures Review

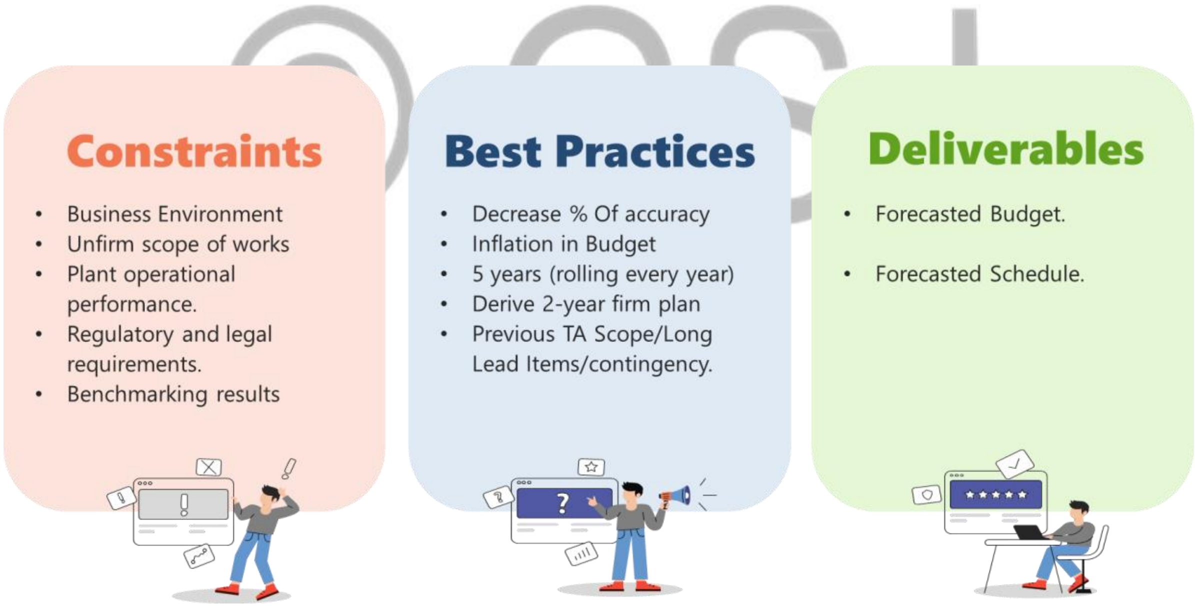

Figure 7: Synopses from literatures

3. RESEARCH METHODOLOGY

We used a qualitative approach to answer our research questions and tested the best practises suggested by literature with industrial exports. We chose this design because it aligned with the theoretical framework and industrial exports. We used the random and purposive technique to select our participants. We aimed to recruit 15 different participants from oil and gas industries. We included only those who had more than 10 years of experience in Oil and Gas Turnaround/Shutdown maintenance. We obtained the informed consent from all the participants before collecting the data. We collected the data from formal questions and answers sessions. And we collected five previous Turnaround maintenance project published data from oil and gas industries to understand their constraints and how they dealt with the issues. We administered the data collection instruments or tools in face-to-face and phone. We analysed the data using content analysis. We used Microsoft office XL Sheet to help us in the data analysis. We presented the results of the data analysis using tables.

4. CASE STUDY ANALYSIS OF AN ACTUAL OIL & GAS PLANT TURNAROUND PROJECT'S BUSINESS PLAN PHASE.

Conducted the case study at Oil & Gas plant Turnaround/shutdown project using the method from (Raoufi et al., 2014), to understand the work, problems, and solutions of Turnaround (TAR) project a in the long-range business planning phase. Wanted to see how the deliverables of each business plan phase matched the ones from the literature reviews. Also wanted to find out what factors are affecting deliverables and how they were managed. Lastly, we aimed to share and discuss the best practices from the literature reviews with the industry experts.

4.1 Deliverables Comparison.

The proposed method stipulates that the orderly comparison should begin by comparing the activities and deliverables of TAR project long range business plan phase. While compiling the activities and deliverables from various writings and case studies, it was able to classify these activities into various groups. Such as, Strategy, cycle determination, Cost, Reliability, Regulations, Dependency, and Resources.

