Developing a Multidimensional Work Breakdown Structure (WBS) for Overhead Electrical Power Distribution Line Projects for Standardizing Document and Database Framework in Project Management [1, 2]

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ABSTRACT

This paper addresses the challenge of ineffective project management in overhead electrical power distribution line projects, focusing on the need for standardized Work Breakdown Structures (WBS). The study employs a multi-attribute decision-making approach to evaluate and select an appropriate WBS coding structure, comparing CSI Omniclass and ISO 19008:2016. The analysis concludes that the CSI Omniclass coding structure is more suitable for developing a standardized multidimensional WBS for overhead electrical power distribution line projects. The paper presents a detailed WBS framework covering design, implementation, and handover phases, utilizing relevant Omniclass tables. This standardized WBS aims to improve project planning, execution, and monitoring, potentially reducing delays and cost overruns common in construction projects. The study emphasizes the importance of aligning the WBS with current practices, providing comprehensive training, and maintaining rigorous oversight during the Front-End Loading phase to mitigate risks and control costs in overhead electrical power distribution line projects.

Keywords: Work Breakdown Structure, WBS, Multidimensional, Overhead Electrical Power Distribution Line Project, OmniClass, ISO 1908:2016, Multi Attribute Decision Making (MADM), Project Management.

INTRODUCTION

A. The Needs of Overhead Electrical Power Distribution Line Project

PT Vale Indonesia is making significant strides with its Indonesia Growth Project (IGP), a key initiative focused on sustainable development. The IGP Pomalaa project, a cornerstone of this initiative, requires an investment of $4.5 billion. Once operation

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[2] This paper was originally prepared during a 6-month long Graduate-Level Competency Development/Capacity Building Program developed by PT Mitrata Citragraha and led by Dr. Paul D. Giammalvo to prepare candidates for AACE CCP or other Certifications. https://build-project-management-competency.com/our-faqs/

begins, it is expected to yield an annual production of 120,000 tons of nickel and 15,000 tons of cobalt, underscoring the company's commitment to responsible growth and its pivotal role in the industry. As of October 2023, following the completion of the FEL 3 documents, the project has entered its initial construction phase. The progress of PT Vale Indonesia's IGP Pomalaa is currently segmented into two parts: early work and main construction.[3].

A critical phase in the early construction involves establishing facilities and infrastructure, particularly a medium-voltage distribution network for electrification needs, supporting future mining operations. PT Vale will utilize renewable energy from the Bakaru Hydroelectric Power Plant. This approach aligns with ESG, emphasizing sustainable resource use, reducing emissions and pollution, and addressing climate change. The goal is to contribute to the Sustainable Development Goals, particularly in affordable and clean energy areas, during the construction and operational phases.[4].

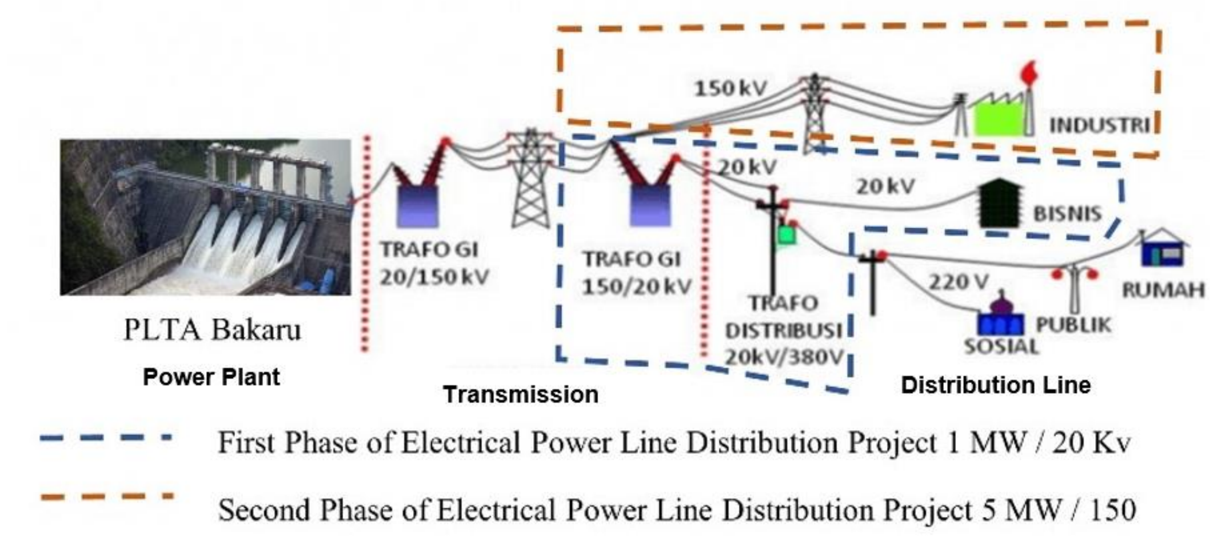

Figure 1. Overhead Electrical Power Distribution Line for PTVI IGP Pomalaa

A significant challenge in the early construction phase is managing the overhead electrical power distribution line: 1000kVa during construction and 5000kVa during operational mining. The 1000kVa Overhead Electrical Power Distribution Line will support essential facilities such as temporary dormitories, training grounds, and the main security gate. The 5000kVa Overhead Electrical Power Distribution Line will cater to the Main Operation Camp area, workshops, magazines, mine entrance, shift change facilities, domestic waste landfill, feed transfer points, and the onshore port.[5].

[3] PT Vale. (2023, October). *Indonesia growth project Pomalaa*. Vale. https://vale.com/in/indonesia-growth-projects-pomalaa
[4] Nindita Radyati, M. R. (2024, May 6). *Training & FGD on PTVI's ESG* [PowerPoint Slides]. Institute for Sustainability and Agility (ISA).
[5] Vale & Worley. (2023). *Integrated Mines of Pomalaa Infrastructure, Facilities, and Utilities Basis of Design* (CP-0000CO-A-70001). Vale. https://globalvale.sharepoint.com/:b:/r/sites/IGPPomalaaEPCBasicDesign/Shared%20Documents/General/00.%20Common/CP-0000CO-A-70001_REV%203_IMP%20Infrastructure%20Facilities%20and%20Utilities%20Basis%20of%20Design.pdf?csf=1&web=1&e=dqyHVj

The construction team is currently working on completing a 1000kVa Overhead Electrical Power Distribution Line Project, scheduled to be finished by December 2024. Following this, they will begin work on a 5000kVa line, with a target completion date of December 2025. These deadlines are crucial as they will enable the start of the first mining operation in the second semester of 2026. One of the primary challenges in achieving these objectives is utilizing local contractor resources, as stipulated by FEL 3. This strategy also seeks to integrate ESG elements, including worker associations, community participation in value chains, and bolstering the local economy, all aligning with the SDGs' aim of promoting decent work and economic growth.

Figure 2. Primary and Accessories Item of 1000kVa Overhead Electrical Power Distribution Line

The 1000kVa Overhead Electrical Power Distribution Line's existing work sequence is illustrated below.

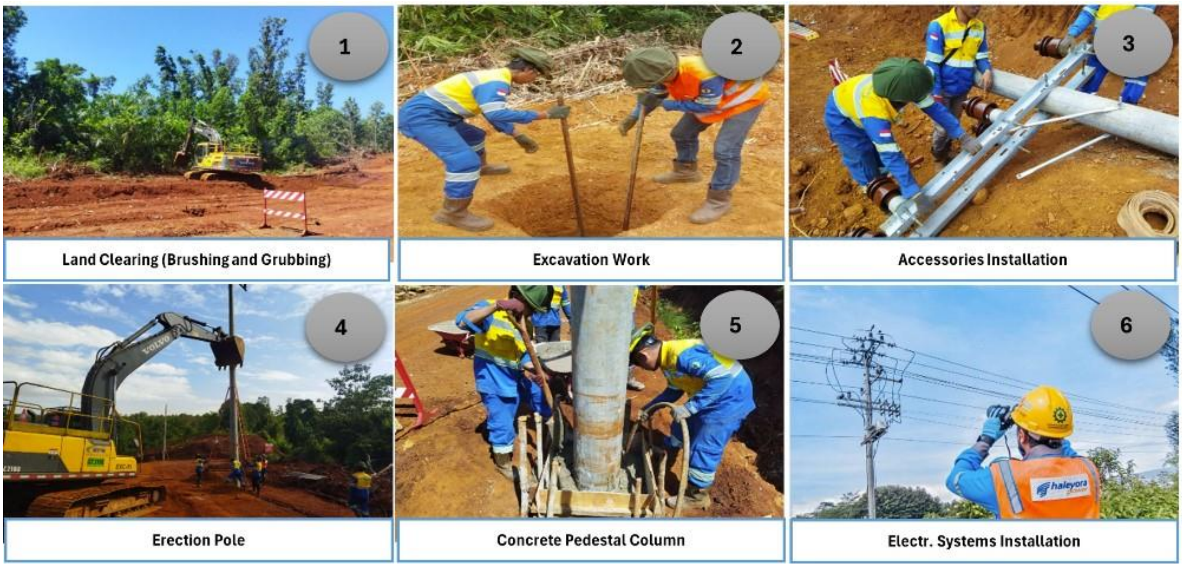

Figure 3. Work Sequence Construction 1000kVa Overhead Electrical Power Distribution Line

B. Ineffective Project Management

Over the past few decades, many large projects across various industries have faced significant schedule delays and cost overruns. In 2023, Indonesia had 197,030 construction companies, a 3.22% decrease from the previous year's total of 203,403. Of these, 82.5% were small-scale contractors, 16.5% were medium-scale contractors, and 1% were large-scale contractors.[6].

KPMG and the Australian Institute of Project Management in 2022 surveys revealed that only about 36% of projects were completed within budget and 32% on schedule. This marks a decrease from 2020, when 40% of projects met their budget, and 42% were.[7].

A recent survey commissioned by Procore Technologies, Inc. and conducted by IDC has highlighted some concerning trends in the construction industry. The survey gathered responses from construction project owners and developers in the U.S. and Canada and revealed that 75% of construction projects were over budget and 77% were delivered late.[8].

Project management plays a vital role in effectively delivering projects across diverse sectors. It is essential to ensure that projects are executed successfully, meet their objectives, and deliver value. Effective project management guarantees that projects are completed on time, within budget, and to stakeholders' satisfaction. However, many projects still need to achieve their intended outcomes despite the abundance of available methodologies, tools, and best practices. Ineffective project management has become a significant issue, resulting in increased costs, delayed timelines, and unmet objectives.[9].

In 2023, Armstrong et al. surveyed in the 2023 Global Construction Survey. They found that 37% of respondents reported missing budget and schedule performance targets over the past year due to a lack of effective risk management, up from 32% in the 2021 survey.[10].

