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Analysis of the Engineering Philosophical Foundation of Annual Strategic Planning at the Polyethylene Plant in Ras Lanuf Company

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ABSTRACT

This study examines the integration of engineering philosophical principles into annual strategic planning at the Ras Lanuf Polyethylene Plant in Libya. Using a quantitative cross-sectional survey design with 150 technical and managerial participants across five operating departments, the research operationalized engineering philosophy across eight dimensions: Engineering Philosophy Awareness, Systems & Operational Foundations, Reliability & Risk Awareness, Decision & Governance Philosophy, Strategic & Operational Alignment, Continuous Improvement & Learning, Human Factors & Socio-Technical Integration, and Measurement, Digitalization & Data Philosophy. Scale reliability analysis confirmed excellent internal consistency (Cronbach's $\alpha = 0.906$). Descriptive findings revealed moderate-to-high overall agreement ($M = 3.4448$, $SD = 0.58253$), with Engineering Philosophy Awareness scoring highest ($M = 3.4978$) and Digitalization & Data Philosophy scoring lowest ($M = 3.4100$). Inferential testing using one-way ANOVA demonstrated no statistically significant differences across job positions ($p = 0.459$), years of experience ($p = 0.842$), or operating departments ($p = 0.137$), indicating a homogeneous engineering culture. Pearson correlation analysis established significant positive associations across all eight dimensions ($r = 0.420$ to 0.603, $p < 0.001$), with the strongest relationship between Continuous Improvement and Digitalization ($r = 0.603$). The findings validate Socio-Technical Systems Theory, Systems Thinking, and Reliability Engineering as an integrated paradigm for petrochemical strategic planning. This research provides actionable guidance for plant management to enhance digital infrastructure, institutionalize cross-functional planning workshops, and formalize engineering philosophy guidelines within strategic planning policies, ultimately contributing to optimized operational performance and long-term industrial sustainability in Libya's petrochemical sector.

Keywords: Engineering philosophy, strategic planning, polyethylene plant, systems thinking, reliability engineering, petrochemical industry, Ras Lanuf

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1. Introduction

In the global petrochemical industry, annual strategic planning serves as a fundamental pillar for enhancing operational efficiency, supply chain resilience, and asset profitability. In capital-intensive polyethylene plants, operational success depends on balancing high capacity utilization with product quality control. Polyethylene production processes operate under severe thermal, mechanical, and thermodynamic constraints where feedstocks are directly tied to volatile international oil markets (Du et al., 2025; Marchetti et al., 2016). To optimize economic returns on capital assets, polymer plants run at high capacity while scheduling complex production wheels across multiple resin grades. However, unscheduled plant downtime, prolonged grade transitions, and off-spec production generate substantial economic penalties, making it vital that annual strategic planning transitions from traditional administrative routines toward a structured engineering philosophy (Marchetti et al., 2013, 2016). Annual strategic planning in petrochemical complexes involves a complex interaction between long-term capacity decisions and short-term operational execution schedules (Zhang et al., 2023). Strategic planners must align discrete-time financial targets with continuous-time chemical plant operations, accounting for feedstock availability, maintenance turnarounds, and retrofit projects (Lindahl, 2023; Wenli et al., 2025). Despite advanced mathematical optimization tools, industrial managers frequently encounter an execution gap between theoretical planning models and actual shop-floor operations.

