

APPLYING PROJECT MANAGEMENT TECHNIQUES

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Introduction and background

The main role of the project manager is to assign the performing organization to achieve the project objectives. In addition, the project lifecycle is a collection of the project phases, where, every project lifecycle has a clear start and definite finish (Laine, 2012).

This technical report will discuss the project “Sustainable Materials Integration in Car Manufacturing”. The project underscores the vital role of sustainable materials in manufacturing, referencing historical engineering failures to stress the importance of selecting materials aligned with performance, safety, and sustainability standards. The project aim is to integrate sustainable materials effectively, optimize manufacturing for eco-efficiency, and exceed regulatory standards for environmental impact and longevity in vehicle development. With increasing consumer awareness of environmental issues, there is a rising demand for eco-friendly alternatives in the automotive industry (Ashby & Jones, 2012).

The primary focus of this project is not only to meet the highest standards of performance and safety but also to redefine sustainability in the industry. Nowadays, consumers prioritize eco-friendly purchases, driving the need for innovative alternatives. This project offers a solution to challenges posed by conventional manufacturing practices, presenting an opportunity for the automotive sector to lead the transition to a greener future (Ghosh, et al., 2020).

The automotive industry relies on a wide range of materials to construct a variety of components to manufacture various parts of the vehicle. These materials include iron, aluminium, steel, glass, rubber, petroleum products and copper. Over time, these materials have become substantially advanced, evolving to become more sophisticated and safer for automotive applications. Figure 1 illustrates the diverse steel used for the different parts of the cars.

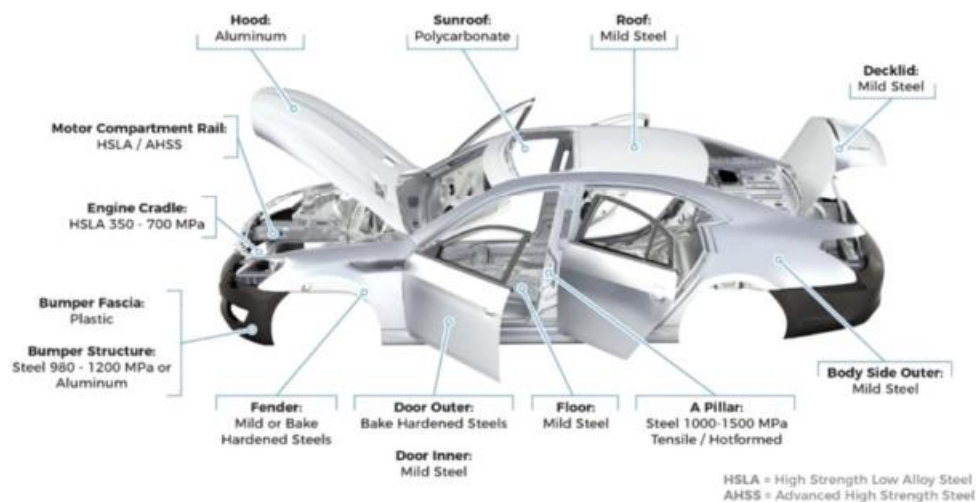


Figure 1. Materials more frequently used in major vehicle ((Ghosh, Ghosh, & Roy, 2020, p.5))

Furthermore, recycled steel provides numerous environmental benefits in car manufacturing. While traditional steel production involves high energy use and emissions, recycled steel offers a sustainable alternative. Here's how (Allwood, et al., 2019):

- **Resource Conservation:** Recycling steel reduces reliance on virgin iron ore, preserving natural resources and mitigating ecological damage from mining.
- **Energy Efficiency:** Melting down scrap steel for reuse requires less energy compared to extracting and processing raw materials. This reduces carbon emissions and energy consumption.
- **Emission Reduction:** Using recycled steel lowers greenhouse gas emissions and air pollutants, contributing to a healthier environment and combating climate change.
- **Waste Diversion:** Recycling steel scrap prevents it from clogging landfills and causing environmental harm. Instead, it is transformed into new products, reducing waste and conserving valuable landfill space.
- **Cost Effectiveness:** Recycled steel can be more economical for car manufacturers due to lower processing costs and competitive scrap prices.

Construction of a network diagram/Gantt Chart and critical path

The shortest duration that is required to complete the project, is known as a Total Project Time (TPT) , which is determined by a series of activities referred to as the critical path(s) (Lockyer & Gordon, 2005). For this technical report, a Gantt chart has been prepared, outlining the primary activities and significant milestones. The Gantt chart encompasses a total of 62 activities and sub-activities. In contrast, the network diagram highlights approximately 48 core activities.

PROJECT NAME: Sustainable Materials Integration in Car Manufacturing

NAME _____

START DATE

END DATE

[illegible]

The network diagram is crucial in network planning, particularly for analysing process capacity and efficiency. It allows for assessing process duration, optimizing resource allocation, and identifying the best process structure, among other benefits (Vasiljević, et al., 2011).