[6] Badan Pusat Statistik. (2023). *Konstruksi dalam Angka 2023* (12th ed.).
[7] Australian Institute of Project Management (AIPM). (2022). *The state of project management 2022 report*. AIPM. Retrieved from https://info.aipm.com.au/hubfs/Reports%20and%20major%20content%20assets/The%20State%20of%20PM%202022%20Report%20FINAL.pdf
[8] A survey, a 'wake-up call,' reveals most construction projects are over budget and late. (2021, August 30). constructconnect.com. https://canada.constructconnect.com/dcn/news/technology/2021/08/survey-a-wake-up-call-reveals-most-construction-projects-are-over-budget-and-late
[9] Atlassian. (n.d.). *12 project management principles & concepts | The Workstream*. https://www.atlassian.com/work-management/project-management/principles
[10] Armstrong, G., Gilge, C., Max, K., & Vora, S. (2023). *Familiar Challenges - New Approaches "2023 Global Construction Survey."*. https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2023/06/familiar-challenges-new-solutions.pdf

Herz M. et al., in their publication, state that 55% of project managers reported that their projects failed to meet their original goals and business intent. Additionally, 37% of projects failed due to unclear objectives and milestones.[11].

In today's fast-paced business environment, organizations must manage projects effectively to deliver results efficiently. This paper aims to shed light on the common problem of ineffective project management and promote the adoption of more robust and efficient project oversight methods. One such method is earned value management, which offers a performance-oriented approach to project management.[12].

C. Project Management Concern on The Need for Standardized WBS

In the dynamic field of project management, it is crucial to maintain a keen awareness of both schedule and cost to ensure the successful completion of any project. These two elements are interdependent and critical in delivering projects on time and within budget. Managing the schedule involves understanding and controlling the timeline of a project, including planning, monitoring, and controlling project activities to meet deadlines. Schedule awareness includes detailed planning, time management, and progress tracking. Effectively managing the schedule ensures that every resource is utilized as planned, minimizes potential delays, and allows the project manager to make critical decisions for improvement through proper monitoring and control.

Adhering to the target construction completion date, a well-defined scope of work, a clear schedule, and a set budget are crucial factors for successfully finishing a project. If the work is completed more quickly than planned, the cost will increase; if the work is performed slowly, the cost will also rise.[13].

Balancing schedule and cost considerations is crucial to effectively managing a project. A well-managed schedule ensures that resources are used as planned, helping minimize delays and significantly impact progress. Monitoring and control are essential for making critical decisions to improve the project. However, the most crucial factor for success is creating a clear and comprehensive scope of work. Without a clear scope, a project cannot be completed. Identifying individuals or organizations responsible for the work and establishing a time frame for completing it is also essential.[14].

Effective scope management is crucial in construction projects for several reasons:

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[11] Herz, M., Krezdorn, N. Epic fail: Exploring project failure's reasons, outcomes, and indicators. *Rev Manag Sci* **16**, 1169–1193 (2022). https://doi.org/10.1007/s11846-021-00479-4
[12] Herz, M., Krezdorn, N. Epic fail: Exploring project failure's reasons, outcomes, and indicators. *Rev Manag Sci* **16**, 1169–1193 (2022). https://doi.org/10.1007/s11846-021-00479-4
[13] Mishakova, A., Vakhrushkina, A., Murgul, V., & Sazonova, T. (2016). Project control is based on a mutual application of pert and earned value management methods. *Procedia Engineering, p. 165*, 1812-1817. https://doi.org/10.1016/j.proeng.2016.11.927
[14] Humphreys, G. C. (2018). *Project management using earned value* (4th ed.). Humphreys & Assoc.

1. **Prevents Scope Creep:** By clearly defining the project scope, you can avoid scope creep, which occurs when additional tasks are added without proper approval, leading to delays and cost overruns[15].
2. **Enhances Communication:** A well-defined scope ensures that all stakeholders have a clear understanding of the project's goals, deliverables, and boundaries, reducing misunderstandings and conflicts.
3. **Improves Planning and Scheduling:** Project managers can create more accurate schedules and budgets with a clear scope, ensuring that resources are allocated efficiently.
4. **Facilitates Risk Management:** Identifying the project scope helps in recognizing potential risks early, allowing for better risk mitigation strategies.
5. **Ensures Quality Control:** Scope management helps maintain the quality of the project's deliverables by setting clear expectations and standards.

Scope management allows project managers to react when a project underperforms in schedule, budget, and quality at the execution stage. Scope management can also minimize project changes and budget omissions and improve the accuracy of project cost estimates and risk responses. For scope management to be effective, though, it needs to rely on a robust work breakdown structure (WBS).[16].

A reliable schedule is more than just a timeline; it is a critical management tool that helps project managers plan, execute, and monitor project activities. It provides a roadmap for project execution, detailing when tasks should start and finish and identifying key milestones. A well-constructed schedule helps anticipate potential delays and mitigate risks, thereby enhancing the likelihood of project success.

In this paper, the author will develop a standardized WBS for Overhead Electrical Distribution Line Projects that can fulfill these plans:

1. Determine the method for developing a Work Breakdown Structure (WBS)/Cost Breakdown Structure (CBS) for the Overhead Electrical Power Distribution Line that covers all aspects and phases of the project and will be used for cost estimation and scheduling.

[15] Senapathy, Y. (2023, May 16). *Project scope management: Definition, importance, benefits, and how it works*. Project Management Training Institute (PMTI) - Best PMP, CAPM, & PMI-ACP Certification Courses Boot Camp Classes | PMTI. Retrieved June 14, 2024, from https://www.4pmti.com/learn/project-scope-management/
[16] Cerezo-Narváez, A., Pastor-Fernández, A., Otero-Mateo, M., & Ballesteros-Pérez, P. (2020). Integration of cost and work breakdown structures in the management of construction projects. *Applied Sciences*, *10*(4), 1386. https://doi.org/10.3390/app10041386

2. Create a new "Overhead Electrical Power Distribution Line" Work Breakdown Structure (WBS) framework.

The result of this development will be a WBS standardization to develop the schedule assessment checklist and a scoring mechanism for the Contractor, as well as feedback to the Owner as per the minimum pass result. Considering this standard will be implemented on a contract basis, contractors will receive guidance on areas where best practices were not fully applied, with recommendations on how to incorporate these practices in future projects to ensure the development of reliable, high-quality schedules.

METHODOLOGY

The author will develop a methodology referring to the procedure described by Sullivan.[17], as shown in **Error! Reference source not found.**.

Figure 4 Engineering Economic Analysis Procedure & Steps of the Scientific Process[18]

The methodology is structured into four subheadings (steps 1–4), while the findings are organized into three subheadings (steps 5–7). By adhering to this methodology, the entire process will be approached scientifically. The following explanations provide further clarity on the steps involved in each stage.

[17] Sullivan, W. G., Wicks, E. M., & Koelling, C. P. (2019). Chapter 1 Introduction of Engineering Economy. In *Engineering Economy Global Edition* (17th ed.). Pearson UK.
[17] Sullivan, W. G., Wicks, E. M., & Koelling, C. P. (2019). Chapter 2 Cost Concepts and Design Economics. In *Engineering Economy Global Edition* (17th ed.). Pearson UK.
[18] Sullivan, W. G., Wicks, E. M., & Koelling, C. P. (2019). Chapter 1 Introduction of Engineering Economy. In *Engineering Economy Global Edition* (17th ed.). Pearson UK.

Step 1 – Problem Definition

Project delay is a significant issue in the early construction phase. The Overhead Electrical Power Distribution Line project is one of the early work projects that must be completed in December 2025. According to the master plan, this project must construct a 16 km Overhead Electrical Power Distribution Line into the PTVI permanent facility. This project will be constructed in 1.5 years until the energized and commissioning phase.

The Challenge

Local contractors will execute The Overhead Electrical Power Distribution Line project in the greenfield area. A comprehensive plan and schedule are a must. All required resources, such as materials availability, concrete supply, workforce, mobile equipment, support facilities (electricity, ventilation, ground support), and construction methods, should be well prepared.

Most of their projects were delayed, especially for local contractors in our operation area. This aligns with Rauzana A and Dharma W's statement.[19], the prevalence of cost overruns and time delays in Indonesian construction projects. By the end of 2017, 460 infrastructure projects in one province in Indonesia had progressed to less than 75% completion, indicating significant delays.

The Overhead Electrical Power Distribution Line Project needs a quality schedule that will be used to measure and control because this project will allow the Project Manager to manage it and promptly respond to any problems that will affect its completion. This schedule will be helpful for the following electrical power distribution line project.

Both owners and contractors must consider cost overruns and time delays because they can impact the project. Even on a larger scale, it will significantly impact national economies. Generally, cost overrun in a project happens when the budget and or cost increases. Time delays happen when the project duration increases because of unpredictable time performance in construction projects. Some previous studies agreed that completing the project within the scheduled duration and planned budget is a critical success factor in project construction.

For this reason, we need to fix the scope of work and WBS first so that "all critical decisions and preparations are made at the beginning of the construction project, which

[19] Rauzana, A., & Dharma, W. (2022). Causes of delays in construction projects in the province of Aceh, Indonesia. *PLOS ONE*, *17*(1), e0263337. https://doi.org/10.1371/journal.pone.0263337

helps to minimize risk, reduce costs, and guarantee the project is finished on schedule and within budget."[20].

The modern concept of military strategy has four primary classifications that are useful for understanding it in any organizational context: Grand Strategy, Strategy, Operations, and Tactics. In the construction project, these four essential ideas are at the root of the usefulness of project organization. They also assist in dividing responsibility between levels of the chain of command so that there is no overlap.[21].

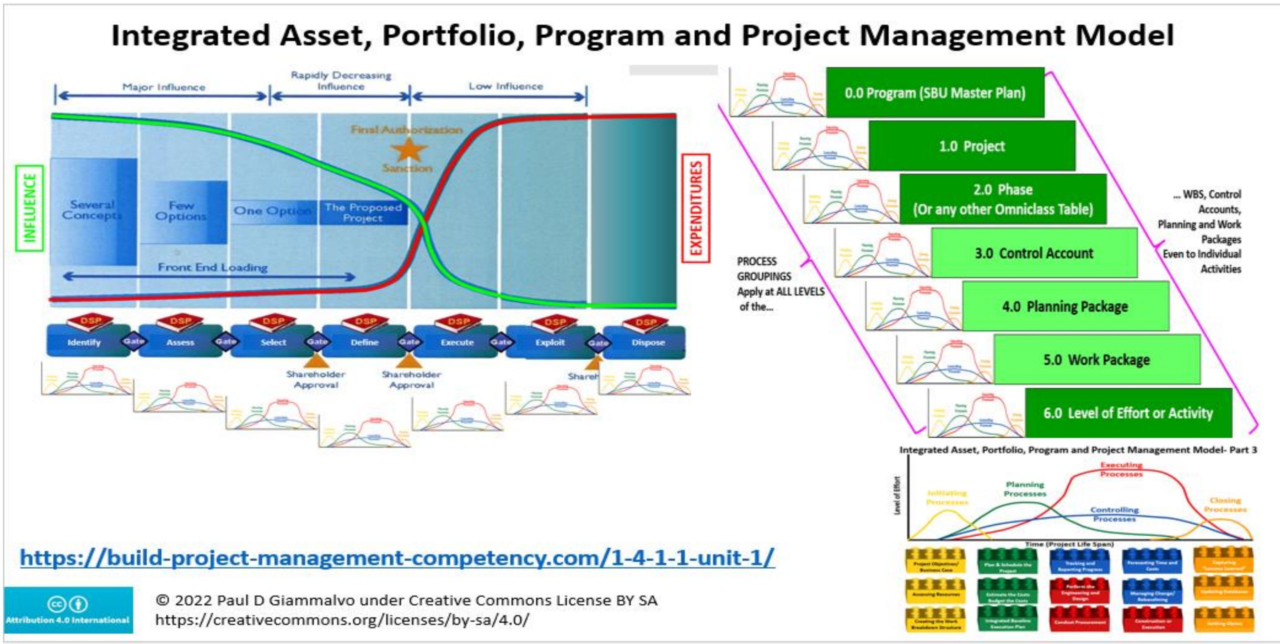

Figure 5. Decision Support Package (DSP) Information (MacLeamy, Paulson, or Boehm Curve)[22]

From Figure , one of the DSP components that must be prepared after selecting the one and best option then entering the proposed project phase gate is level 4 – WBS.