At the Ras Lanuf Polyethylene Plant in Libya, a fundamental problem exists regarding the lack of systematic integration of engineering philosophical principles into annual strategic planning. Although strategic planning is a vital management function in Libya's oil and gas sector, current practices remain overwhelmingly managerial and administrative. Consequently, conventional planning cycles lack structured incorporation of core engineering philosophies, including systems thinking, reliability engineering, risk analysis, socio-technical integration, and digital governance. While the annual strategic plan at Ras Lanuf plays a central role in setting production targets, allocating maintenance budgets, scheduling unit turnarounds, and enforcing quality standards, the extent to which this plan reflects structured engineering logic remains empirically unexamined. Technical factors known to govern plant performance—such as process stability, equipment reliability, and feedstock quality—are frequently treated as isolated operational issues rather than integrated elements of strategic planning. As a result, planning at the plant risks relying on fragmented, experience-based approaches that fail to capture the complex reality of modern petrochemical systems, potentially inducing operational inefficiencies and increased failure risks. To resolve this problem, this study is guided by five primary research questions: (1) To what extent are engineering philosophical principles integrated into annual strategic planning at Ras Lanuf? (2) What role do engineering factors play in planning decisions? (3) How effectively aligned are strategic plans with daily plant operations? (4) What is the role of digital data systems in supporting strategic planning? (5) How do engineering philosophical foundations influence overall plant performance? Correspondingly, the main objective of this study is to analyze the role of engineering philosophical foundations in shaping annual strategic planning and to evaluate its systemic integration across operational functions at the Ras Lanuf Polyethylene Plant. Specific research objectives include: investigating the integration of systems thinking, reliability engineering, and risk-based decision-making into planning cycles; determining whether current planning reflects administrative heuristics versus engineering logic; evaluating the alignment between strategic goals and plant operations; assessing the role of digitalization and KPI measurement systems; and examining demographic variation in engineering philosophy awareness across departments.

The practical and academic significance of this research is substantial. Practically, this study provides Ras Lanuf management with a structured, evidence-based framework to evaluate and enhance its annual strategic planning processes. By identifying operational gaps across systems thinking, risk management, and digital measurement, the findings enable plant leadership to transition toward an evidence-based, engineering-driven management model. This transition supports optimized maintenance scheduling, minimizes grade transition off-spec production, reduces unscheduled equipment downtime, and strengthens the plant's competitive positioning within the Libyan petrochemical sector. Academically, this research bridges a literature gap by integrating engineering philosophy with industrial strategic management and empirical research. Translating complex engineering concepts into eight validated survey constructs provides a novel socio-technical methodology for industrial research in developing economies. For this study, Engineering Philosophical Foundation is operationally defined as the principles and frameworks—encompassing systems thinking, reliability, governance, and digitalization—that guide decision-making in strategic planning (Bristol, 2018; Buletova & Gorelova, 2017). Annual Strategic Planning is defined as a systematic organizational process used to define long-term goals, allocate resources, and establish operational priorities over a twelve-month cycle (Mousa et al., 2024). Systems Thinking refers to a holistic approach recognizing that individual organizational components operate as interconnected parts of a larger system (Senge, 2006; Checkland, 1999). Reliability Engineering Philosophy represents the integration of equipment reliability, failure analysis, and risk-based principles into planning processes (Du et al., 2025; ISO, 2018).

2. Literature Review

Engineering philosophy represents an emerging multidisciplinary domain investigating the intellectual, epistemological, ethical, and methodological foundations of engineering practice (Bristol, 2018; López-Cruz, 2021). Historically differentiated from theoretical sciences due to its practical orientation toward action and creation, modern engineering philosophy examines how technical knowledge is generated, validated, and applied within complex organizational settings (Dias, 2020; Korte et al., 2022). In industrial environments, engineering philosophy provides a comprehensive framework for decision-making, risk management, and strategic planning. Epistemologically, engineering philosophy addresses how operational data and empirical evidence are transformed into valid organizational knowledge (Buletova & Gorelova, 2017). Ontologically, it views industrial organizations as complex socio-technical systems comprising physical process units, automated control systems, environmental boundary conditions, and human operational agents (Buch, 2018; Tumidei et al., 2020). Integrating philosophical principles into industrial management enables organizations to reconcile technical feasibility with economic efficiency, safety, and environmental sustainability (Donia & Shaw, 2021; Nair & Bulleit, 2019).

Engineering management serves as the structural link between corporate strategy and technical operations. While conventional management often emphasizes financial metrics and administrative structures, engineering management incorporates technological capabilities, physical plant constraints, reliability requirements, and process safety standards directly into strategic decision-making (Chikasha et al., 2021; Kusumawardhani et al., 2017). Strategic planning within petrochemical plants requires sophisticated coordination between continuous cracking and polymerization processes, supply chain logistics, preventive maintenance turnarounds, and product quality specifications (Marchetti et al., 2016; Zhang et al., 2023). Empirical studies demonstrate that industrial enterprises adopting engineering-based strategic planning achieve superior operational performance, higher capacity utilization, and enhanced organizational resilience compared to firms relying purely on administrative planning models (Mousa et al., 2024; Quaglia, 2013). By grounding strategic planning in structured engineering logic, plant managers can systematically identify process bottlenecks, evaluate operational tradeoffs, and implement robust scenario-based decision-making (Oliver, 2023; Phaal et al., 2024).