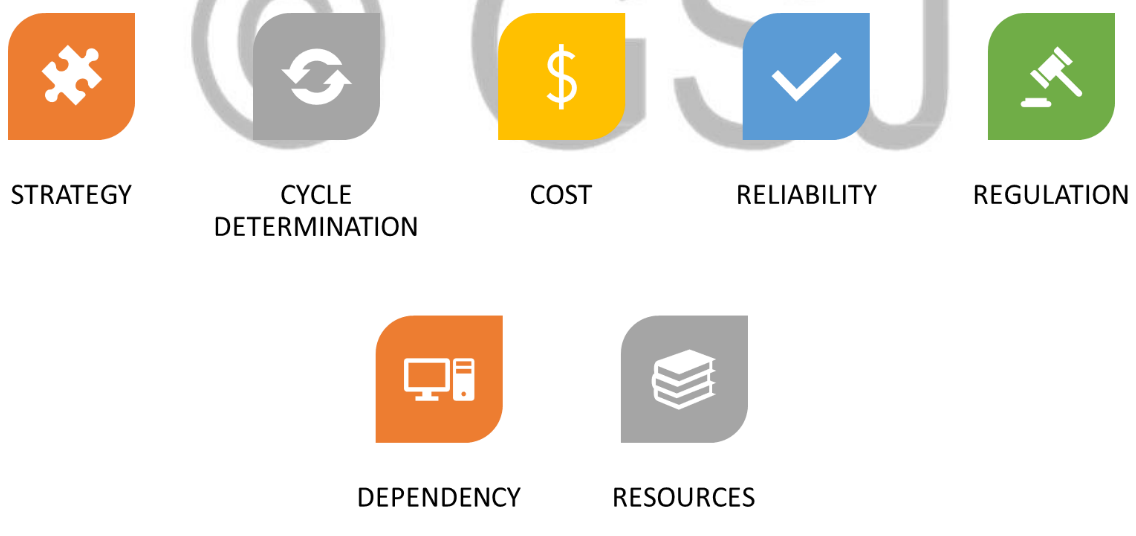

Figure 8 Deliverables Categories.

- **<u>Strategy</u>** group includes activities like alignment of the turnaround statement of commitment with the corporate vision and mission and Confirming contracting & procurement strategy. <u>Case study Results</u>: The management is choosing which plant to put in Turnaround, based on the corporate strategy for production planning and the performance of the plants.
- **<u>Cycle determination</u>** group includes activities like benchmarking, best practice comparison, confirming KPI (Key Performance Indicators), and complete long-term plan.
  <u>Case study Results:</u> The management team has officially confirmed the timeline and the main success criteria for the Turnaround Maintenance project.

- **<u>Cost</u>** groups include such as, corporate level investment plan, expenditure plan and project budget estimation.
  <u>Case study Results:</u> The Turnaround Management Team's initial estimate, based on previous TAR's project actual cost, market Inflation and contingency, has been approved by the management as the budget for the Turnaround projects.

- **<u>Reliability</u>** group includes activities like plant equipment performance, major overhauling equipment, process operating conditions, single line equipment conditions and safety critical equipment performance.
  <u>Case study Results:</u> The Turnaround Management Team identify the initial scopes based on previous Turnaround projects scopes, single line equipment, risk-based inspection strategy, and current asset operating conditions.
- **<u>Regulations</u>** category includes activities such as, pressure vessels regulations as per American Petroleum Institute pressure and Other local government regulations.
  <u>Case study Results:</u> Refinery plants use as below mandatory inspections.
    - American petroleum Institute (API) because they deal with many vessels that operate under high pressure.
    - Emergency Shutdown (ESD) – Systems which will either prevent loss of containment from happening or mitigate the consequences.
- **<u>Dependency</u>** groups include activities like inter-process plant alignments, product market demands and Upstream and downstream plant alignments.
  <u>Case study Results:</u> The schedule for Turnaround Maintenance is based on the inputs from corporate planning, which considers the supply from Upstream, the demand from the market, and the needs of downstream.
- **<u>Resources</u>** groups includes activities like long lead material identification based on earlier turnarounds, Starts buying action for long lead items and confirm existing inventory capabilities.
  <u>Case study Results:</u> Checks Insurance spares availability and Refurnished spares from previous Turnaround maintenance projects.