[20] The H+M Industrial Team. (2023, July 12). *Front-end loading project management: Planning for success*. H+M Industrial EPC. https://www.hm-ec.com/blog-posts/front-end-loading-project-management-planning-for-success-hm

[21] Security and Strategic Studies at Military School – Osona Base - 2024/2025. https://namibiahub.com/security-and-strategic-studies-at-military-school-osona-base/

[22] Giammalvo & PTMC, P. D. (2021). Chapter 1. Governance and Integration. In *Project Control/PMO Handbook of Best Tested and Proven Practices, Unit 11 Managing Process* (p. 78). PTMC.Giammalvo, P. D. (2021). Decision. PM World Journal, 10(6).

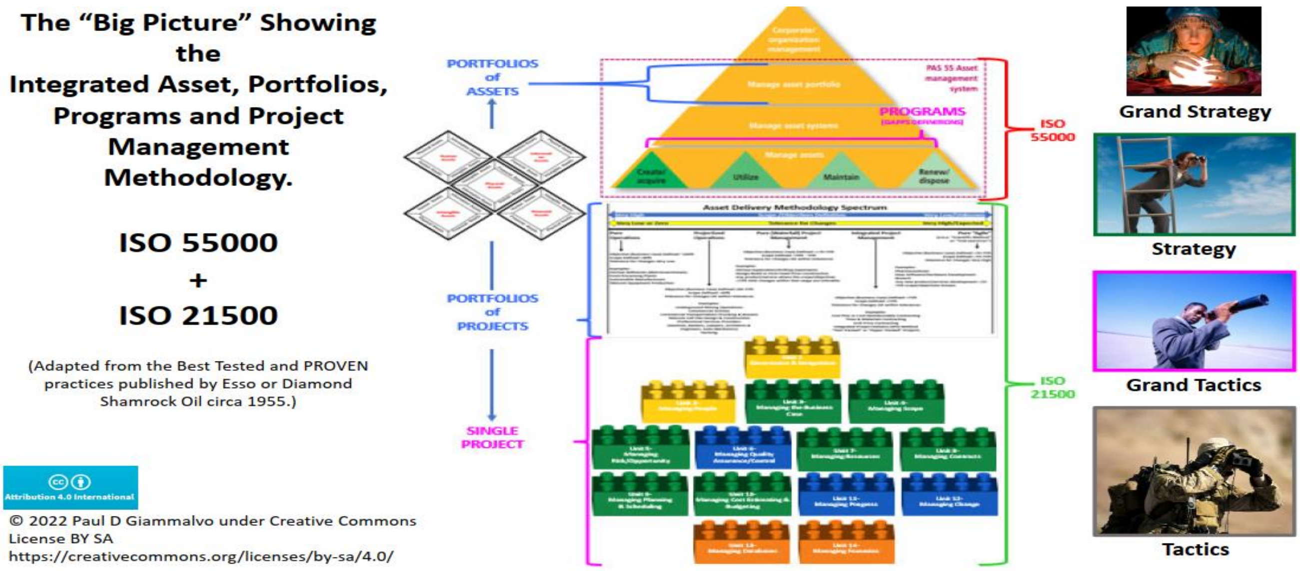

Figure 6. Big Picture that showing the integrated project management methodology[23]

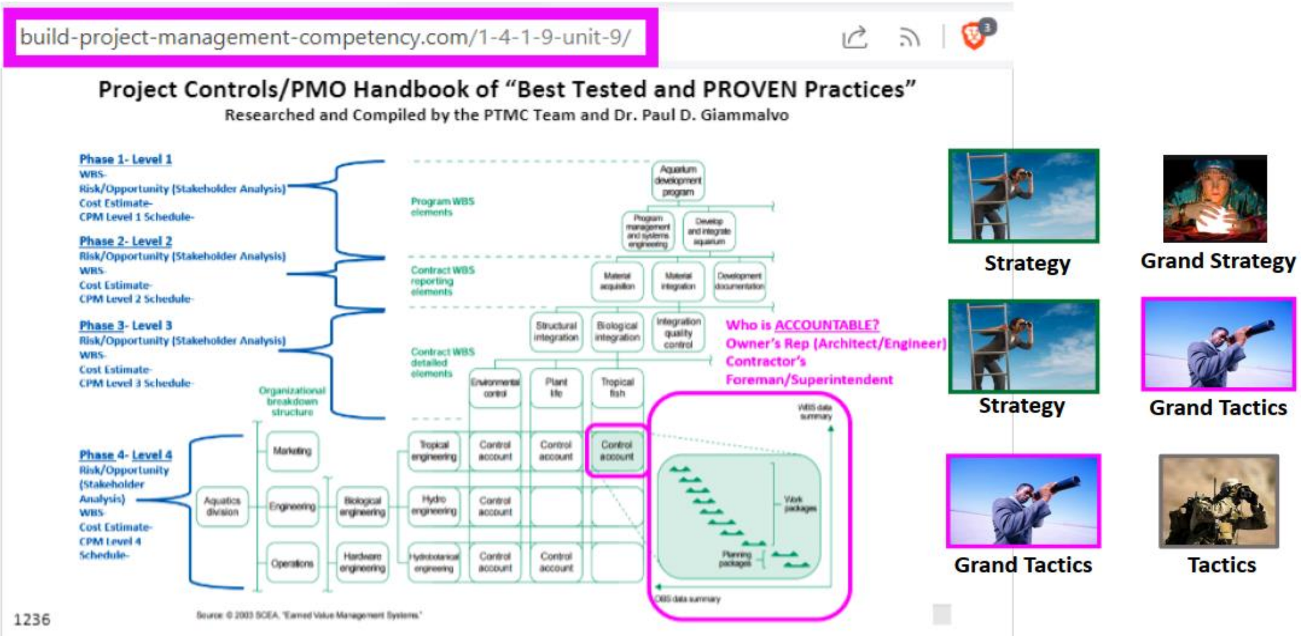

Figure 7. The concept of work and planning package activities and the control account[24]

[23] Giammalvo & PTMC, P. D. (2021). Chapter 1. Governance and Integration. In *Project Control/PMO Handbool of Best Tested and Proven Practices, Unit 11 Managing Process* (p. 14). PTMC.Giammalvo, P. D. (2021). Decision. PM World Journal, 10(6).
[24] Giammalvo & PTMC, P. D. (2021). Chapter 1. Governance and Integration. In *Project Control/PMO Handbook of Best Tested and Proven Practices, Unit 11 Managing Process* (p. 14). PTMC.Giammalvo, P. D. (2021). Decision. PM World Journal, 10(6).

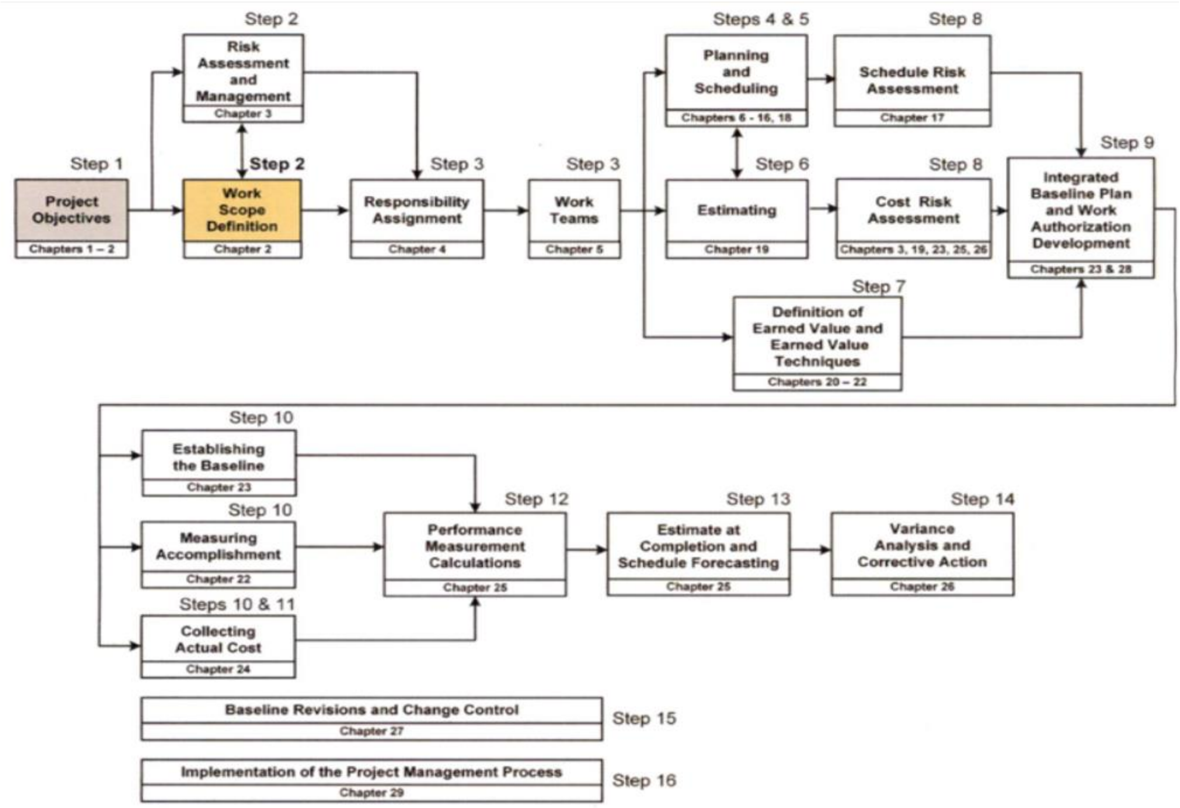

Figure 8. Earned Value Project Management: The Process[25]

Figures 7 and 8 show that the work breakdown structure is the most important phase. This phase should be clear because it is a baseline that will be used to define the project's resources, schedule, and cost. If we pick the wrong or inappropriate WBS, the successful construction project will suffer from completion delays and cost overruns.

When we develop the WBS in construction, the WBS must respond to eight potential questions from our stakeholders. One potential solution to this issue is to use Tesseract. "In geometry, a tesseract or 4-cube is a four-dimensional hypercube, analogous to a two-dimensional square and a three-dimensional cube."[26]. Similar to how a square's perimeter comprises four edges and a cube's surface is composed of six square faces, the hypersurface of a Tesseract is formed by eight cubical cells (unfolded Tesseract). This unfolded Tesseract is the best analogy for answering eight high-level questions for stakeholders. The Tesseract and the eight questions for stakeholders, which are analogous to the unfolded Tesseract, can be seen more clearly in Figure .