Systems thinking represents a core pillar of modern engineering philosophy, conceptualizing organizations as holistic entities characterized by feedback loops, departmental interdependencies, and dynamic operational constraints (Checkland, 1999; Senge, 2006). In contrast to reductionist management evaluating departments in isolation, systems thinking examines how operational adjustments induce systemic effects across the enterprise (Meredith & Mantel, 2019). In a complex petrochemical facility like the Ras Lanuf Polyethylene Plant, systems thinking provides the conceptual framework required to align raw ethylene cracking, catalyst preparation, fluidized bed reactor operations, pelletization, and quality testing into a unified strategic plan (INCOSE, 2023). Furthermore, systems thinking underpins reliability engineering and asset management frameworks—such as ISO 55000—by demonstrating that equipment failure risks and maintenance backlogs directly affect long-term corporate strategy and plant availability (ISO, 2018; Rødseth & Schjølberg, 2017; Spüntrup et al., 2021).

To establish an operational framework for empirical measurement, this study operationalizes the Engineering Philosophical Foundation of Annual Strategic Planning across eight complementary dimensions: (1) *Engineering Philosophy Awareness*, evaluating participant understanding of how engineering principles shape decision-making (Bristol, 2018); (2) *Systems and Operational Foundations*, assessing the application of holistic systems thinking, process constraint identification, and bottleneck analysis (Tumidei et al., 2020; Castro & Téllez, 2025); (3) *Reliability and Risk Awareness*, measuring the integration of equipment failure trends, asset integrity, and risk management into planning (Du et al., 2025; Li & Du, 2023); (4) *Decision and Governance Philosophy*, evaluating the extent to which organizational decisions are structured, transparent, documented, and evidence-based (Quaglia, 2013; Ricard, 2013); (5) *Strategic and Operational Alignment*, assessing the translation of corporate goals into daily shop-floor engineering routines (Mousa et al., 2024; Lima & Guirardello, 2025); (6) *Continuous Improvement and Organizational Learning*, measuring the systematic utilization of operational feedback, post-campaign lessons learned, and Kaizen loops (Imai, 1986; Czachorowski & Haskins, 2021); (7) *Human Factors and Socio-Technical Integration*, evaluating operator involvement, workload considerations, technical training, and interdepartmental coordination (Trist & Emery, 1960; Horaguchi, 2024); and (8) *Measurement, Digitalization, and Data Philosophy*, examining reliance on accurate KPIs, digital monitoring dashboards, and advanced data analytics (Gomaa, 2025; Zulkafli & Kopanos, 2018). Tables 1, 2, and 3 map these dimensions to the literature, supporting theoretical concepts and empirical synthesis.

Table 1. Mapping of Questionnaire Sections to Engineering Philosophy Principles

Questionnaire Section	Core Dimension Evaluated	Primary Scholarly References	Conceptual Link to Survey Items
Section A	Demographic & Background Context	Demographic screening standards	Captures position, experience, and department to analyze perception variance.