Task	Description	Activity	Duration (days)	Optimistic	Most Likely	Pessimistic	PERT Value
1	Initiation Project: Define the project purpose and the main objectives	1	0	10	17	15	15.50
2	Receive information from stakeholders to clearly outline project boundaries	1-2	15	7	6	12	7.17
3	Market Research & Analysis	2-3	14	6	6	5	
4	Identification of market trends in sustainable car demand	3-3A	7	11	14	8	12.50
5	Analyze competitor approaching to sustainability	3-3B	4	8	9	12	9.33
6	Research on customer preferences for eco-friendly vehicles	3-3C	6	6	8	12	
7	Identification of market trends in sustainable car demand	3A-3B	4	8	10	11	9.83
8	Material Sourcing	3C-4	3	8	7	9	
9	Implementation of any required design modifications along with material research	4-4A	4	11	12	7	
10	Conduct of initial testing to ensure compatibility and performance	4A-4B	6	11	9	7	
11	Conduction of initial testing to ensuring the compatibility and performance	3B-5	16	4	5	8	5.33
12	Evaluate and address issue related to material integration	4-4B	4	9	10	12	
13	Conducting initial test to ensure compatibility and performance	4B-5	6	4	10	6	
14	Cost Analysis: Evaluation of the cost implications of using sustainable materials	6B-7	4	10	7	15	8.83
15	Overall cost of the project with additional expenses	7-7A	7	1	2	15	4.00
16	Evaluate and address issues related to material integration	7A-9	5	5	8	12	8.17
17	Perform cost analysis: Evaluate the cost implications of using sustainable materials	7A-9C	2	4	9	11	8.50
18	Project plan: Developing a comprehensive cost analysis report, start to think about the Network diagram	6A-8	3	6	10	16	
19	Project Planning and Scheduling: Developing a detailed project plan outlining tasks	8-8A	4	8	9	8	
20	Create a comprehensive project schedule	8-8B	2	7	10	12	
21	Identification critical path and milestone	8A-8C	3	4	6	8	
22	Regulatory Compliance: Regulations with environmental	5-6	4	5	6	4	5.50
23	Investigations and ensure compliance with environmental regulations	6-6A	3	6	8	4	7.00
24	Work and collaborating with regulatory bodies for necessary approvals	6A-6B	3	8	5	8	6.00
25	Develop a comprehensive cost analysis report and initiate Network diagram sequences	8B-8C	3	9	10	9	
26	Training Program	8C-9	4	8	10	8	9.33
27	Developing a training program for the staff	9-9A	3	8	9	11	9.17
28	Focusing on working with sustainable materials and adhering to best practices	9A-9B	2	9	10	12	10.17
29	Training sessions and bring feedback for improvements	9B-9C	3	12	10	9	10.17
30	Productions Simulations: Simulate the production process using sustainable materials	9A-10	3	13	9	10	9.83
31	Develop a detailed project plan outlining tasks	9C-10	2	9	8	10	8.50
32	Improve manufacturing workflow	10-11	3	8	7	12	8.00
33	Quality control	11-12	4	6	5	10	6.00
34	Quality control Implementation: Establishment a robust quality control system for sustainable materials	12-12A	4	1	5	8	4.83
35	Implementation of checkpoints through the production line	12A-12B	3	6	10	8	
36	Implement quality control checkpoints throughout the production line	12C-14C	5	8	9	12	
37	Train quality control along with trial runs	12B-12C	2	5	8	10	
38	Capable test: Sustainable car for enduring tests	12A-13	3	5	8	12	8.17
39	Environmental impact Assessment: Establish procedures for regulatory compliance with environment	13-14	4	7	8	12	8.50
40	Conducting a comprehensive assessment of the car's environmental impact	14-14A	5	14	9	3	8.83
41	Measurements carbon footprint and other sustainability indicators	14A-14B	3	8	6	12	7.33
42	Generating a report highlighting eco-friendly aspects	14B-14C	2	9	5	16	7.50
43	Regulatory Compliance: Performance and test along with necessary certifications to meet the regulation	14C-15	4	2	6	10	6.00
44	Acceptance Testing: Invite users to drive and give feedback on the sustainable car	14A-16	3	4	8	10	7.67
45	Invite users to drive and provide feedback on the sustainable car during acceptance testing	15A-16	4	9	11	12	10.83
46	Incorporate users suggestions on final adjustments	16-16A	4	6	7	15	8.17
47	Ensure that legislation meet the final design	15-15A	2	15	11	8	11.17
48	Product launch Preparation: Organize the final event	16A-17	4	7	8	8	7.83
Total project cost							

Main activities on the critical path

Main milestones in a project

Figure 4 illustrates activities included the Network Diagram, those in green are activities that are on the critical path in the Network diagram and in black are outlined the activities for which the slack duration has been calculated.

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The first step involves listing all the tasks necessary to achieve the project's goal. Tasks should be specific and measurable, directly contributing to the project objectives. Followings steps are outlined below:

Table 1. Tasks necessary to achieve the project's objectives

Creating the Diagram	Project managers use tools like the Precedence Diagramming Method (PDM) or Arrow Diagramming Method (ADM) to map out activities and their dependencies. PDM uses nodes and arrows to represent activities and their relationships.
Determining Duration	Time estimates for each activity are then made considering resources, constraints, and past data, establishing the project timeline.
Identifying Critical Path:	The critical path, the longest sequence of dependent activities, determines the shortest project duration. Activities on this path have zero slack, meaning any delay extends the overall project timeline (Moga, et al., 2009).

Figure 5 illustrates the Network diagram along with the critical path in orange and in white activities on the slack.

The project schedule model is developed using schedule network analysis, a comprehensive technique that incorporates methodologies like the critical path method, resource optimization, and various modelling techniques.

Beyond these methods, the analysis also involves critical assessments such as:

- Evaluating whether combining schedules can prevent delays when multiple paths meet or separate at a specific time.
- Examining the network to identify activities with high risk or long lead times along the critical path.

It is fundamental to stress that schedule network analysis is a step-by-step journey, continuously fine-tuned until we achieve a strong, reliable schedule. This ongoing process ensures that our schedule stays flexible and responsive to the ever-changing needs and complexities of the project (Guide, 2001).

Role of Communication

Effective communication is vital for successful project management, influencing critical aspects like design changes, project timelines, and cost performance. Conversely, poor communication in team members can lead to project overruns, rework, and disputes, causing delays and increased costs.