[25] Humphreys, G. C. (2018). Chapter 2. Definition of Scope, Work Breakdown Structure (WBS), and WBS Dictionary (p. 40). *Project management using earned value* (4th ed.). Humphreys & Assoc.
[26] *Tesseract*. (2024, September 2). Wikipedia, the free encyclopedia. Retrieved September 20, 2024, from https://en.wikipedia.org/wiki/Tesseract

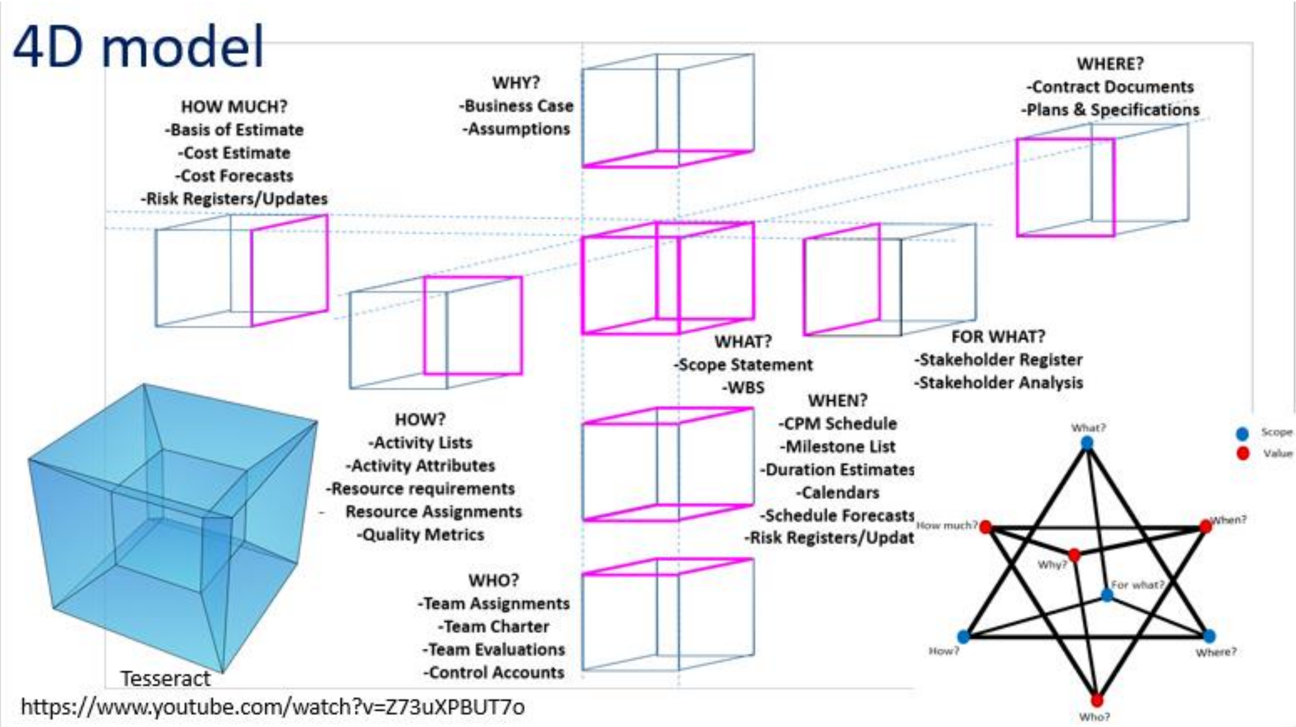

Figure 9. Eight questions to be answered if asked by our stakeholders (stakeholder needs)[27 28 29]

This Tesseract analogy will enhance the "development of accurate project requirements, provide an improved understanding of building projects and the process of linking additional data dimensions to building models, and give real-time and centralized information to project stakeholders."[30] In practice, it is feasible to model every aspect of a construction site—including fencing, storage areas, scaffolding, machinery, and signage—and visualize it realistically, aided by advanced technologies like virtual reality (VR), augmented reality (AR) or mixed reality (MR).[31]AR, VR, and MR can virtually bring key personnel to any job site, enabling more people to be present without needing travel or physical interaction, reducing risks and logistical challenges.

This multidimensional WBS refers to the Tesseract analogy, where tasks and deliverables organize work and additional factors like time, cost, risk, and resources (see

[27]*Hypercube*. (2024, August 30). Wikipedia, the free encyclopedia. Retrieved September 20, 2024, from https://en.wikipedia.org/wiki/Hypercube
[28] Leynaud, X., Giammalvo, P. D., & Moine, J. Y. (2019). Multidimensional Project Breakdown Structures - The Secret to Successful Building Information Modeling (BIM) Integration. *DCB Publishing*.
[29] Arba, D. (2021). Best Tested and Proven Practices for Hospital Construction: Standardized Multidimensional WBS/CBS Coding Structures. *PM World Journal*, *10*(2).
[30] News Desk. (2024, May 21). *What are bim dimensions? 2d, 3d, 4d, 5d, 6d, 7d and even 8d*. SurveyingGroup. https://www.surveyinggroup.com/what-are-bim-dimensions-2d-3d-4d-5d-6d-7d-and-even-8d/
[31]Editorial Team. (2021, November 26). *8D BIM: What is it and what are its benefits?* BibLus. https://biblus.accasoftware.com/en/8d-bim-what-is-it-and-what-are-its-benefits/

Error! Reference source not found.).[32] Organizations can significantly enhance project p erformance and results using the object-oriented multidimensional WBS.

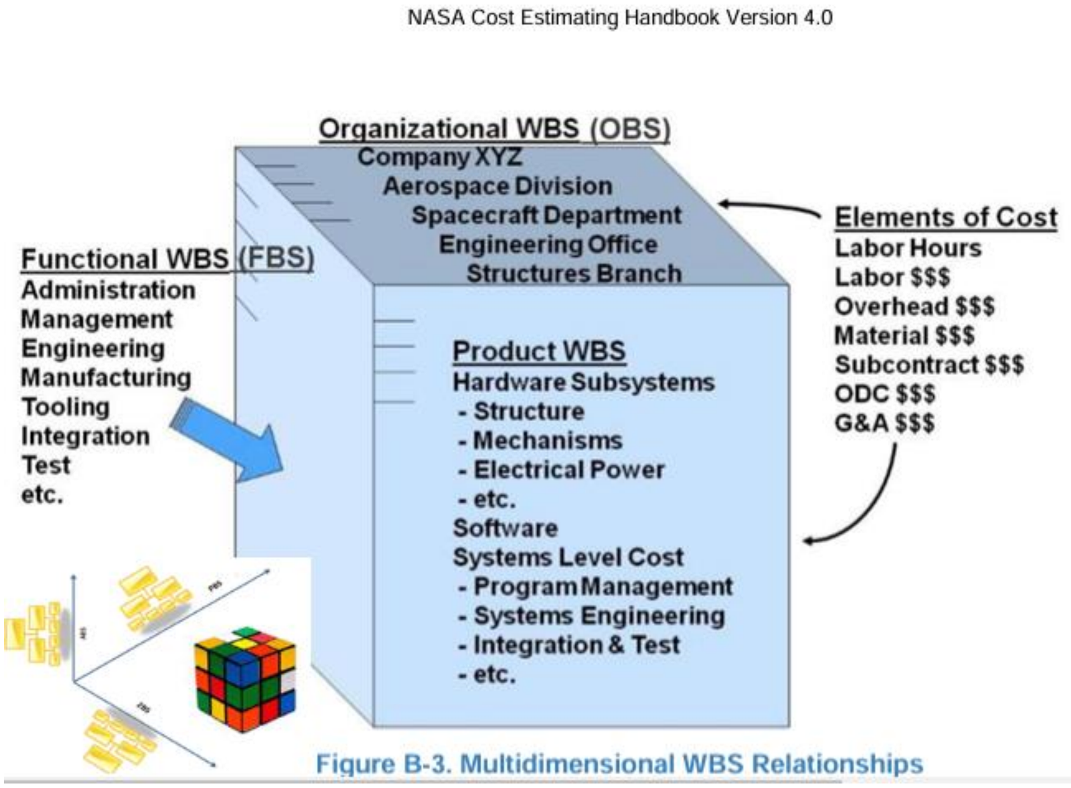

Figure B-3. Multidimensional WBS Relationships

Figure 9. Multidimensional WBS Relationships[33]

In developing a multidimensional Work Breakdown Structure (WBS), a ***Flat File Database*** collect data in a single table without inherent relationships, suitable for primary, linear projects. A ***Relational Database*** organizes data into multiple related tables, using keys to link dimensions like tasks, resources, and timelines, which is ideal for detailed tracking and complex queries. An ***Object-Oriented Database*** represents data as objects with encapsulated data and behavior, supporting inheritance and polymorphism, making it best for dynamic and flexible data modeling in complex projects. Each type of database offers unique advantages depending on the complexity and requirements of your multidimensional WBS.

Step 2 – Development on Feasible Alternative

Defining the "work scope definition" within the WBS Dictionary is crucial. Although breaking down the project scope into a WBS helps organize the work, it does not define each task alone. Depicting each element of the WBS is essential to facilitate clear

[32] Andrian, Y. P. (2024). Building an Econometrics Model for Pier Construction in an Indonesian Oil and Gas Company; *PM World Journal*, Vol. XIII, Issue IV, April.
[33] *U.s. National Aeronautics And Space Administration. (2017). NASA cost estimating handbook Ver 4.0. Createspace Independent Publishing Platform.*

communication and ensure all project team members are on the same track. Two feasible alternatives for determining the WBS are using Omniclass and ISO 19008:2016.

”The WBS” serves as a framework for defining all project work elements and their interrelationships, collecting and organizing information, developing relevant cost and revenue data, and integrating project management activities."[34]. Because of WBS's importance, choosing suitable WBS coding structures to implement in an electrical power distribution line project is important.

ISO 19008: 2016 is a Standard Cost Coding System (SCCS) for oil and gas production and processing facilities. It is a replacement for the Norsok Z-014.[35]. This SCCS consists of three individual hierarchical classification structures (facets)36, which are PBS, SAB, and COR.