Questionnaire Section	Core Dimension Evaluated	Primary Scholarly References	Conceptual Link to Survey Items
Section B	Engineering Philosophy Awareness	Bristol (2018); Buletova & Gorelova (2017); Dias (2020)	Measures baseline understanding and perceived importance of engineering philosophy.
Section C	Systems & Operational Foundations	Quaglia (2013); Zhang et al. (2023); Philbin & Kennedy (2020)	Evaluates holistic system perspectives, process interdependencies, and bottleneck analysis.
Section D	Reliability & Risk Awareness	Du et al. (2025); Li & Du (2023); Donia & Shaw (2021)	Assesses the integration of equipment failure trends, risk assessment, and safety indicators.
Section E	Decision & Governance Philosophy	Quaglia (2013); Ricard (2013); Liem (2015)	Evaluates evidence-based decision transparency, documentation, and governance structures.
Section F	Strategic & Operational Alignment	Chikasha et al. (2021); Mousa et al. (2024); Oliver (2023)	Measures alignment between corporate strategy, plant maintenance, and engineering limits.
Section G	Continuous Improvement & Learning	Czachorowski & Haskins (2021); Gidiagba et al. (2023); Imai (1986)	Assesses integration of operational feedback, lessons learned, and iterative planning updates.
Section H	Human Factors & Socio-Technical Integration	Horaguchi (2024); Trist & Emery (1960); Buch (2018)	Evaluates technician involvement, operator workload, training, and departmental coordination.
Section I	Measurement, Digitalization & Data Philosophy	Gomaa (2025); Phaal et al. (2024); Zulkafli & Kopanos (2018)	Examines reliance on calibrated instrumentation, real-time digital dashboards, and analytics.

Table 2. Supporting Literature for Key Engineering Philosophy Principles in Strategic Planning

Questionnaire Dimension	**Supporting Literature / Theoretical Concept**	**Theoretical Justification & Organizational Impact**
Engineering Philosophy Awareness	Definition of engineering philosophy (Bristol, 2018); Pragmatism & ethics (Nair & Bulleit, 2019).	Establishes a shared organizational culture where engineering principles guide strategic decision-making.
Systems & Operational Foundations	Holistic systems theory (Senge, 2006; Checkland, 1999); Process optimization (Castro & Téllez, 2025).	Ensures strategic plans account for non-linear process interactions, capacity limits, and bottlenecks.
Reliability & Risk Awareness	Asset management standards (ISO 55000, 2018); Failure mode modeling (Li & Du, 2023).	Incorporate risk mitigation, preventive maintenance, and asset integrity into strategic budget allocations.
Decision & Governance Philosophy	Evidence-based management (Quaglia, 2013); Traceability & accountability (Ricard, 2013).	Ensures strategic planning decisions are transparent, scientifically defensible, and documented.
Strategic & Operational Alignment	Enterprise-wide optimization (Zhang et al., 2023); Refinery MILP planning (Lima & Guirardello, 2025).	Eliminates the gap between high-level corporate targets and daily plant engineering execution capabilities.
Continuous Improvement & Learning	Kaizen & organizational learning (Imai, 1986); Participatory feedback loops (Phaal et al., 2017).	Fosters an adaptive organizational environment that refines future planning cycles using historical plant data.
Human Factors & Socio-Technical Integration	Socio-technical systems theory (Trist & Emery, 1960); Human-AI collaboration (Horaguchi, 2024).	Recognizes that engineering technology succeeds only when aligned with technician skills and ergonomics.

Questionnaire Dimension	Supporting Literature / Theoretical Concept	Theoretical Justification & Organizational Impact
Measurement, Digitalization & Data Philosophy	Industry 4.0 & digital twin modeling (Gomaa, 2025); Automated analytics (Zulkafli & Kopanos, 2018).	Replaces subjective opinion with calibrated real-time plant data, digital dashboards, and predictive metrics.

Table 3. Synthesis of Literature on Engineering Philosophy and Strategic Planning in Industrial Operations

Source Author(s)	Research Context	Methodology / Focus	Key Empirical Findings	Relevance to Present Study
Mousa et al. (2024)	Global Manufacturing Sector	Empirical survey & regression analysis	Strategic planning significantly improves organizational performance when technical constraints are integrated.	Validates the link between engineering-based planning philosophy and operational efficiency.
Oliver (2023)	Global Industrial Operations	Case study analysis of scenario planning	Pragmatic philosophy and scenario planning enhance enterprise adaptability in volatile markets.	Highlights practical scenario planning frameworks for dynamic petrochemical facilities.
Abusaloua et al. (2015)	Regional / Libya (AlBrega Co.)	Empirical water treatment case study	Identified severe operational constraints resulting from poor engineering planning and maintenance deferral.	Demonstrates engineering-based operational challenges within the Libyan industrial context.
Tertouche et al. (2021)	Regional / Libya	Experimental laboratory trials	Electrocoagulation optimization achieved 91% BOD removal compared to conventional biological treatment.	Provides empirical evidence of technical process optimization in Libyan industrial plants.
Philbin & Kennedy (2020)	Global Manufacturing	Performance metrics analysis	Overemphasis on financial metrics without engineering context degrades	Underscores the necessity of balancing financial goals with technical engineering foundations.