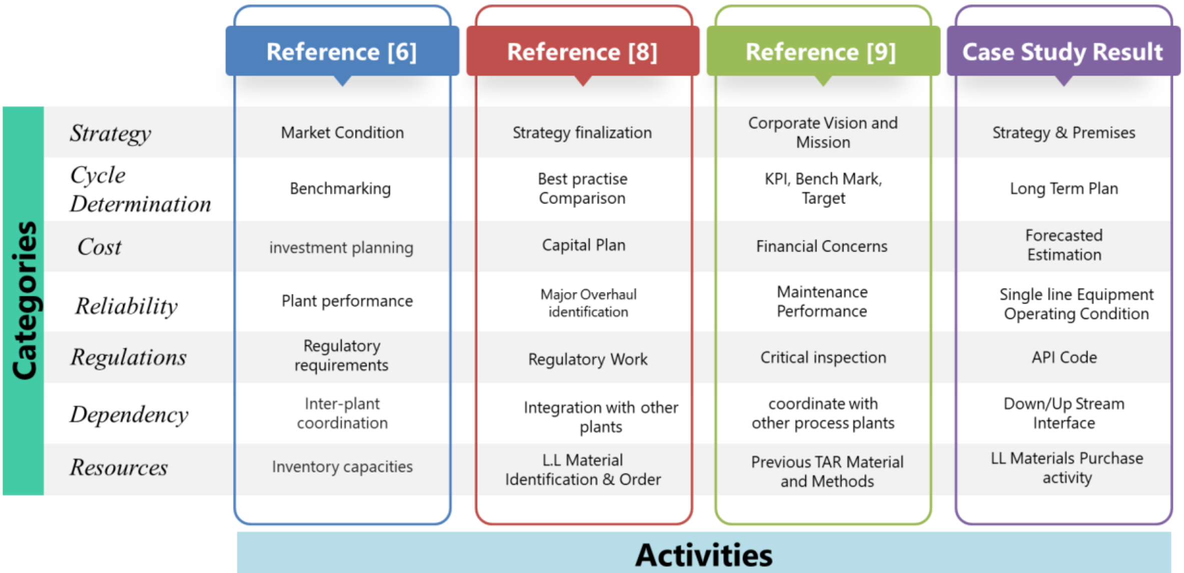

Figure 9: Comparison of company activities to literature activities

Figure 4 illustrates the comparison of Turnaround maintenance project long range business plan phase activities between oil & gas industries where our studies conducted along with literature reviews. Literature reviews are majorly related to oil and gas plants and our case studies also from refineries.

Therefore, activities are performed on long term business plan stage is almost same. However, terms used in each organization are different and understanding is same.

Although each oil & gas company follows the same Turnaround process, accomplishment of those activities varies from one company to another. Categories are generic and will give any company a better perspective of how their practices are similar or different to best practices.

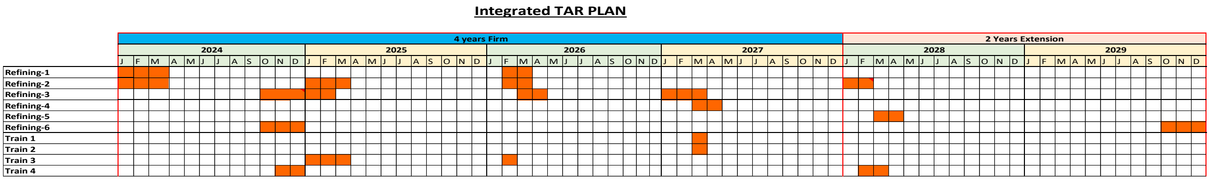

Figure 10: Case Study Integrated Plan

4.2 Known Constraints and Its solution.

Table 1: Comparison of Case Study with Literature results for Constraints and Best practices

Deliverables	Constrains		Best Practices	
	Literature Result	Case Study Result	Literature Result	Case Study Result
Budget Forecast (Accuracy must be as close as possible to Actual.)	Market Conditions	Higher Service Cost due to Economical Inflation	70% accuracy	60% Accuracy
	Unconfirmed Scope	Increased Scope	Previous TAR Scopes and Lessons Learned	Previous TAR final scopes, Materials and Service cost
			Controlling procedure	Stagewise Scope controlling
Schedule Forecast Number of Days Period of Execution	Equipment operational performance.	Reliability Issues	Derive 2 year Firm plan	A long term (5-yearly) TAR plan is released every year firm Plan
		Operational Bottle necks		
	Bench Marking Interplant Coordination's	Market product demand		
		Up/Down streams integration		

In this paper, we examine how turnaround (TAR) projects in the oil and gas sector approach the long-range business planning phase, which is crucial for, producing reliable estimates of the project budget and schedule. We conduct case studies and literature reviews to identify the familiar challenges and best practices that affect this phase, and we summarize our findings in Table 1, where we contrast the various aspects of the phase across various TAR projects.