- **PBS (Physical Breakdown Structure)**
  “PBS defines the physical/functional components of field installations. The PBS provides a classification structure, which enables an oil and gas production and processing facility configuration scheme to be classified. System/facilities descriptions in PBS are only intended to provide guidelines for cost coding, as the systems/facilities normally are designed and laid out differently and uniquely for each development project according to technical and functional requirements, construction philosophy, and project realization strategies.”[37]

- **SAB (Standard Activity Breakdown)**
  “SAB classifies the activity component of the scope of work. The alphabetical prefix introduces a code for using SCCS throughout all project phases, from exploration to removal of facilities.”[38]

- **COR (Code of Resource)**
  “COR classifies all project resources according to the type of contract/resource that is involved in the activity and has an associated set of rates. This hierarchical structure classifies the complete scale of resources in developing offshore and onshore facilities.”[39]

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[34] Rashid, M. E. (2016). The Influence of Non-Standard Work Breakdown Structure on Change Orders and Cost Estimation for Sudan Oil and Gas Projects. *PM World Journal*, *5*(12).
[35] Norsk Industri. (2016). *Norsok Analysis Project*. https://www.norskindustri.no/contentassets/bd73caa821de492480ab6c43b3e7556a/final-report-norsok-analysis-project-29-01-2017-eng-an.pdf
[36] International Organization for Standardization. (2016). *Standard cost coding system for oil and gas production and processing facilities (ISO Standard No. 19008)* (1st ed.).
[37] Ibid
[38] Ibid
[39] Ibid

Omniclass: OmniClass is designed to provide a standardized basis for classifying information created and used by the North American architectural, engineering, and construction (AEC) industry throughout the whole facility life cycle from conception to demolition or reuse and to encompass all the different types of construction that make up the built environment. OmniClass is intended to organize, sort, and retrieve information and derive relational computer applications. These are then divided into 15 suggested Tables for organizing construction information. The OmniClass Tables correspond to this arrangement of information:

Table ID	Defenition
Table 11 - Construction Entities by Function	Construction Entities by Function are significant, definable units of the built environment comprised of interrelated spaces and elements and characterized by function.
Table 21 - Elements	An Element is a major component, assembly, or "constituent of a construction entity with a characteristic function, form, or position" (ISO 12006-2:2015). Predominating functions include, but are not limited to, supporting, enclosing, servicing, and equipping a facility. Functional descriptions can also include a process or an activity.
Table 22 - Work Results	Work Results are construction results achieved in the production stage or by subsequent alteration, maintenance, or demolition processes, and identified by one or more of the following: the particular skill or trade involved; the construction resources used; the part of the construction entity which results; the temporary work or other preparatory or completion work which results. ISO 12006-2: 2015 defines work result as view of construction result by type of work activity and resources used and defines construction result as a construction object which is formed or changed in state as the result of one or more construction processes using one or more construction resources.
Table 23 - Products	Products are components or assemblies of components for permanent incorporation into construction entities.
Table 31 - Phases	Phases are periods of time in the duration of a construction project identified by the overall character of the construction processes which occur within it.
Table 32 - Services	Services are the activities, processes and procedures provided by participants in the design and construction process, and relating to the construction, design, maintenance, renovation, demolition, commissioning, decommissioning, and all other functions occurring in relation to the life cycle of a construction entity
Table 33 - Disciplines	Disciplines are the practice areas and specialties of the participants who are performing services during the life cycle of a construction entity, considered in light of education and training required to perform in those disciplines. Disciplines are presented without regard to the job functions that may be performed by individuals or teams, which are classified by Table 34 - Organizational Roles. Disciplines from Table 33 can be combined with entries from Table 34 - Organizational Roles to provide a more complete classification of a construction participant's role, such as an Electrical Contracting (discipline) Supervisor (organizational role)
Table 36 - Information	Information is data referenced and utilized during the process of creating and sustaining the built environment.

Table 1. Omniclass Voting Appropriate WBS Alternative[40]

Step 3 – Selection of Appropriate WBS Alternative

We use multi-attribute decision-making (MADM) to select a suitable method to define the WBS for the 5 MW Overhead Electrical Power Distribution Line Project. A multi-attribute decision-making (MADM) method defines how the information on attributes is processed to decide the best possible choice among the possible alternatives."[41].

[40] The Construction Specifications Institute, Inc. (CSI). (2019). *Introduction and User's Guide, Introduction Edition: 2.1, 2019-02-22 Release*. In OmniClass® A Strategy for Classifying the Built Environment (2.1st ed.).
[41] Ilbahar, E., Cebi, S., & Kahraman, C. (2019). A state-of-the-art review on multi-attribute renewable energy decision making. *Energy Strategy Reviews*, *25*, 18-33. https://doi.org/10.1016/j.esr.2019.04.014

MADM methods offer a structured approach for evaluating and ranking these alternatives. The author will use the MADM method to objectively evaluate and choose suitable WBS coding structures to implement in electrical power distribution line projects.

Attribute	Description	Criteria
Phase	The main stage in the lifecycle of line distribution project, starting from conception to completion	Design Phase
		Construction Phase
		Handover Phase
Engineering	Activities related to planning, design, and technical preparation before the start of physical construction	Surveying
		Design Phase
		Drawing
Procurement	Activities related to procurement material that essential as the key material in the construction phase	Procurement All Material
Construction	The physical execution phase where produced resources are utilized to build the line distribution	Shelter Construction
		Land Clearing
		Excavation
		Accecories Installation
		Erection Pole
		Concrete Pole Pedestal
		Guywire Installation
		Pulling Cable
		Travo Installation
		Grounding Installation
		Anti Climb Installation
		Pole Label Installation
Completion	Activities required to finalize construction including inspection, testing, and commisioning until the project is ready to operate and handed over to owner	Commisioning

Table 2. Selection Criteria of Appropriate WBS Alternative[42]

"The choice of attributes used to judge is one of the most important tasks in multi-attribute decision analysis". Selecting attributes is usually the result of group consensus and is subjective. The final list of attributes, monetary and nonmonetary, is heavily influenced by the decision problem and by an intuitive feel for which attributes will or will not pinpoint relevant differences among feasible, unreliable, and difficult to manage. If some attributes

[42] By Author

in the final list lack specificity or cannot be quantified, it will be necessary to subdivide them into lower-level attributes that can be measured.[43].

Step 4 – Selection of Acceptable Criteria for WBS Selection

In this step, the author identifies and selects a relevant table from each WBS coding structure that matches the criteria that the author already made. The results are shown in **Error! Reference source not found.** for CSI Omniclass WBS and **Error! Reference source not found.** for ISO 19008:2016 WBS.

Identifying feasible alternatives and appropriate attributes represents much of the work associated with multi-attribute decision analysis. The next task is to develop metrics and measurement scales that permit various states of each attribute to be represented. A subjective assessment of a metric that has a grade of poor, fair, reasonable, perfect, and excellent. In many problems, the metric is simply the scale upon which a physical measurement is made.[44]

Criteria	Omni Class														
	11	12	13	14	21	22	23	31	32	33	34	35	36	41	49
Energy Distribution Facility Project	1							1							
Design Phase								1							
Construction Phase								1							
Handover Phase								1							
Surveying	1	1				1			1						
Design Phase	1	1				1			1						
Drawing	1	1				1			1						
Procurement All Material							1	1							
Shelter Construction	1	1			1	1	1								
Land Clearing	1	1			1	1	1								
Excavation	1	1			1	1	1								
Accecories Installation	1	1			1	1	1								
Erection Pole	1	1			1	1	1								
Concrete Pole Pedestal	1	1			1	1	1								
Guywire Installation	1	1			1	1	1								
Pulling Cable	1	1			1	1	1								
Travo Installation	1	1			1	1	1								
Grounding Installation	1	1			1	1	1								
Anti Climb Installation	1	1			1	1	1								
Pole Label Installation	1	1			1	1	1								
Commisioning	1	1													
Total	17	16	0	0	12	15	13	5	3	0	0	0	0	0	0

Table 3. CSI Omniclass Attribute for MADM Analysis[45]

[43] Sullivan, W. G., Wicks, E. M., & Koelling, C. P. (2020). Chapter 14 Decision Making Considering Multiattributes. In *Engineering Economy Global Edition* (17th ed.). Pearson UK.
[44] Sullivan, W. G., Wicks, E. M., & Koelling, C. P. (2020). Chapter 14 Decision Making Considering Multiattributes. In *Engineering Economy Global Edition* (17th ed.). Pearson UK.
[45] By Author

Criteria	ISO 19008:2016		
	PBS	SAB	COR
Energy Distribution Facility Project	1	1	1
Design Phase	1	1	
Construction Phase	1	1	
Handover Phase	1	1	
Surveying			
Design Phase	1	1	1
Drawing	1	1	1
Procurement All Material		1	
Shelter Construction	1	1	1
Land Clearing	1	1	1
Excavation	1	1	1
Accecories Installation	1	1	1
Erection Pole	1	1	1
Concrete Pole Pedestal	1	1	1
Guywire Installation	1	1	1
Pulling Cable	1	1	1
Travo Installation	1	1	1
Grounding Installation	1	1	1
Anti Climb Installation	1	1	1
Pole Label Installation	1	1	1
Commisioning		1	
Total	**18**	**20**	**15**

Table 4. ISO 19008:2016 Attribute for MADM Analysis[46]

FINDINGS

Step 5 – Analysis and Comparison for Each Alternative

After analyzing the WBS coding structures of CSI Omniclass (Table 3) and ISO 19008:2016 (Table 4), it is concluded that both can be applied to Overhead Electrical Power Distribution Line projects. However, as shown in Table 5, the CSI Omniclass WBS coding structure meets all project criteria. Therefore, a standardized multidimensional WBS for an Overhead Electrical Power Distribution Line project will be developed using the CSI Omniclass coding structure.

[46] By Author

Attribute	Value	Dimension High Value	OmniClass		ISO 19008:2016	
			Value	Dimension High Value	Value	Dimension High Value
Phase	1	0	1.00	-	2.00	1.00
	2	1				
Engineering	1	0	4.00	0.75	2.00	0.25
	2	0.25				
	3	0.5				
	4	0.75				
	5	1				
Procurement	1	0	2.00	1.00	1.00	-
	2	1				
Construction	1	0	5.00	1.00	3.00	0.50
	2	0.25				
	3	0.5				
	4	0.75				
	5	1				
Completion	1	0	2.00	1.00	1.00	-
	2	1				
Total			**OmniClass**		**ISO 19008:2016**	
				3.75		1.75

Table 5. Omniclass & ISO 19008:2016 MADM Analysis[47]

Step 6 – Standardizing A WBS using CSI Omniclass Coding Structure

OmniClass provides a method for classifying the fully built environment through the project life cycle. OmniClass intentionally includes content from all types of construction—commercial and institutional buildings, horizontal construction like roads and railways, process plants and industrial construction, heavy civil projects like dams and bridges, and even single-family residential construction.

This breadth and depth of coverage allow for organizing, filtering, sorting, and retrieving information and standardizing digital data exchanges.[48]. Based on Table 5, the CSI Omniclass coding structure will be used to create a multidimensional WBS for an Overhead Electrical Power Distribution Line project, utilizing Tables 11[49], 21[50], p. 22[51], p.

[47] By Author
[48] Ibid
[49] OmniClass. (2020). Entity by Fucntioon - Table 11. https://www.csiresources.org/standards/omniclass
[50] OmniClass. (2020). Elements - Table 21. https://www.csiresources.org/standards/omniclass
[51] OmniClass. (2020). Work Results - Table 22. https://www.csiresources.org/standards/omniclass

23[52], p. 31[53], p. 32[54], p. 33[55], and 36[56], ranked according to the MADM results in Table 5.