Source Author(s)	Research Context	Methodology / Focus	Key Empirical Findings	Relevance to Present Study
			operational efficiency.	
Castro & Téllez (2025)	Global Process Industry	Process optimization modeling	Integrated evaluation of chemical production pathways optimizes operating expenditure and product yields.	Demonstrates how fundamental engineering principles directly inform strategic planning decisions.

3. Method

This chapter presents the quantitative research methodology utilized to empirically evaluate the Engineering Philosophical Foundation of Annual Strategic Planning at the Ras Lanuf Polyethylene Plant. Grounded in a positivist research philosophy, this study assumes an objective reality that can be measured and analyzed through deductive statistical techniques (Creswell & Creswell, 2018). Positivism is ideally suited for this investigation as it enables the objective measurement of pre-defined perceptual constructs—encompassing engineering awareness, systems foundations, reliability focus, and data philosophy—to establish generalizable empirical patterns across departments (Sekaran & Bougie, 2016). The operational design is a quantitative, descriptive-correlational, cross-sectional survey. The descriptive component profiles participant perceptions across the eight engineering philosophy dimensions, while the correlational component quantifies the strength, direction, and significance of relationships among constructs (Fraenkel et al., 2019; Lavrakas, 2008).

The target population comprised all technical, operations, engineering, quality, safety, and managerial staff directly involved in or possessing substantial operational knowledge of annual strategic planning at the Ras Lanuf Polyethylene Plant in Libya. The target population encompassed Process Engineers, Operations Supervisors, Maintenance Engineers, Safety Officers, Quality Assurance Specialists, and Plant Managers. Given the specialized nature of this technical workforce within a single petrochemical complex, a purposive sampling strategy was employed (Etikan et al., 2016). Official access was secured in collaboration with Ras Lanuf plant management, establishing a target sample of 150 qualified professionals. Sample size adequacy was verified using Tabachnick and Fidell’s (2019) sample size guideline (N > 50 + 8m, where m = 8 dimensions), which requires a minimum of 114 cases. Furthermore, power analysis confirmed that N = 150 provides statistical power exceeding 0.90 at \alpha = 0.05 for detecting moderate effect sizes (f^2 = 0.15) (Cohen, 1992). All 150 questionnaires were fully completed and returned (100% usable response rate) across five primary operating departments: Maintenance (n = 33, 22.0\%), Safety (n = 32, 21.3\%), Quality (n = 29, 19.3\%), Production (n = 28, 18.7\%), and Planning/Management (n = 28, 18.7\%).

Data collection utilized a structured questionnaire operationalizing the theoretical framework into 32 standardized items across eight core dimensions (4 items per dimension): Engineering Philosophy Awareness (Items B1–B4), Systems & Operational Foundations (Items C1–C4), Reliability & Risk Awareness (Items D1–D4), Decision & Governance Philosophy (Items E1–E4), Strategic & Operational Alignment (Items F1–F4), Continuous Improvement & Learning (Items G1–G4), Human Factors & Socio-Technical Integration (Items H1–H4), and Measurement, Digitalization & Data Philosophy (Items I1–I4). All items utilized a 5-point Likert scale (1 = "Strongly Disagree" to 5 = "Strongly Agree"). Content validity was established by an expert panel, retaining items achieving a CVI \ge 0.80 (Polit & Beck, 2006). Double-blind back-translation confirmed conceptual equivalence (Brislin, 1970). A pilot study with 30 technical participants established scale internal consistency (\alpha = 0.906) and confirmed construct validity via EFA (Fornell & Larcker, 1981; Nunnally & Bernstein, 1994).