According to Naoum (1994) and Sun and Meng (2009), ineffective communication can drive the need for project changes, while Chapman (1998) emphasizes that inadequate information exchange negatively impacts project performance. According to Anantatmula (2015) communication is a crucial factor in project success. When facing a design change, it is essential to act promptly and plan the right response. Addressing these issues early in the project can minimize their impact on both time and cost. This proactive approach helps mitigate risks like delays and cost overruns, ensuring smoother project outcomes (Yap, et al., 2017).

The project author aims to minimize design changes during the project lifecycle to avoid disruptions and inefficiencies. According to Abdul-Rahman et al. cited in Yap, Abdul-Rahman, & Chen,(2017), changes and rework are additional efforts needed to fix initial inaccuracies caused by design alterations.

On the other hand, findings from a study by Burati et al. cited in Yap, Abdul-Rahman, & Chen, (2017) evidenced that 79% of rework expenses observed in industrial engineering projects are caused by design alterations, errors, and oversights. This can cause delays and disruptions to the project lifecycle's performance, ultimately resulting in budget overruns and schedule delays.

To improve project communication management, Prescott (2013) suggests leveraging communication theories such as diffusion theory and communication accommodation theory. These theories offer valuable insights into optimizing communication strategies for project success (Yap, et al., 2017). In addition, clear and effective communication plays a vital role in project management, ensuring tasks are well-defined, promoting teamwork, and actively involving all stakeholders (Ssenyange, et al., 2017).

Clear and effective communication is essential for top-notch performance in project management. It establishes clarity, minimizes confusion, and fosters collaboration, enabling teams to achieve objectives with precision.

Strategic planning and the meticulous development of a detailed Project Communications Management Plan are vital steps to ensure clear and effective communication throughout the project lifecycle.

Effective communication cultivates a shared understanding among team members, aligning efforts with project goals and promoting synergy while reducing misunderstandings. Project managers must prioritize communication planning to their project's needs. Open communication within teams encourages innovation and creativity by facilitating idea exchange and problem-solving. This collaborative environment empowers team members, driving continuous improvement and project success

However, ineffective communication can hinder progress, leading to confusion, conflict, and inefficiency. To mitigate risks, project managers must establish clear communication protocols and cultivate a culture of transparency, trust, and collaboration (Olena, 2015).

Therefore, the main benefits of an Improved communication is pivotal in establishing clear objectives for project success. By articulating and disseminating project goals, scope, and desired outcomes to all stakeholders, project managers ensure a shared understanding among team members. Transparent channels align individual efforts with overarching goals, fostering accountability and unity. This unified vision guides collaboration and drives progress, laying a solid foundation for achievement in project management (Cervone, 2014).

The role of communication in improved performance is integrated into project success, impacting performance in many ways such as (Anantatmula, 2010):

- **Create clarification in the communication:** Transparent communication ensures that project goals and expectations are clearly understood by all team members.
- **Define specific roles and responsibilities:** Clarifying roles and responsibilities within the team is imperative for improving performance and managing conflicts
- **Manage outcomes:** Clearly defining project mission and objectives facilitates formal evaluation of project outcomes, promoting performance, motivation, recognition, and synergy within teams

Pert Analysis and risk management techniques

The expected time between the events can be evaluated as:

$$t_e = \frac{a + 4m + b}{6}$$

where t_e =expected time, a = *most optimistic time*, m = *most likely*, b = *pessimistic time* (Kerzner, 2017).

When applying Pert (Program Evaluation and Review Technique) analysis to this project, it's vital to address and mitigate various risks. Selecting sustainable materials involves intricate decision-making processes (Ismaeel, 2023). However, with potential delays in one task rippling through others, impacting the overall project timeline (Eldem, et al., 2022). Moreover, the automotive sector in developing nations faces multifaceted challenges like inadequate infrastructure, environmental concerns, and a dearth of skilled labour. The network diagram highlights training, crucial in bridging the gap between expectations and reality, especially in regions with skill shortages in automotive engineering and manufacturing (Monye, et al., 2023). As public awareness about environmental issues and climate change increases, there is growing pressure from society for governments, businesses, and communities to take immediate action. Consequently, governments are implementing regulations and laws that require firms to adapt their operations to meet strict environmental standards. Changes in regulations or issues with non-compliance could pose risks to project timelines, necessitating proactive risk management strategies (Richter & Medunic, 2020).

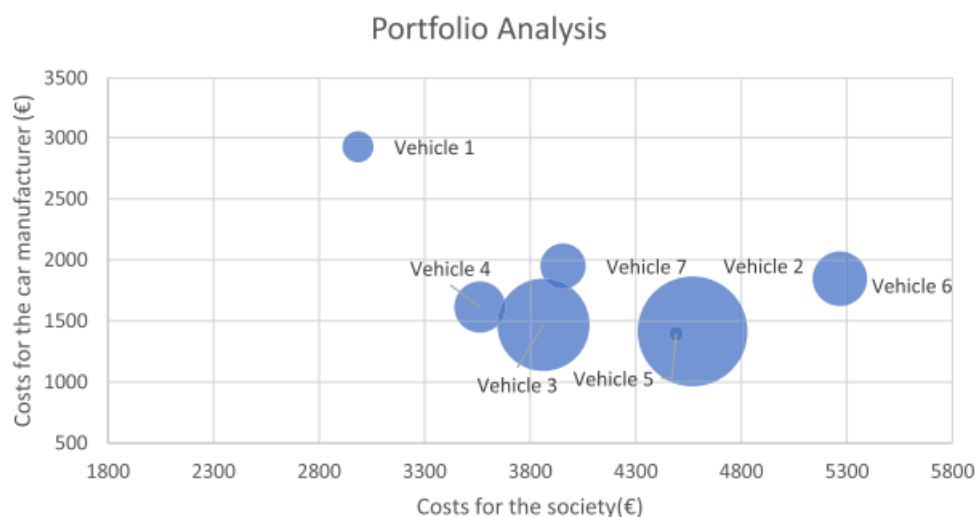


Figure 6. Costs of the entire car manufacture and the civil society costs (Iken, Morel, & Aggeri, 2019,p.6)

Using a standardized approach across various products and considering their annual sales volumes enables a thorough comparison of all vehicles in a car manufacturer's lineup regarding direct costs (material expenses) and external costs (environmental damage). This comparison is shown in Figure 6, where bubble sizes represent vehicle sales volumes. Thus, costs pose a risk for sustainable materials and manufacturing processes, as they may fluctuate, affecting the project budget (Iken, et al., 2019).