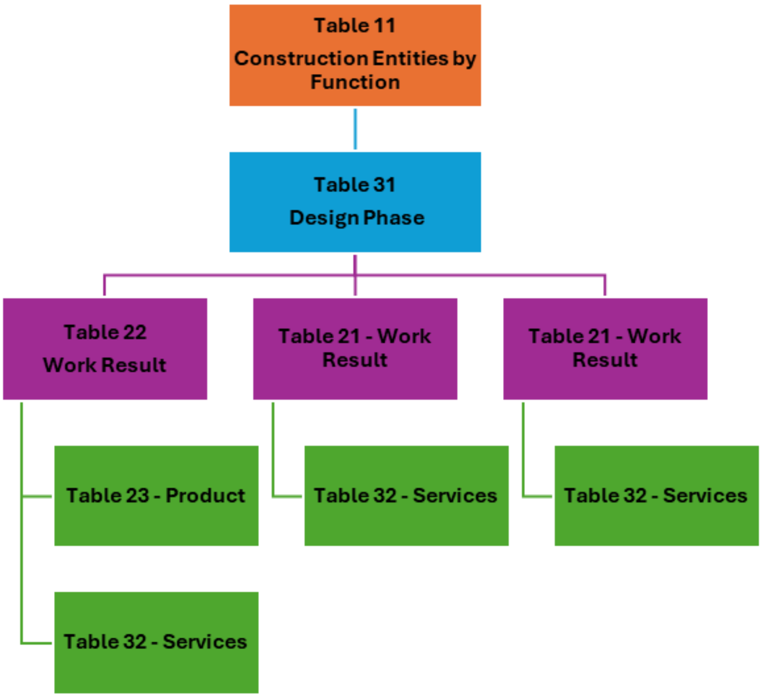

Figure 11a. Proposed WBS Structure for Design Phase Electrical Power Line Distribution Project Using CSI Omni Class Table[57]

[52] OmniClass. (2020). Products - Table 23. https://www.csiresources.org/standards/omniclass
[53] OmniClass. (2020). Phases - Table 31. https://www.csiresources.org/standards/omniclass
[54] OmniClass. (2020). Services - Table 32. https://www.csiresources.org/standards/omniclass
[55] OmniClass. (2020). Disciplines - Table 33. https://www.csiresources.org/standards/omniclass
[56] OmniClass. (2020). Information - Table 36. https://www.csiresources.org/standards/omniclass
[57] By Author

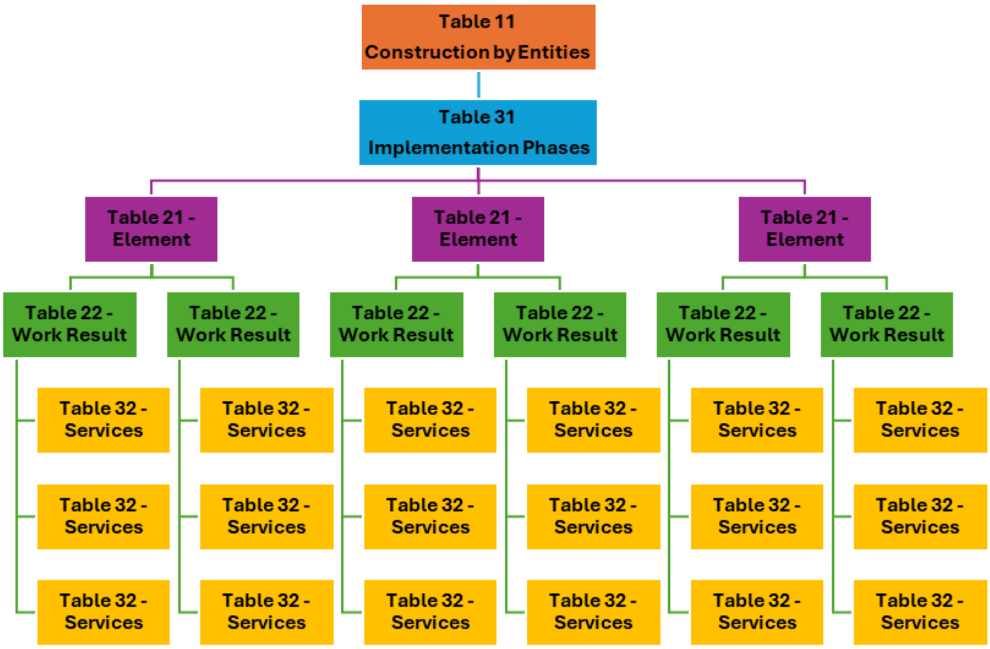

Figure 11a. Proposed WBS Structure for Design Phase Electrical Power Line Distribution Project Using CSI Omni Class Table[58]

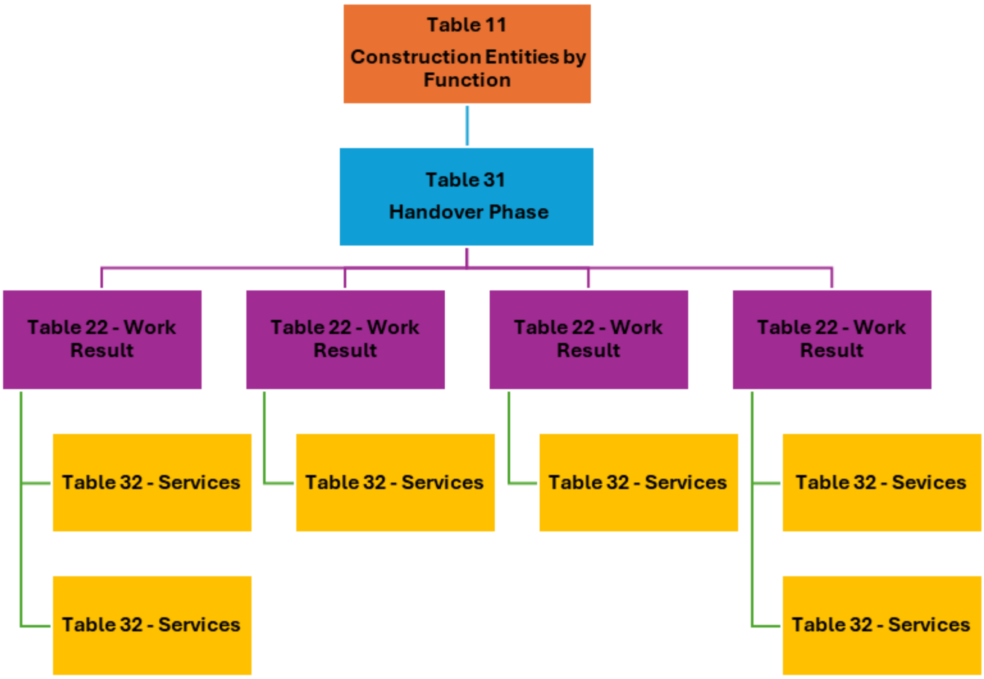

Figure 11c. Proposed WBS Structure for Implementation Phase Electrical Power Line Distribution Project Using CSI Omni Class Table[59]

[58] By Author
[59] By Author

The WBS Standardization for the Overhead Electrical Power Distribution Line Project is shown in

- Appendix 1. WBS Standardization Table for Overhead Electrical Power Distribution Line Project.
- Appendix 2 Detail WBS Structure for *Design Phase* Overhead Electrical Power Distribution Line Project.
- Appendix 3. Detail WBS Structure for *Implementation Phase* Overhead Electrical Power Distribution Line Project.
- Appendix 4. Detail WBS Structure for *Handover Phase* Overhead Electrical Power Distribution Line Project.

Step 7 – Performance Monitoring

To ensure the effectiveness of the Project Breakdown Structure (PBS) for the Overhead Electrical Power Distribution Line Project, the following steps are essential:

a. Pre-Implementation Evaluation:

- Assess the compatibility of the planned Work Breakdown Structure (WBS) with current practices.
- Establish company procedures and standards to support the implementation of the Multidimensional WBS during the Front-End Loading phase.
- Train schedulers and cost analysts on the Multidimensional WBS structure.

b. Implementation:

- Use a standardized bidding template to align contractor bids with project requirements.
- Integrate advanced project management software to enhance construction cost estimates, improve material selection, and reduce human errors.

These measures will ensure the comprehensive incorporation of all project aspects into the WBS, resulting in more organized and efficient project management. Additionally, continuous monitoring and feedback mechanisms shall be established to address any issue promptly and maintain alignment with project goals. This structured approach will facilitate better decision-making and resource allocation throughout the project lifecycle.

CONCLUSION

The Overhead Electrical Power Distribution Line Project is a critical component that supports crucial facilities. Given its importance, the overhead Overhead Electrical Power Distribution Line project demands meticulous attention. Essential decisions and preparations made during the Front-End Loading (FEL) phase are crucial for mitigating risks, reducing costs, and ensuring timely and budget-compliant project completion. Subject to our objective in this paper, the authors summarize that:

a. Determine the method for developing a Work Breakdown Structure (WBS)/Cost Breakdown Structure (CBS) for The Overhead Electrical Power Distribution Line that covers all factors and phases of the project and will be used for cost estimation and scheduling.
    - Utilizing the Multi-Attribute Decision Making (MADM) method, it is concluded that a standardized Multidimensional WBS for the overhead electrical power distribution line project can be effectively developed using the CSI Omniclass coding structure.

b. Create a new "Overhead Electrical Power Distribution Line" Work Breakdown Structure (WBS) framework.
    - This new "Overhead Electrical Power Distribution Line" Work Breakdown Structure (WBS) framework is determined into level 4-WBS. According to Omniclass table, Level 1 WBS subject to Table 11[60] Entities by Function, Level 2 WBS subject to Table 31[61] Phases, Level 3 WBS subject to Table 21[62] subject to Elements and Level 4 WBS subject to Table 22[63] Work Result & Table 32[64] Services.

Attention must be given to aligning the WBS with current practices and standards, providing comprehensive training for schedulers and cost analysts, utilizing advanced project management software for accurate cost estimation and material selection, and maintaining rigorous oversight during the FEL phase to mitigate risks and control costs.

[60] Ibid
[61] Ibid
[62] Ibid
[63] Ibid
[64] Ibid

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APPENDICES

Appendix 1. WBS Standardization Table for Overhead Electrical Power Distribution Line Project.