Statistical analysis was executed using IBM SPSS Statistics (Version 28). Preliminary screening confirmed dataset completeness (N = 150). Normality of the overall Total Score was established using the One-Sample Kolmogorov–Smirnov test (D = 0.060, p \ge 0.200). Scale reliability was confirmed via Cronbach's alpha (\alpha = 0.906). Descriptive statistics summarized demographic profiles and construct scores. Inferential parametric testing utilized One-Way Analysis of Variance (ANOVA) to evaluate potential score differences across demographic categories (job position, experience, department). Pearson correlation analysis (r) evaluated the strength and significance ($p < 0.05$) of inter-relationships among the eight dimensions. Ethical protocols strictly complied with international guidelines: informed consent prefaced the survey, participant anonymity was maintained, data were stored on encrypted servers, and formal organizational clearance was granted prior to deployment (Resnik, 2020).

4. Data Analysis

A total of 150 completed questionnaires were collected across the Ras Lanuf Polyethylene Plant, achieving a 100% usable response rate. Scale reliability analysis yielded an overall Cronbach's alpha coefficient of 0.906 across all 32 items, confirming excellent internal consistency well above the 0.70 benchmark (Nunnally & Bernstein, 1994).

The demographic profile of the 150 respondents demonstrates balanced representation across organizational functions and experience levels. Departmental distribution showed that Maintenance comprised 22.0% (n = 33), Safety comprised 21.3% (n = 32), Quality comprised 19.3% (n = 29), Production comprised 18.7% (n = 28), and Planning/Management comprised 18.7% (n = 28). Professional experience in petrochemical operations showed a diverse workforce: 32.0% (n = 48) possess less than 5 years of experience, 26.7% (n = 40) possess 5–9 years, 23.3% (n = 35) possess 15 or more years, and 18.0% (n = 27) possess 10–14 years. Table 4 details participant experience levels.

Table 4. Departmental Distribution of Study Participants

Plant Department	Frequency (n)	Percentage (%)
Maintenance Department	33	22.0
Safety Department	32	21.3
Quality Department	29	19.3
Planning / Management Department	28	18.7
Production Department	28	18.7
Total	150	100.0

Table 5. Distribution of Respondents According to Years of Experience

Years of Professional Experience	Frequency (n)	Percentage (%)
Less than 5 years	48	32.0
5–9 years	40	26.7
10–14 years	27	18.0
15 or more years	35	23.3
Total	150	100.0

Normality of the overall Total Score was formally tested using the One-Sample Kolmogorov–Smirnov test (D = 0.060, p = 0.200), confirming normal score distribution. Table 6 presents the Kolmogorov–Smirnov test summary. Descriptive statistics for the overall Engineering Philosophical Foundation score revealed an overall mean of M = 3.4448 (SD = 0.58253), with participant scores ranging from 1.81 to 4.59 on a 5-point Likert scale, reflecting moderate-to-high overall agreement across the organization. Table 7 summarizes overall descriptive metrics.

Table 6. Kolmogorov–Smirnov Test of Normality for Total Score

Statistical Parameter	Metric Value
Total Sample Size (N)	150
Most Extreme Differences (Absolute)	0.060
Most Extreme Differences (Positive)	0.051
Most Extreme Differences (Negative)	-0.060
Kolmogorov–Smirnov Test Statistic (D)	0.060
Asymptotic Significance (2-sided p-value)	0.200* (Normal Distribution Confirmed)

** This is a lower bound of the true significance (Lilliefors corrected).*

One-Way Analysis of Variance (ANOVA) tested whether overall Engineering Philosophical Foundation scores differed significantly across demographic categories. Comparing scores across Job Positions revealed no statistically significant differences (F(4, 145) = 0.912, p = 0.459, \eta^2 = 0.025). Finally, comparing scores across Operating Departments revealed no statistically significant differences (F(4, 145) = 1.773, p = 0.137). Table 7 presents departmental ANOVA results. These inferential findings confirm that awareness and adoption of engineering philosophy principles are homogeneous across plant organizational levels, experience cohorts, and departments.