In project management, risk is assessed based on two factors:

- The potential negative consequences on a project activity.
- The probability or likelihood of those consequences happening.

This relationship is often represented as $\text{Risk} = \text{Impact} \times \text{Probability}$.

The risk is an inherent part of any project. Therefore, it is crucial to develop the ability to identify the potential risks and understand how to effectively handle them. A risk, in this context refers to any event that, upon occurrence, could either positively or negatively influence project objectives. In addition, the main goals of the risk management are minimize the probability of a risk event occurring and to minimize its impact on project objectives. Notably, not all the risks are negative. Those with the potential for a positive impact on the project are termed opportunities (Dodd, et al., 2024).

The risk could impact the business in different ways (Berry & Collier, 2007):

- **Risk Identification:** Regular risk assessments help businesses spot vulnerabilities and take proactive measures to mitigate potential threats.
- **Risk Mitigation:** Investments in technology, infrastructure, and safety protocols minimize the likelihood of adverse events. Insurance coverage can also transfer certain risks and reduce financial liabilities.
- **Risk Monitoring and Control:** Robust monitoring mechanisms enable businesses to track risks continuously, intervening promptly to mitigate emerging threats and adjust strategies as needed.
- **Compliance and Regulation:** Adhering to laws and regulations is crucial for effective risk management, helping businesses avoid penalties and reputational damage.
- **Business Continuity Planning:** Developing comprehensive plans ensures operational resilience by identifying critical functions and potential disruptions, and minimizing downtime during adverse events.

Overall, businesses play a vital role in managing risks through proactive engagement in identification, mitigation, monitoring, compliance, and continuity planning efforts.

The main model that can be applied to manage those risk is the **Project management framework**.

Assessment of the likelihood and impact of each identified risk on project objectives like cost, schedule and quality using quantitative analysis techniques.

Furthermore, continuously monitor and reassess risks through the project lifecycle to detect emerging threats and ensure the effectiveness of mitigation strategies. Regular reviews help maintain alignment with project goals and adapt to changing circumstances (Stevenson, 2022).

Below are the main activities where risks and mitigation strategies have been identified:

➤ **Initiation Project:**

PERT Analysis: Estimate project objective definition time and scope change likelihood.

Risk Management: Identify stakeholder conflicts, and establish change control.

Mitigation: Regular stakeholder meetings, and clear communication channels.

➤ **Material Sourcing:**

PERT Analysis: Assess sourcing duration and material availability risks.

Risk Management: Diversify suppliers, and conduct risk assessments.

Mitigation: Maintain buffer stock, and establish alternative sourcing options.

➤ **Cost Analysis:**

PERT Analysis: Estimate project costs and cost estimation uncertainty.

Risk Management: Develop a risk register, and establish contingency reserves.

Mitigation: Conduct cost sensitivity analysis, and negotiate pricing contracts.

➤ **Project Planning and Scheduling:**

PERT Analysis: Identify critical path activities, assess task duration variability.

Risk Management: Develop schedule buffers, implement risk response.

Mitigation: Regular progress monitoring, resource allocation flexibility.

➤ **Regulatory Compliance:**

PERT Analysis: Estimate regulatory approval time and assess changes likelihood.

Risk Management: Monitor regulations, develop mitigation plans.

Mitigation: Engage legal experts, establish compliance checkpoints.

➤ **Training Program:**

PERT Analysis: Estimate training duration, and assess effectiveness variability.

Risk Management: Conduct pre-training assessments, and implement feedback mechanisms.

Mitigation: Customize training content, and provide ongoing support.

➤ **Quality Control Implementation:**

PERT Analysis: Estimate quality control duration, assess product quality variability.

Risk Management: Implement statistical process control, develop improvement initiatives.

Mitigation: Regular quality audits, employee training programs.

➤ **Environmental Impact Assessment:**

PERT Analysis: Estimate assessment time, assess data collection uncertainty.

Risk Management: Engage environmental experts, and establish monitoring protocols.

Mitigation: Conduct periodic environmental audits, and implement sustainable practices.

➤ **Product Launch Preparation:**

PERT Analysis: Estimate launch preparation time, and assess marketing uncertainty.

Risk Management: Develop a flexible launch plan, and implement risk response strategies.

Mitigation: Conduct market surveys, plan for potential logistical issues.

“Rouse (2005) mentioned that a framework can be considered as a conceptual structure purported to guide a process. Young (2018) affirmed that a risk management framework can be deemed as a conceptual structure consisting of a set of components to ensure effective risk management for supporting safe and sound business decision-making” (Awuah & Young, 2021, p. 2).

The risk management framework serves as a comprehensive conceptual structure incorporating an organization's management procedures, principles, and policies for addressing risks. Young, as cited in Awuah & Young (2021), emphasizes the importance of integrating this framework across different aspects of organizational management to enhance enterprise risk management and overall organizational effectiveness (Awuah & Young, 2021).