I. Degreased Accuracy.

To solve problems which are occurring due to business environment, earlier studies suggesting having reduced accuracy in estimation. Our case study also agrees on the same.

In addition to above Percentage of accuracy depends upon the company practices. Since long range business plan occurs around 5 years before, country's financial inflation may vary with this period. Results, increased service, and material cost which affects accuracy of estimation. The same way, Plants are in operating condition, where wear and tear are operational issues. Results more scope. This affects overall estimation. Therefore, Industries are trying to estimate budget as close as possible. Literature study levels, (Hariyanto et al., 2020) TAR project can consider 70% accuracy. Means that estimation can vary from -30% to +30%. For example, if a project team estimates 10 MUSD, then the actual cost of the project can raise up to 13 MUSD or can lower to 7MUSD. (Lawrence, 2012) suggesting that business plan stage results in a ±50% accuracy estimate. However, accuracy should be increase in further stages of the project.

The estimated budget must be as accurate as possible because any deviation from the actual cost will impact the performance of Turnaround maintenance projects. However, achieving 100% accuracy is not feasible, as there are many internal and external factors that affect the budget and are beyond the control of decision makers. Therefore, they will try to estimate as close to 100% as they can. According to our case study, the team uses the agreed percentage deviation to manage constraints. They aim for 60% accuracy, but the management often asks them to improve it.

II. Previous Turnaround projects Reference.

Unconfirmed scope of works in one of the major challenges in business plan decision making. It is especially important to manage it properly before making conclusion. Our study reveals that previous Turnaround actual Scope works can be initial reference to manage the business plan outcomes.

As previous studies (Lawrence, 2012) (Jackson, 2022) have shown, using the past Turnaround scopes of works as a starting point for the Next Turnaround projects is a good practice, since 80% of the scopes are repeated in each Turnaround. (Hey ,2017) By using a Risk based inspection (RBI) strategy, we can have more certainty about the scope of works. This strategy determines a fixed interval for inspecting the static equipment, which are the main components of any Turnaround maintenance projects.

Our case study plants are using components such as Preventive Maintenance (PM) plans and Corrective actions which are waiting for Turnaround windows to conclude business plan decisions. PM plans includes static equipment and ESD Equipment. Static equipment interval coming from RBI strategy and ESD equipment intervals are defined safety procedures. Corrective actions which cannot be executed during normal plant operations. These two components confirm more than 75% of overall scopes. In addition to that to PM Plans are double checked with previous turnarounds actual scopes.

III. Scope Control Measures.

Scope control is the solution to the problem of additional scopes affecting business plan decisions. These scopes are generated by the production of plants, which leads to equipment deterioration. This is the conclusion of our study.

(Hey, 2019) Our literature reviews evidencing that well defining scope control can optimize additional scopes included to overall scope of Turnaround projects. In addition to that (Hey ,2017) suggesting reliability centred maintenance (RCM) also controlling the additional scopes. RCM aims to develop specific maintenance strategy on each assets-based factors such as original equipment manufacturer (OEM) suggestion, asset condition monitoring and predictive maintenance.

Our case study plants are following, First, Stage wise Scope closure, second, Additional work Request (AWR) workflow, and third, Reliability Centred Maintenance. Stage wise scope closure concludes the scope in various stages. Initially finalize high-cost Items, secondarily closes the activities which can executed by inhouse with less cost involvement, and finally close the activity no cost involvement, the activities can be managed with already available resources. The Additional work request includes approval from management level as well. AWR Workflow controls for Less cost items are managed at Middle managers level however, for High cost and critical activities involved Items Turnaround project steering committee approves it. This approval at various level forces request to rethink about decision of adding new scopes. RCM also followed in our case study plants for rotating equipment. Which is helping to predict the maintenance activities.

IV. Two years Firm plan.

Regulations and benchmarking studies influence our business plan decisions. Regulations require us to conduct mandatory inspections, while benchmarking studies recommend us to increase the turnaround interval cycle.