Descriptive statistics were computed for each of the eight individual survey dimensions. All eight dimensions recorded positive mean scores above 3.40 on a 5-point Likert scale. Engineering Philosophy Awareness achieved the highest score (M = 3.4978, SD = 0.79404), followed by Systems & Operational Foundations (M = 3.4640, SD = 0.74160), Human Factors & Socio-Technical Integration (M = 3.4617, SD = 0.74845), Decision & Governance Philosophy (M = 3.4567, SD = 0.76454), Reliability & Risk Awareness (M = 3.4300, SD = 0.72994), Strategic & Operational Alignment (M = 3.4283, SD = 0.75881), Continuous Improvement & Learning (M = 3.4183, SD = 0.81487), and Measurement, Digitalization & Data Philosophy (M = 3.4100, SD = 0.78700). Table 8 presents the dimension descriptive statistics.

Table 7. Descriptive Statistics of Questionnaire Dimensions (N = 150)

Dimension Name	**Minimum**	**Maximum**	**Mean Score**	**Std. Deviation**
Engineering Philosophy Awareness	1.33	5.00	3.4978	0.79404
Systems & Operational Foundations	1.40	5.00	3.4640	0.74160
Reliability & Risk Awareness	1.50	5.00	3.4300	0.72994
Decision & Governance Philosophy	1.50	4.75	3.4567	0.76454
Strategic & Operational Alignment	1.50	5.00	3.4283	0.75881
Continuous Improvement & Learning	1.25	5.00	3.4183	0.81487
Human Factors & Socio-Technical Integration	1.75	5.00	3.4617	0.74845
Measurement, Digitalization & Data Philosophy	1.25	5.00	3.4100	0.78700

Pearson correlation analysis evaluated bivariate inter-relationships among the eight dimensions. The results revealed statistically significant, moderate-to-strong positive correlations across all 28 dimension pairs ($p < 0.001$), with coefficients ranging from $r = 0.420$ to $r = 0.603$. The strongest positive correlation occurred between Continuous Improvement & Learning and Measurement, Digitalization & Data Philosophy ($r = 0.603$, $p < 0.001$), followed by Reliability & Risk Awareness and Continuous Improvement & Learning ($r = 0.583$, $p < 0.001$), and Engineering Philosophy Awareness and Human Factors Integration ($r = 0.570$, $p < 0.001$). Table 4.10 displays the complete Pearson correlation matrix.

Table 8. Pearson Correlation Matrix Among the Eight Dimensions

Dimension	1	2	3	4	5	6	7	8
Awareness	1.000							

Dimension	1	2	3	4	5	6	7	8
Systems	0.559***	1.000						
Reliability	0.505***	0.472***	1.000					
Governance	0.446***	0.512***	0.512***	1.000				
Alignment	0.491***	0.518***	0.485***	0.509***	1.000			
Improvement	0.537***	0.528***	0.583***	0.551***	0.555***	1.000		
Human Factors	0.570***	0.529***	0.542***	0.459***	0.528***	0.460***	1.000	
Digitalization	0.513***	0.527***	0.542***	0.521***	0.420***	0.603***	0.497***	1.00

**** Correlation is statistically significant at the 0.001 level (2-tailed), N = 150.*

5. Discussion and Implications

This chapter interprets the empirical findings in relation to the research objectives, existing engineering management literature, and theoretical frameworks. The descriptive findings demonstrate that technical personnel at the Ras Lanuf Polyethylene Plant hold positive perceptions regarding the Engineering Philosophical Foundation of Annual Strategic Planning (M = 3.4448, SD = 0.58253). This confirms that employees recognize engineering philosophy as a vital framework supporting plant decision-making, departmental coordination, and long-term performance (López-Cruz, 2021; Tumidei et al., 2020). Evaluating individual dimensions revealed that Engineering Philosophy Awareness achieved the highest mean (M = 3.4978), indicating a strong baseline understanding across the workforce. Systems & Operational Foundations (M = 3.4640) and Human Factors Integration (M = 3.4617) also scored highly, confirming that participants view the plant as an interconnected socio-technical system requiring close collaboration among production, maintenance, safety, and quality teams (Checkland, 1999; Senge, 2006; Trist & Emery, 1960). Conversely, Measurement, Digitalization & Data Philosophy recorded the lowest relative score (M = 3.4100), highlighting an organizational need for further investment in real-time digital monitoring and automated analytics (Gomaa, 2025; Zulkafli & Kopanos, 2018).