Cost of individual activities

Table 2. Cost of individual activities

Task	Description	Activity	Duration (days)	Resources	Cost £
1	Initiation Project: Define the project purpose and the main objectives	1	0	1M,1C,1L	2,000
2	Receive information from stakeholders to clearly outline project boundaries	1-2	15	1C,1L	15,000
3	Market Research & Analysis	2-3	14	1M,1L	21,000
4	Identification of market trends in sustainable car demand	3-3A	7	1C,1L	7,000
5	Analyze competitor approaching to sustainability	3-3B	4	1M,2C,1L	10,000
6	Research on customer preferences for eco-friendly vehicles	3-3C	6	2M,2L	18,000
7	Identification of market trends in sustainable car demand	3A-3B	4	2L,1C	5,000
8	Material Sourcing	3C-4	3	1M,1L	4,500
9	Implementation of any required design modifications along with material research	4-4A	4	2M,2L	12,000
10	Conduct of initial testing to ensure compatibility and performance	4A-4B	6	2M,1C,2L	21,000
11	Conduction of initial testing to ensuring the compatibility and performance	3B-5	16	1M,1C,1L	32,000
12	Evaluate and address issue related to material integration	4-4B	4	3M,1L	14,000
13	Conducting initial test to ensure compatibility and performance	4B-5	6	2C,1L	4,000
14	Cost Analysis: Evaluation of the cost implications of using sustainable materials	6B-7	4	3M,2L,1C	6,000
15	Overall cost of the project with additional expenses	7-7A	7	1M,1L,1C	14,000
16	Evaluate and address issues related to material integration	7A-9	5	1M,2C	6,000
17	Perform cost analysis: Evaluate the cost implications of using sustainable materials	7A-9C	2	1M,1L,1C	4,000
18	Project plan: Developing a comprehensive cost analysis report, start to think about the Network diagram sequences	6A-8	3	2M,2L,2C	6,000
19	Project Planning and Scheduling: Developing a detailed project plan outlining tasks	8-8A	4	1M,2L,1C	10,000
20	Create a comprehensive project schedule	8-8B	2	1M,1C,1L	4,000
21	Identification critical path and milestone	8A-8C	3	2M,2C	9,000
22	Regulatory Compliance: Regulations with environmental	5-6	4	1M,3C	10,000
23	Investigations and ensure compliance with environmental regulations	6-6A	3	1M,3C,1L	9,000
24	Work and collaborating with regulatory bodies for necessary approvals	6A-6B	3	2M,1L	7,500
25	Develop a comprehensive cost analysis report and initiate Network diagram sequences	8B-8C	3	3L	4,500
26	Training Program	8C-9	4	3M,1L	14,000
27	Developing a training program for the staff	9-9A	3	1C,1L	3,000
28	Focusing on working with sustainable materials and adhering to best practices	9A-9B	2	3M	6,000
29	Training sessions and bring feedback for improvements	9B-9C	3	2M,1C,1L	9,000
30	Productions Simulations: Simulate the production process using sustainable materials	9A-10	3	5C	7,500
31	Develop a detailed project plan outlining tasks	9C-10	2	3M,2C,1L	5,000
32	Improve manufacturing workflow	10-11	3	2C,2L	4,000
33	Quality control	11-12	4	1M,1C,3L	12,000
34	Quality control Implementation: Establishment a robust quality control system for sustainable materials	12-12A	4	2L	4,000
35	Implementation of checkpoints through the production line	12A-12B	3	2M,3L	6,500
36	Implement quality control checkpoints throughout the production line	12C-14C	5	1M,4L	15,000
37	Train quality control along with trial runs	12B-12C	2	2C	2,000
38	Capable test: Sustainable car for enduring tests	12A-13	3	3M,1C,2L	15,000
39	Environmental impact Assessment: Establish procedures for regulatory compliance with environmental regulations	13-14	4	1M,2L	10,000
40	Conducting a comprehensive assessment of the car's environmental impact	14-14A	5	1M	5,000
41	Measurements carbon footprint and other sustainability indicators	14A-14B	3	1M,3C,1L	9,000
42	Generating a report highlighting eco-friendly aspects	14B-14C	2	3C	3,000
43	Regulatory Compliance: Performance and test along with necessary certifications to meet the regulations	14C-15	4	2M,1C	10,000
44	Acceptance Testing: Invite users to drive and give feedback on the sustainable car	14A-16	3	1M,1C,3L	9,000
45	Invite users to drive and provide feedback on the sustainable car during acceptance testing	15A-16	4	1L,2C	4,000
46	Incorporate users suggestions on final adjustments	16-16A	4	3M	12,000
47	Ensure that legislation meet the final design	15-15A	2	1M,4L	6,000
48	Product launch Preparation: Organize the final event	16A-17	4	1M,1C,1L	8,000
Total project cost				£	434,500
					£
Main activities on the critical path				1M=	1000
Main milestones in a project				1C=	500
				1L=	500

Table 2 illustrates the main cost of individual activities of the project Sustainable Materials Integration in Car Manufacturing.

Crash costing techniques

Typically, risk management follows a systematic approach, encompassing three main stages: Identification, Assessment, and Mitigation. The second phase, known as supply chain risk assessment, typically involves two key components (Zimmer, et al., 2017):

- Evaluating the severity or impact of adverse effects in the event of a risk occurrence.
- Assessing the probability of these effects occurring

For the crash costing certain activities have been selected as illustrated in the Figure 8 the new Network Diagram and Table 2 to ensure that even though the cost of the activities increases, the duration is reduced, whereas Table 4 illustrates the final cost of the 4 main activities:

Market Research and Analysis

In crash costing techniques Market Research and Analysis stand out as a crucial activity, especially in the global automotive markets. Import regulations heavily influence market entry strategies, requiring companies to balance local production costs against importing vehicles or parts with added fees. Localized production often leads to smaller production runs and higher costs, while global sourcing may reduce leverage and increase supplier management expenses.

Continuous monitoring of market trends, competitor actions, and customer preferences is essential throughout the project. This ongoing research ensures strategies remain aligned with evolving market demands. Robust supply chains and strategic supplier relationships are key components of effective global procurement and logistics as illustrated in Appendix 1 (Bechmann & Scherk, 2010).