From earlier studies (Elfeituri et al., 2019) suggesting having initiative-taking approach instead of waiting for traditionally reactive or time-based approach. This will help the business to solve the problem immediately instead of waiting for Turnaround/Shutdown windows. (Solomon Associates, 2023) Solomon benchmark studies suggesting extending the Turnaround cycle up to six years with mini short shutdown in between to meet the maintenance needs such regulations and OEM Needs. (Hey, 2019) confirming and showing two years firm plan from their studies.

Case study plants are also bound by regulations such as RBI, SCE and Management advice to follow Bench Marking studies. To solve these issues, they are following two-year firm plan which is confirming the Next Turnaround schedule. Two-year firm Turnaround plan officially announced by management team normally Turnaround steering committee. Turnaround management team starts preparing their Turnaround after the Two-year firm plans. Normally they did not experience any changes in Turnaround schedule after the two-year firm plans.

4.3 Newly Industrialised constraints from Case studies.

Recently, some new challenges have emerged in the industries that affect the long-term business plan. A case study identified two new challenges that the users faced. They are Pandemic and Increased Raw Material cost. Due to the COVID-19 pandemic, governments and companies implemented new medical and hygienic rules. These created extra expenses for the TAR contractor, who provides workforce service for the TAR project. The service cost of the TAR project increased because of the new pandemic rules. Geopolitical issues caused raw material shortage, which affected the TAR project by reducing the material availability percentage and increasing spare parts cost. To manage these factors, the company follows two ways: one is to lower the accuracy of estimation, and the other is to order early to ensure availability and get long term agreement with the supplier to control the price of the materials.

5. CONCLUSION AND RECOMMENDATION.

This study has three sections. First, it presents the deliverables of the long-term business plan phase for TAR projects, which are based on literature reviews. It also discusses the budget forecast and schedule confirmation from a case study. Second, it identifies the constraints that affect the deliverables directly. These constraints are external environment, unclear scopes of work, operational conditions, and dependencies with downstream and upstream activities. Third, it suggests the best practices to manage the factors that influence the long-range planning objectives. The best practices are the agreed accuracy percentage for budget deviations, use of previous TAR project data for cost estimations, and yearly rolling firm plan. The study uses a theoretical and practical approach. It reviews, analyses, and summarizes various literature for all the sections. Then it conducts a case study in a refinery where complex TAR projects are conducted every year to verify the theoretical findings with practical experiences. Moreover, it learns about the new industrial constraints.

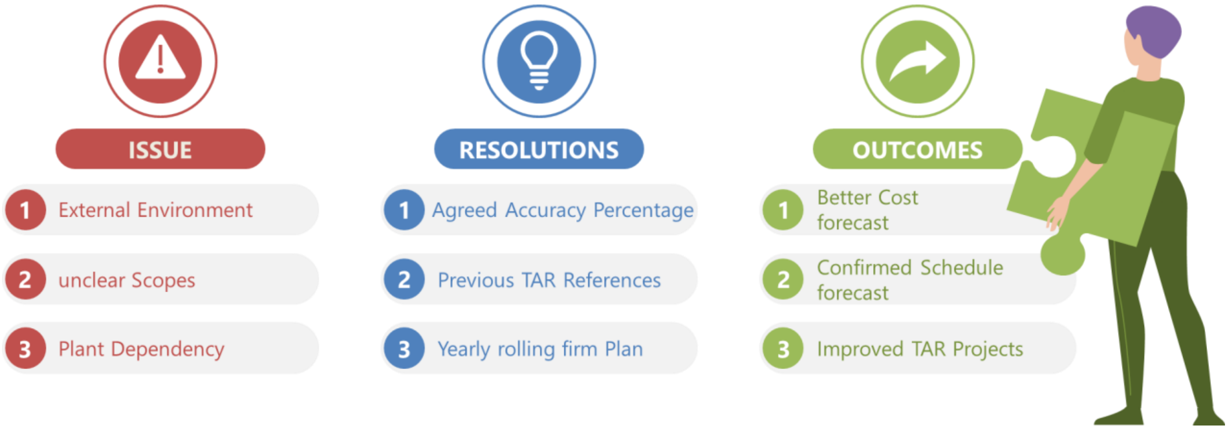

Figure 11 Summary of Conclusion

This research can be further developed to identify new challenges in long-term business plan stages of TAR projects as economic and industrial growth creates new opportunities.

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