Inferential ANOVA testing demonstrated no statistically significant differences in overall engineering philosophy scores across job positions ($p = 0.459$), years of experience ($p = 0.842$), or operating departments ($p = 0.137$). This absence of demographic variance provides compelling evidence of a pervasive, highly integrated engineering culture at Ras Lanuf. Technical principles are shared uniformly across technicians, engineers, supervisors, and department managers, supporting Systems Thinking Theory (Senge, 2006) by showing that shared mental models across functional silos enhance operational coordination. Furthermore, Pearson correlation analysis established statistically significant positive associations across all eight dimensions ($r = 0.420$ to 0.603, $p < 0.001$). The strong link between Continuous Improvement and Digitalization ($r = 0.603$) demonstrates that data-driven digital infrastructure directly reinforces organizational learning (Imai, 1986; Phaal et al., 2024), while the link between Reliability and Continuous Improvement ($r = 0.583$) proves that asset integrity management is inseparable from organizational learning (Du et al., 2025; ISO, 2018).

The theoretical and practical implications of these findings are substantial. Theoretically, this study advances industrial management literature by establishing an empirically validated framework bridging abstract engineering philosophy with strategic management in North African petrochemical complexes. It validates Socio-Technical Systems Theory, Systems Thinking, and Reliability Engineering as an integrated paradigm. Practically, the findings offer actionable guidance for Ras Lanuf management and National Oil Corporation (NOC) executives. First, plant leadership must capitalize on high employee awareness by formalizing engineering philosophy guidelines within strategic planning policies. Second, executive management should target capital investments toward upgrading digital monitoring infrastructure, expanding SCADA integration, and deploying predictive analytics dashboards to strengthen the digitalization dimension. Third, interdepartmental planning workshops should be institutionalized to maintain strong cross-functional alignment and reinforce risk-based asset management protocols across maintenance and production teams.

6. Limitations and Future Research Study

Several methodological limitations should be acknowledged when evaluating the conclusions of this study. First, this research was conducted within a single petrochemical complex—the Ras Lanuf Polyethylene Plant in Libya. While providing deep, context-specific insights into polyolefin manufacturing, the findings may require adaptation before generalizing to other petrochemical facilities, oil refineries, or offshore platforms operating under different organizational cultures or regulatory regimes. Second, the study utilized a cross-sectional survey design, measuring perceptions at a single point in time, which inherently limits the capacity to evaluate longitudinal changes across multi-year planning cycles. Third, the evaluation relied on self-reported technical surveys capturing professional perceptions rather than direct, multi-year physical plant key performance indicators (e.g., actual maintenance downtime hours, off-spec resin production volumes, or financial return-on-assets). Fourth, while the model evaluated eight core dimensions, exogenous macro-environmental factors—such as national political instability and international supply chain disruptions—were not explicitly modeled.

To build upon these findings, future research should pursue several promising avenues. First, researchers should expand the geographic and sector scope by conducting comparative multi-site studies across petrochemical and refining complexes throughout the Middle East and North Africa (MENA) region. Second, longitudinal research designs should be employed to track how embedding engineering philosophy into strategic planning influences objective plant performance metrics over multi-year operational campaigns. Third, future investigations should integrate perceptual survey metrics with objective, real-time plant Distributed Control System (DCS) data, Computerized Maintenance Management System (CMMS) logs, and financial accounting records using Structural Equation Modeling (SEM). Fourth, future research should explore the moderating role of leadership styles, digital maturity levels, and Industry 4.0 artificial intelligence adoption in enhancing the impact of engineering philosophy on strategic planning outcomes.

In conclusion, this study empirically proves that engineering philosophy provides a highly effective, integrated framework for annual strategic planning at the Ras Lanuf Polyethylene Plant. By demonstrating that engineering philosophy awareness, systems thinking, reliability management, evidence-based governance, socio-technical integration, and data philosophy function synergistically across all plant departments, this research offers petrochemical enterprise managers a clear, actionable roadmap to enhance strategic plan execution, optimize plant operational performance, and achieve long-term industrial sustainability.

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