The activity Market Research and Analysis has been chosen for the Crash costing because there are different ways to easily reduce the duration, such as:

- Utilize Automation: In other words, implement automated tools to speed up data collection and analysis, reducing manual effort.
- Outsourcing Options: Consider outsourcing specific tasks to experts for quick insight saving time and effort.

As illustrated in Table 3 both alternatives can reduce the activity by 2 days and increase the cost from £21,000 to £30,000.

Evaluate and Address Integration Material Issues

The choice to prioritize Evaluating and Addressing Integration Material Issues for crash costing stems from its crucial role in mitigating risks linked to handling significant materials within the warehouse.

One notable risk outlined in Appendix 2 concerns the handling of materials contaminated with pollutants, solvents, and chemicals, along with plastic and metal containers, posing potential threats to both the environment and human health (Bosak & Kabdi, 2015).

The activity of Evaluate and Address Integration Material issue has been chosen because:

- Cross-Functional Teams: Foster collaboration among different teams involved in material integration to streamline decision-making.
- Stakeholder engagement involves the stakeholders early to address issues promptly and prevent delays.

For this reason, the evaluation and address of integration material issue the days were reduced by 3 days and the initial cost was increased from £32,000 to £45,000.

Regulatory Compliance:

The choice to prioritize Regulatory Compliance in the crash costing plan is crucial for ensuring strict adherence to environmental regulations and standards, directly impacting project outcomes and overall business performance. The findings tentatively mirror the principles of ecological modernization, suggesting that regulation can drive innovation. The prevalent response, as shown in Appendix 3 regulation has limited benefits, it is closely linked to the necessity of maintaining supplier contracts (Smith & Crotty, 2008).

Continuous Monitoring and Updates:

- Real-Time Monitoring: Implement systems for monitoring regulatory changes in real-time to adapt compliance strategies proactively.
- Regular Training: Provide ongoing training sessions to keep the team updated on regulatory requirements.

Prioritizing Regulatory Compliance and employing strategies like real-time monitoring and regular training aims to reduce the crash duration by 2 days. However, this accelerated timeline incurs an additional initial cost of £15,000. This investment is necessary to uphold regulatory standards and mitigate risks effectively, ensuring project success and long-term industry credibility.

Establish procedures for regulatory compliance with environmental regulations

Implementing procedures for regulatory compliance with environmental regulations in the crash costing plan reflects the increasing importance of environmental sustainability in today's business landscape (Jermsittiparsert, et al., 2019).

Therefore, two main strategies have been considered:

- Iterative Refinement: Adopt an iterative approach for ongoing procedure adjustments based on feedback and regulatory changes.
- Regular Updates: Stay updated on environmental regulations and promptly integrate changes into procedures.

These strategies reduce the crash duration by 2 days but increase the initial cost by £15,000. This investment demonstrates a commitment to environmental compliance, contributing to the project's success and sustainability.

Figure 7. Revised Network Diagram after crash costing

Table 3.Crash costing of the project

Activity	Description	Normal Duration (Days)	Crash Duration (Days)	Normal cost £	Crash cost per week	
2-3	Market research and analysis	14	12	21000	30000	
3B-5	Evaluate and address integration material issue	16	13	32000	45000	
5-6	Regulatory Compliance	4	2	10000	20000	
13-14	Environmental impact Assessment: Establish procedures for regulatory compliance with environmental regulations	4	2	10000	15000	

Activity	Normal Duration (Days)	Crash Duration (Days)	Normal Cost "£"	Crash Cost "£"	Crash Increase	Crash cost per day
2-3	14	12	21000	30000	9000	4500
3B-5	16	13	32000	45000	13000	6500
5-6	4	2	10000	20000	10000	5000
13-14	4	2	10000	15000	5000	2500
		Total	73000			

Crash cost sequences						
Activity	Crash cost per day £	Normal duration (days)	Crash Duration (days)	Time saved	Comulative project cost increased	
2-3	4500	14	12	2	9000	
3B-5	6500	16	13	3	22000	
5-6	5000	4	2	2	32000	
13-14	2500	4	2	2	37000	
					Total comulative cost"£"	100000