Criteria Fulfilled	Omniclass Title	Table		Omniclass Number
Electrical Power Line Distribution	**Overhead Electrical Power Distribution Line**	**11**	**Construction Entities By Function**	**11-42 27 32**
Design Phase	Design Phase	31	Phases	31-40 00 00
Survey Report	Site Survey	22	Work Results	22-02 21 13
Surveying	Surveying	32	Services	32-35 47 23
Soil Investigation	Subsurface Investigation	22	Work Results	22-02 30 00
Soil Investigation	Investigating	32	Services	32-35 47 19
Engineering Adm & Mgmt	Project Management & Coordination	22	Work Results	22-01 31 00
Engineering Deliverable List	Designing	32	Services	32-41 71 00
Procedure	Designing	32	Services	32-41 71 00
Detail Engineering Design	Shop Drawings, Product Data and Samples	22	Work Results	22-01 33 23
Calculation	Calculating	32	Services	32-35 57 43
Developing	Developing	32	Services	32-35 57 37
Spesification	Specifying	32	Services	32-49 41 00
Shop Drawing & Data Sheet	Developing	32	Services	32-35 57 37
RFC	Reporting	32	Services	32-27 31 19
Procurement	Multiple Contract Coordination	22	Work Results	22-01 31 16
Rope, Wire, Cables	Rope	23	Product	23-13 23 21
Electrical Support Wires	Electrical Support Wires	23	Product	23-35 33 13 17
Switchgear	Switchgear	23	Product	23-35 31 31
Transformer	Transformer	23	Product	23-35 31 31
Electrical Distribution Control Panels	Electrical Distribution Control Panels	23	Product	23-35 31 15
Disconnect Switches	Disconnect Switches	23	Product	23-35 37 19
Electrical Grounding Device	Electrical Grounding Device	23	Product	23-35 39 11
Lightning Arresters	Lightning Arresters	23	Product	23-35 39 15 11
Surge Protection Devices	Surge Protection Devices	23	Product	23-35 39 17
Diesel Generator Sets	Diesel Generator Sets	23	Product	23-35 11 15 11
Electrical Utility Poles	Electrical Utility Poles	23	Product	23-39 23 11 11
Insulators	Electrical Conductor Insulation	23	Product	23-35 33 13 15
Fuse Cut Out	Fuses	23	Product	23-35 29 29
Technical Evaluation	Procuring	32	Services	32-11 55 00
Buy Material	Buying	32	Services	32-11 55 13
Scheduling	Scheduling of work	22	Work Results	22-01 32 13
Work Schedule	Scheduling	32	Services	32-19 31 00
Examination and Preparation	Construction Layout	22	Work Results	22-01 71 00
Mapping	Mapping	32	Services	32-57 51 13
Preconstruction	Construction Surveying	22	Work Results	22-01 71 23 16
Stake out	Surveying	32	Services	32-57 51 11
Mob & Demob Resources	Mobilization	22	Work Results	22-01 71 13
Mob & Demob of Personnel and working tools	Transporting	32	Services	32-57 41 11
Material Transportation	Delivering	32	Services	32-57 41 17
Mob & Demob of Heavy Equipment	Excavators	22	Work Results	22-41 61 23
Mob & Demob of HE	Transporting	32	Services	32-57 41 11

Table 6. WBS Standardization for 5 MW Electrical Power Line Distribution Project[65]

[65] By Author. If you would like a copy of the template, please email me at asdam.siswandy@gmail.com

Appendix 2. Detail WBS Structure for Design Phase Overhead Electrical Power Distribution Line Project

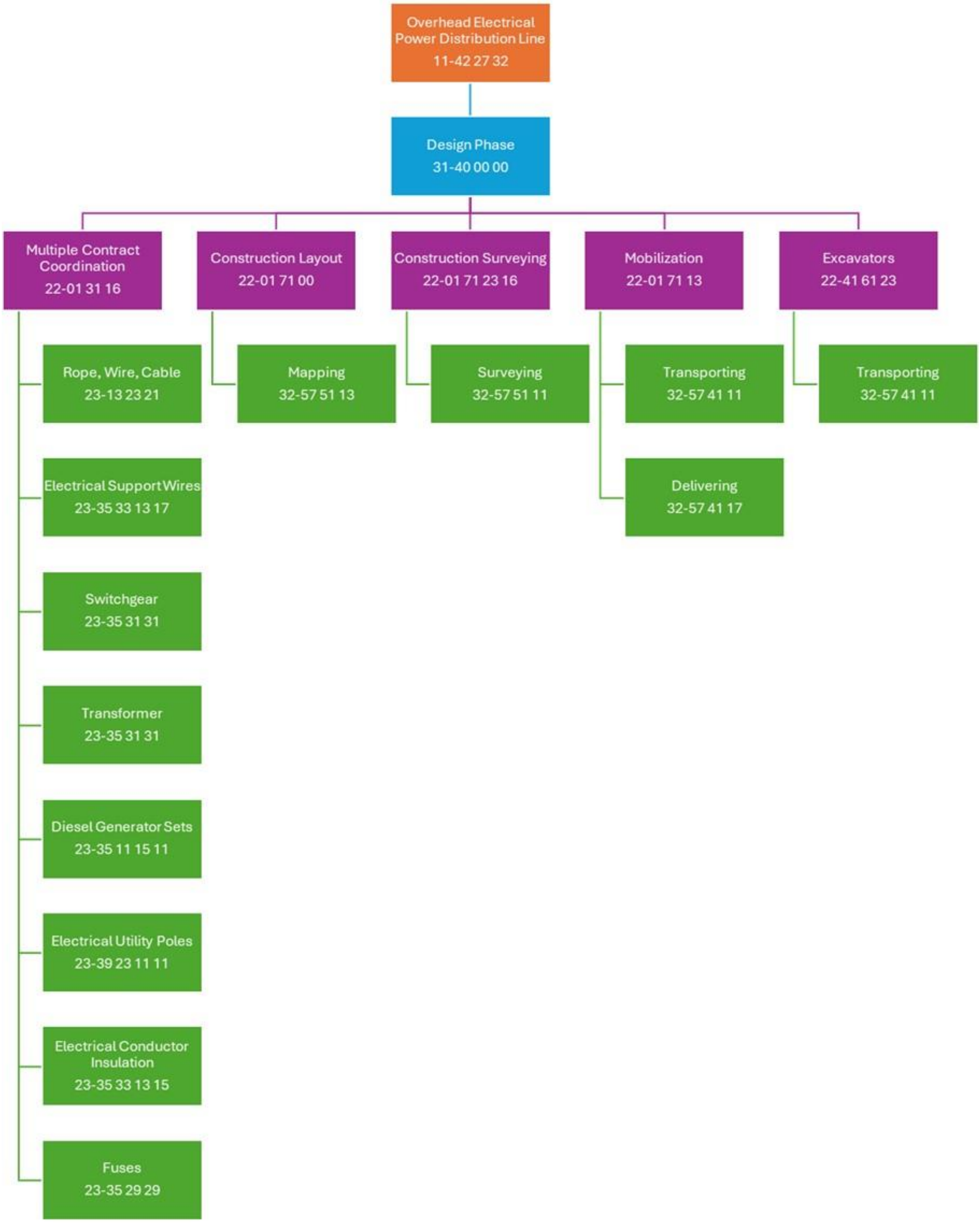

Figure 12a. Detail WBS Structure for Design Phase Electrical Power Line Distribution Project[66]

[66] By Author. If you would like a copy of the template, please email me at asdam.siswandy@gmail.com

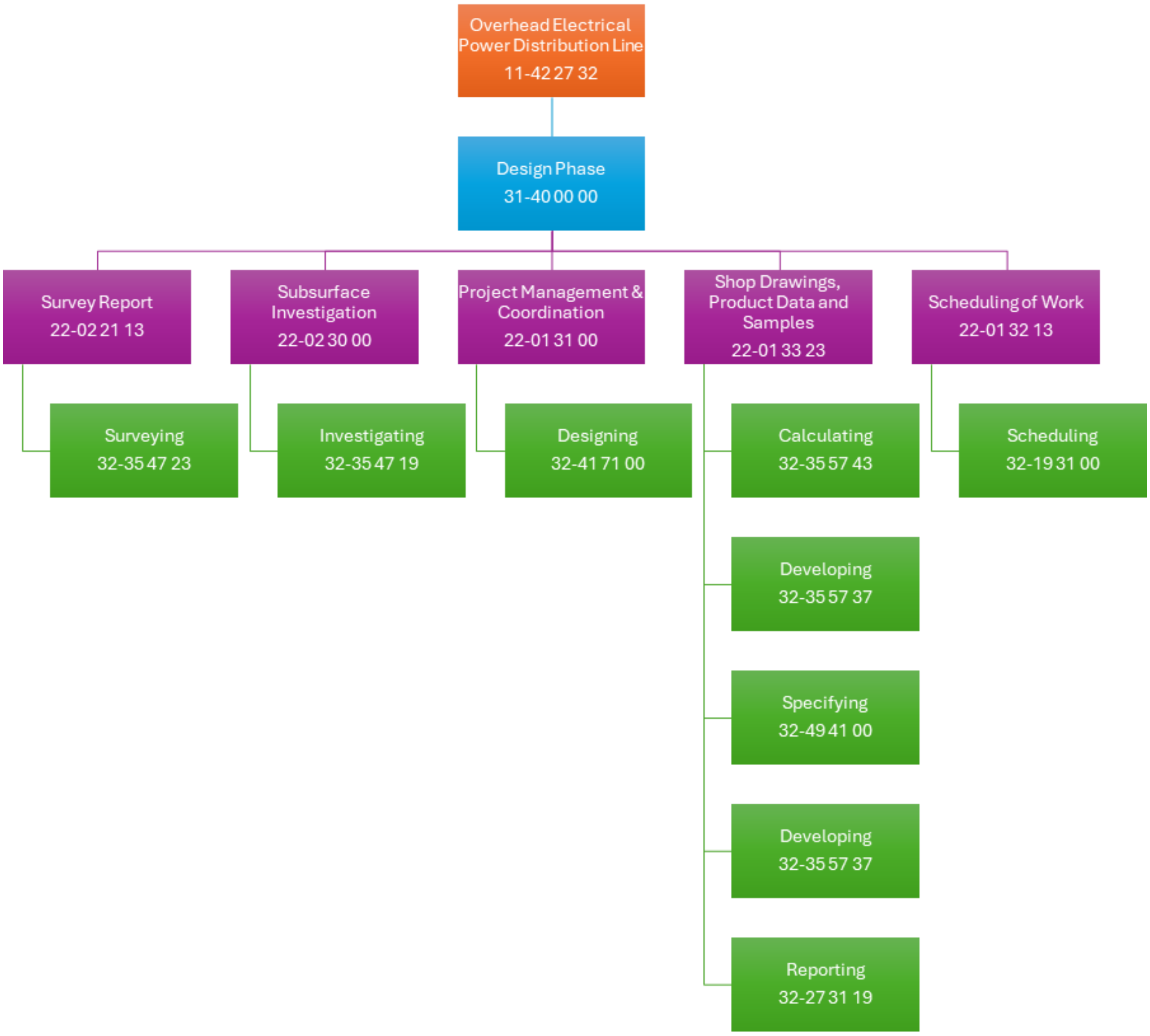

Figure 12b. Detail WBS Structure for Design Phase Electrical Power Line Distribution Project[67]

[67] By Author. If you would like a copy of the template, please email me at asdam.siswandy@gmail.com

Appendix 3. Detail WBS Structure for *Implementation Phase* Overhead Electrical Power Distribution Line Project