Table 4. Final table of crash costing

Task	Description	Activity	Duration (days)	Resources	Cost £	Final cost after crash costing
1	Initiation Project: Define the project purpose and the main objectives	1	0	1M,1C,1L	2,000	2000
2	Receive information from stakeholders to clearly outline project boundaries	1-2	15	1C,1L	15,000	15000
3	Market Research & Analysis	2-3	14	1M,1L	21,000	30000
4	Identification of market trends in sustainable car demand	3-3A	7	1C,1L	7,000	7000
5	Analyze competitor approaching to sustainability	3-3B	4	1M,2C,1L	10,000	10000
6	Research on customer preferences for eco-friendly vehicles	3-3C	6	2M,2L	18,000	18000
7	Identification of market trends in sustainable car demand	3A-3B	4	2L,1C	5,000	5000
8	Material Sourcing	3C-4	3	1M,1L	4,500	4500
9	Implementation of any required design modifications along with material research	4-4A	4	2M,2L	12,000	12000
10	Conduct of initial testing to ensure compatibility and performance	4A-4B	6	2M,1C,2L	21,000	21000
11	Conduction of initial testing to ensuring the compatibility and performance	3B-5	16	1M,1C,1L	32,000	45000
12	Evaluate and address issue related to material integration	4-4B	4	3M,1L	14,000	14000
13	Conducting initial test to ensure compatibility and performance	4B-5	6	2C,1L	4,000	4000
14	Cost Analysis: Evaluation of the cost implications of using sustainable materials	5B-7	4	3M,2L,1C	6,000	6000
15	Overall cost of the project with additional expenses	7-7A	7	1M,1L,1C	14,000	14000
16	Evaluate and address issues related to material integration	7A-9	5	1M,2C	6,000	6000
17	Perform cost analysis: Evaluate the cost implications of using sustainable materials	7A-9C	2	1M,1L,1C	4,000	4000
18	Project plan: Developing a comprehensive cost analysis report, start to think about the Network diagram	6A-8	3	2M,2L,2C	6,000	6000
19	Project Planning and Scheduling: Developing a detailed project plan outlining tasks	8-8A	4	1M,2L,1C	10,000	10000
20	Create a comprehensive project schedule	8-8B	2	1M,1C,1L	4,000	4000
21	Identification critical path and milestone	8A-8C	3	2M,2C	9,000	9000
22	Regulatory Compliance: Regulations with environmental	5-6	4	1M,3C	10,000	20000
23	Investigations and ensure compliance with environmental regulations	6-6A	3	1M,3C,1L	9,000	9000
24	Work and collaborating with regulatory bodies for necessary approvals	6A-6B	3	2M,1L	7,500	7500
25	Develop a comprehensive cost analysis report and initiate Network diagram sequences	6B-8C	3	3L	4,500	4500
26	Training Program	8C-9	4	3M,1L	14,000	14000
27	Developing a training program for the staff	9-9A	3	1C,1L	3,000	3000
28	Focusing on working with sustainable materials and adhering to best practices	9A-9B	2	3M	6,000	6000
29	Training sessions and bring feedback for improvements	9B-9C	3	2M,1C,1L	9,000	9000
30	Productions Simulations: Simulate the production process using sustainable materials	9A-10	3	5C	7,500	7500
31	Develop a detailed project plan outlining tasks	9C-10	2	3M,2C,1L	5,000	5000
32	Improve manufacturing workflow	10-11	3	2C,2L	4,000	4000
33	Quality control	11-12	4	1M,1C,3L	12,000	12000
34	Quality control Implementation: Establishment a robust quality control system for sustainable materials	12-12A	4	2L	4,000	4000
35	Implementation of checkpoints through the production line	12A-12B	3	2M,3L	6,500	6500
36	Implement quality control checkpoints throughout the production line	12C-14C	5	1M,4L	15,000	15000
37	Train quality control along with trial runs	12B-12C	2	2C	2,000	2000
38	Capable test: Sustainable car for enduring tests	12A-13	3	3M,1C,2L	15,000	15000
39	Environmental impact Assessment: Establish procedures for regulatory compliance with environment	13-14	4	1M,2L	10,000	15000
40	Conducting a comprehensive assessment of the car's environmental impact	14-14A	5	1M	5,000	5000
41	Measurements carbon footprint and other sustainability indicators	14A-14B	3	1M,3C,1L	9,000	9000
42	Generating a report highlighting eco-friendly aspects	14B-14C	2	3C	3,000	3000
43	Regulatory Compliance: Performance and test along with necessary certifications to meet the regulation	14C-15	4	2M,1C	10,000	10000
44	Acceptance Testing: Invite users to drive and give feedback on the sustainable car	14A-16	3	1M,1C,3L	9,000	9000
45	Invite users to drive and provide feedback on the sustainable car during acceptance testing	15A-16	4	1L,2C	4,000	4000
46	Incorporate users suggestions on final adjustments	16-16A	4	3M	12,000	12000
47	Ensure that legislation meet the final design	15-15A	2	1M,4L	6,000	6000
48	Product launch Preparation: Organize the final event	16A-17	4	1M,1C,1L	8,000	8000
Total project cost					£ 434,500	471500
				£		
Main activities on the critical path				1M=	1000	
Main milestones in a project				1C=	500	
				1L=	500	

Project handover issues

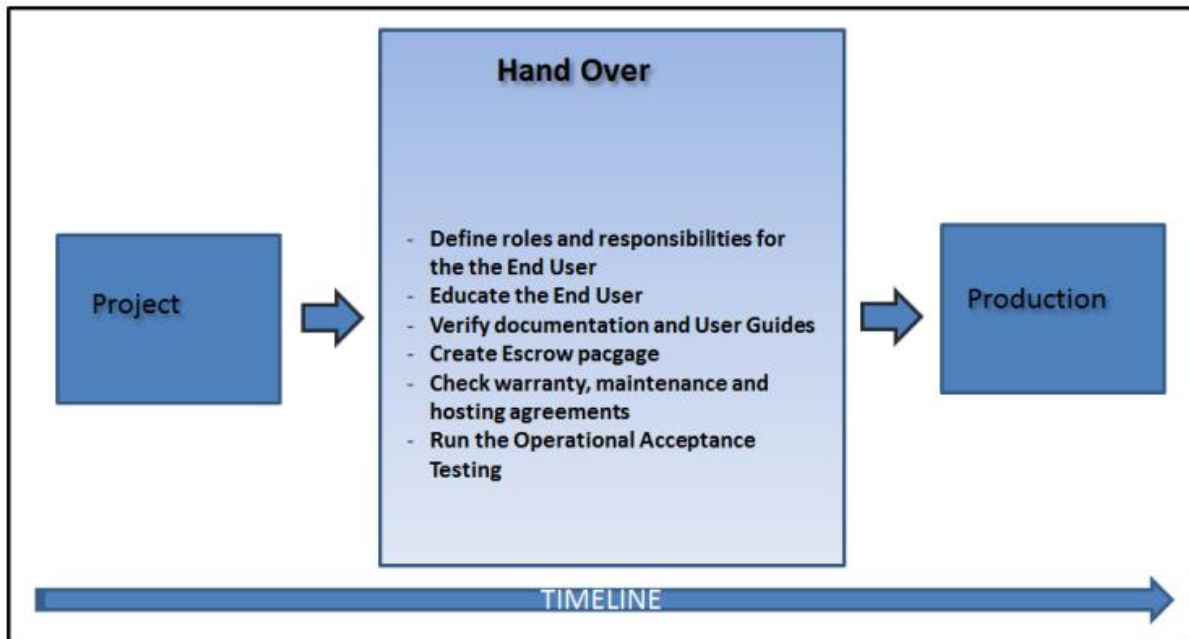


Figure 8. Project Handover process (Laine, 2012,p.).

This section involves a discussion related to the client regarding project handover. Transparent communication channels, as illustrated in Figure 10, are vital for effective collaboration among the project team, client, and stakeholders.

Comprehensive training sessions for the client's team are vital, supported by detailed documentation, empowering them to utilize project deliverables effectively.

Regardless of the project's nature, establishing a team with clear responsibilities is predominant, where, defined roles mitigate confusion and enhance the overall efficiency.

Identifying and addressing potential risks during handover is essential for continuity. Proactive risk management ensures disruptions are minimized, supported by effective communication, marketing, financial management, and decision-making practices.

To summarize, successful project handover relies on transparent communication, training, risk management, and clear team responsibilities. By taking proactive steps, laying the foundation for enduring collaboration and success in the long term (Laine, 2012).

Conclusion

The report aimed to integrate sustainable materials into car manufacturing through meticulous planning and effective communication under the project manager's guidance.

Highlighting the importance of recycling, particularly recycled steel, as evidence of our commitment to environmentally responsible practices in the automotive industry. This reflects the growing impact for eco-friendly solutions to address environmental concerns.

A clear Gantt Chart along with detailed critical path, milestones and sub-activities were produced to ensure that project success was within set timelines. Additionally, a network diagram in Figure 8 demonstrates how to crash costing reduced activity durations, but increased project costs from Tables 3 and 4, showing our strategic decision-making abilities.

The duration of Material Research and Analysis activity was reduced due to the outsourcing of specific tasks to experts. The activity of Evaluation and Address Material Integration was reduced by working with different teams and having effective communication with shareholders. The difference of cost between of the initial project and after crash costing is £37,000, which will ensure that certain activities will commence earlier.

To conclude, in any project communication is the key along with time. Regulatory and environmental considerations also played a significant role, contributing to the reduction of the two main activities. Although cost increases may create concerns, shorter activity durations will enhance overall project efficiency. Moving forward, the recommendations will be to keep on monitoring regulations and exploring alternative solutions to mitigate cost escalations and be open to innovative approaches that can help mitigate any potential increases in costs.

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Appendices

Appendix 1

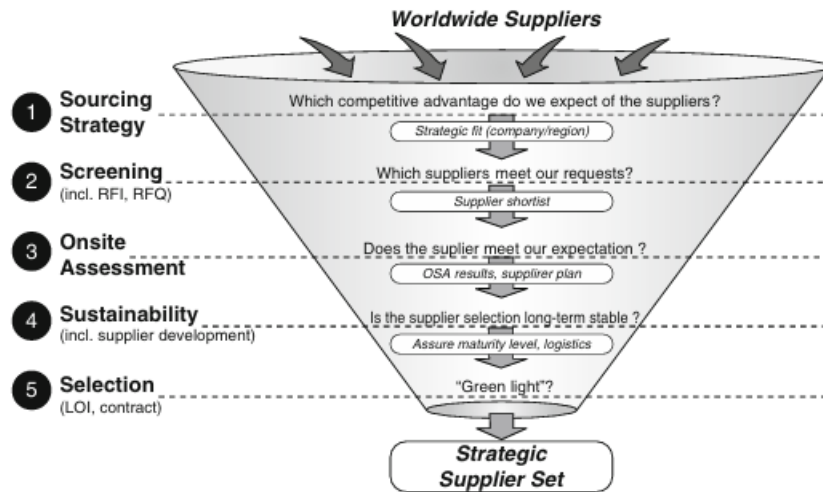
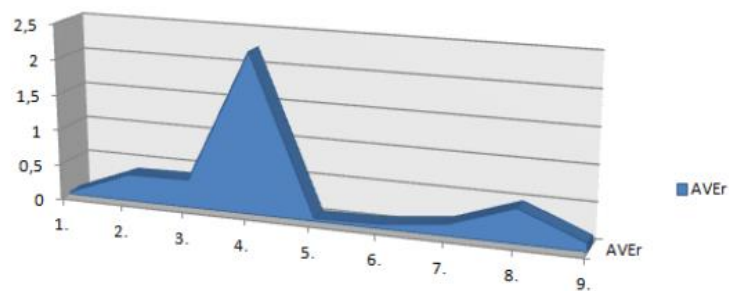


Figure 9. Best-cost country sourcing (Bechmann & Scherk, 2010,p.184)

Appendix 2



Legend:

- | | |
|---|--|
| 1. Receipt of material | 6. Contact, welding, soldering, cutting contacts |
| 2. Transportation of the product to the warehouse | 7. Stripping of cables |
| 3. Transportation by forklift | 8. Cable formation, repairs |
| 4. Handling in the warehouse | 9. Electrical control, packaging |
| 5. Cutting the cables | |
- AVER - Average risk of an individual production phase of the product

Figure 10. Total environmental-safety and technical risks lifecycle (Bosak & Kabdi, 2015,p.5)

Appendix 3

Reaction to environmental regulation	Number of firms agreeing (frequency)	%
It is costly, and there are no benefits	2	6
It is costly, but has limited benefits (e.g. compliance maintains contracts)	14	44
Limited costs, indirect benefits (e.g. reduces legislative exposure)	11	32
Leads to innovation and other benefits (e.g. develops new competencies and capabilities, develops market opportunities, generates competitive advantage)	6	8

Figure 11. Responses to regulations (Smith & Crotty, 2008,p.345)