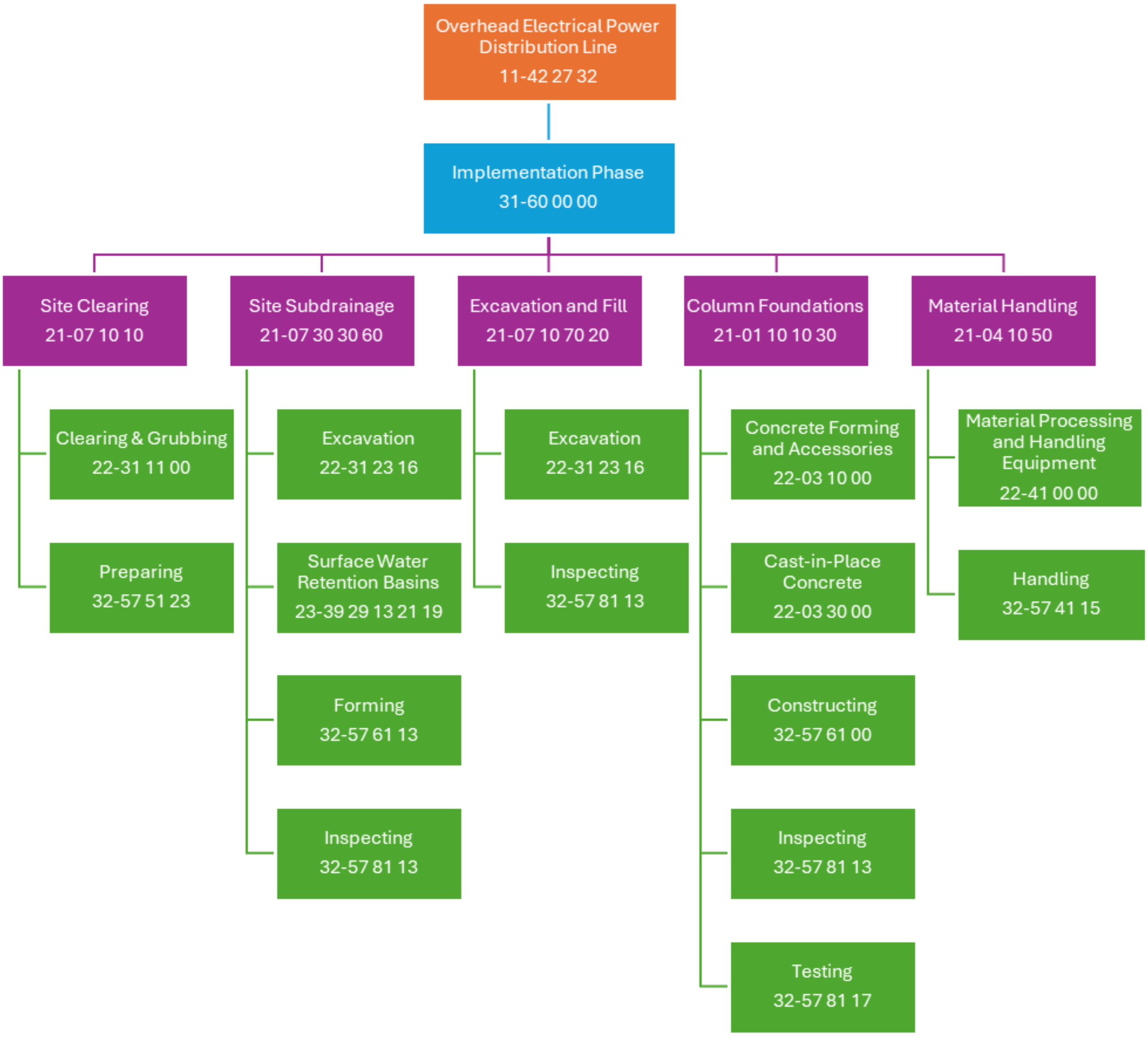

Figure 13a. Detail WBS Structure for Implemetation Phase Electrical Power Line Distribution Project[68]

[68] By Author. If you would like a copy of the template, please email me at asdam.siswandy@gmail.com

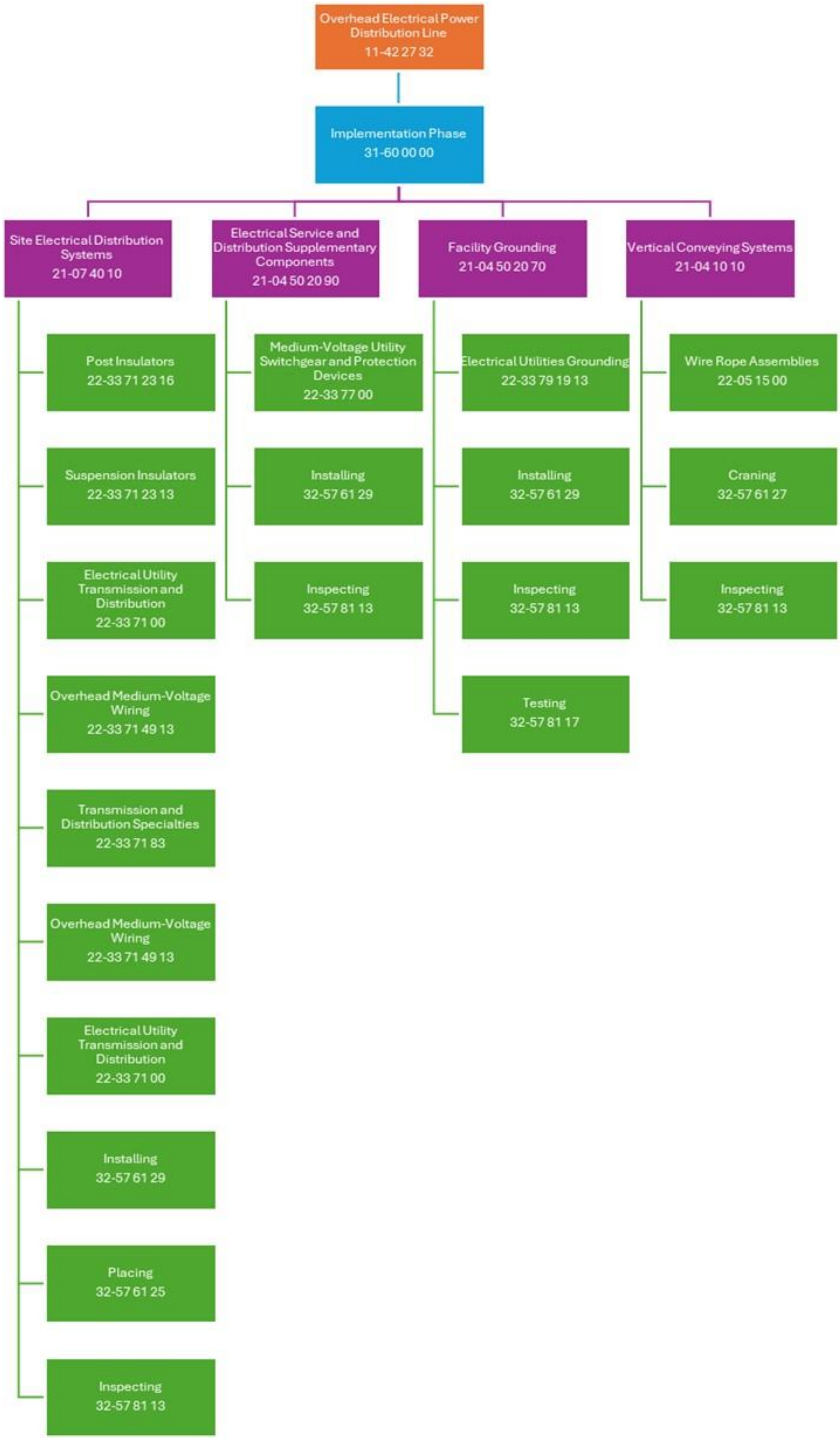

Figure 13b. Detail WBS Structure for Implementation Phase Electrical Power Line Distribution Project[69]

[69] By Author. If you would like a copy of the template, please email me at asdam.siswandy@gmail.com

Appendix 4. Detail WBS Structure for *Handover Phase* Overhead Electrical Power Distribution Line Project

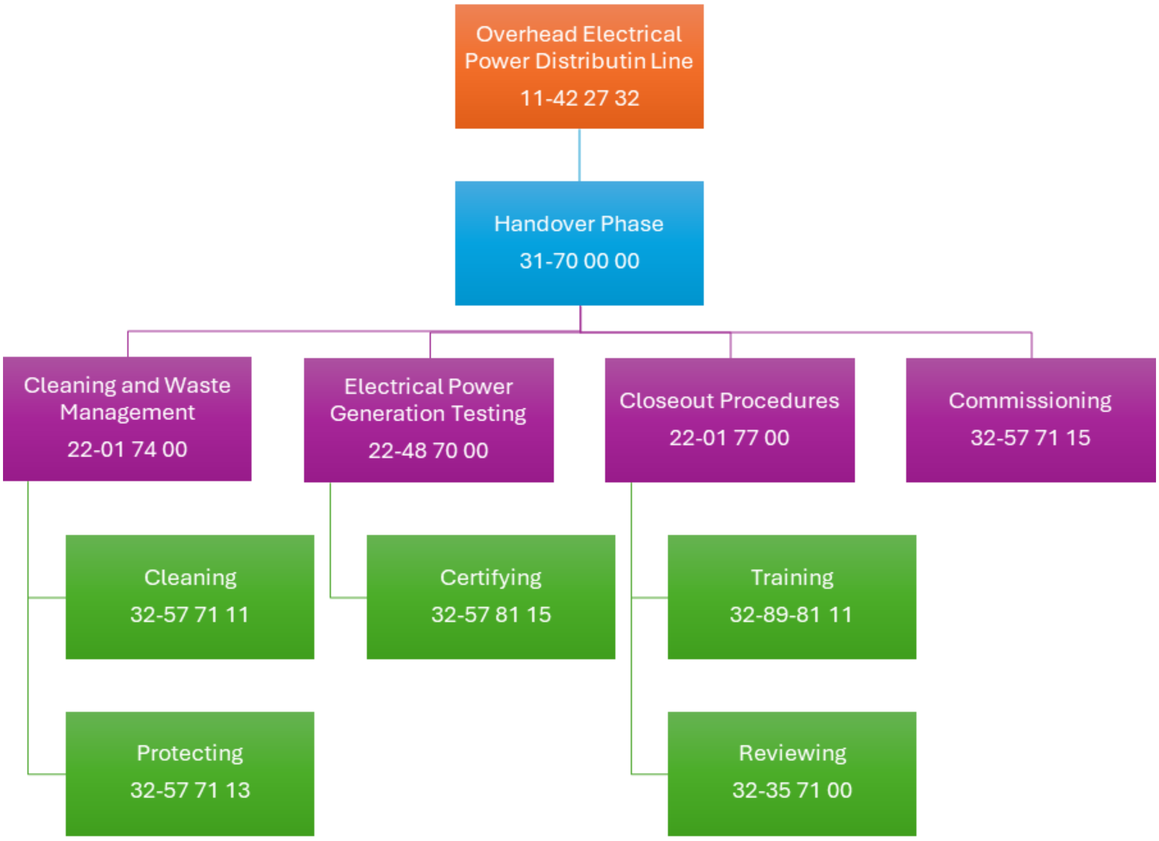

Figure 14. Detail WBS Structure for Handover Phase Electrical Power Line Distribution Project[70]

[70] By Author. If you would like a copy of the template, please email me at asdam.siswandy@gmail.com

About the Author

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Achmad Siswandy Asdam is a civil engineer at the Nickle Mining Company of Indonesia, with more than seven years of professional expertise in the Mineral and coal Mining sectors. Additionally, he has served as a project engineer for Construction Services and Facilities on the Indonesia Growth Project at Nickle Mining Company. He holds a bachelor's degree in civil engineering from Hasanuddin University (UNHAS) and is pursuing a master's degree program in Management that focuses on ESG Sustainability. He is attending a distance learning course led by Dr. Paul D. Giammalvo, CDT, CCE, MScPM, MRICS, GPM-m Senior Technical Advisor at PT Mitrata Citragraha, to obtain Certified Cost Professional certification from AACE International.

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