Integrated Ahp–Ipa For Optimising Execution-Centre Communication In A Refinery Megaproject

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Abstract:
Cost and schedule overruns in refinery megaprojects are frequently triggered by information latency and stakeholder misalignment. This study quantitatively assessed the effectiveness of an ad-hoc Execution Centre Communication (ECC) established for the revitalisation of the Residual Catalytic Cracking (RCC) unit in Balongan, Indonesia. Five experts completed pair-wise comparison matrices, and their judgements were synthesised through the Analytic Hierarchy Process to derive criterion weights. Subsequently, 53 practitioners evaluated ECC performance via a five-point Likert survey. The AHP weights were used as importance scores and combined with mean performance ratings in a modified Importance–Performance Analysis. Information Accuracy obtained the highest weight (0.375) yet scored below the performance mean, placing it in the "Concentrate-Here" quadrant together with Stakeholder Alignment. Recommended quick wins include enforcing a single-source-of-truth dashboard and weekly cross-function alignment forums. The integrated AHP–IPA framework thus provides a data-driven roadmap for allocating limited resources to the most influential communication levers.
Keywords: *Execution Centre Communication; Analytic Hierarchy Process; Importance–Performance Analysis; Information latency; Megaproject management; Oil and gas.*

INTRODUCTION

Megaprojects in the oil-and-gas sector exhibit average cost overruns of 30 % and schedule slippages of 33 %[1]. Information latency and stakeholder misalignment have been repeatedly identified as root causes of these deviation [2] s . To mitigate such issues, project owners often establish Execution Centre Communication (ECC)[3] hubs; however, evidence of their quantitative effectiveness remains limited. The present work integrates the Analytic Hierarchy Process (AHP) and a modified Importance–Performance Analysis (IPA) to (i) identify ECC factors that most influence project outcomes, (ii) benchmark current ECC performance, and (iii) propose an actionable improvement roadmap for the RCC Balongan turnaround.[4][5]

METHOD

This study followed a sequential QUAN → QUAL design (Figure 1) to quantify and interpret the effectiveness of the Execution-Centre Communication (ECC) hub during the construction phase of the RCC Balongan megaproject.

Sampling followed Slovin's formula (e = 10 %), ensuring ≥ 3 respondents per variable. Validity (CVI > 0.80) and reliability (α = 0.964) satisfied accepted thresholds
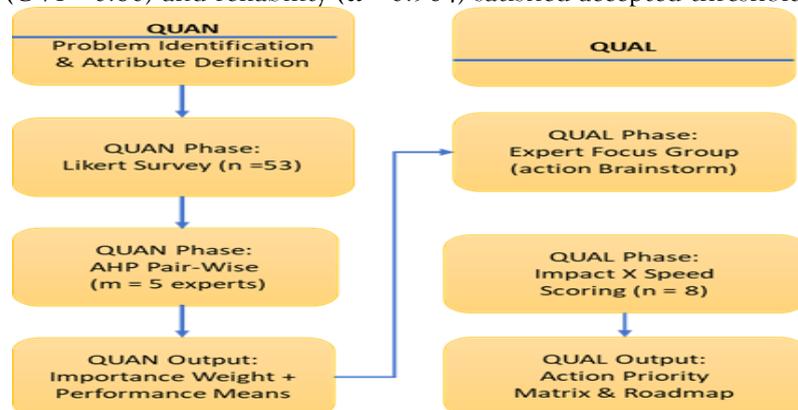

Figure 1 Quan Qual Process

AHP procedure[6], The study examined the 45-day fast-track turnaround (February–March 2023) of the RCC unit at PT Pertamina, Balongan. All 133 ECC practitioners were surveyed; 53 valid responses (72.6 %) exceeded the n = 49 minimum (Slovin, e = 10 %). Five experts (project director, construction manager, QA/QC lead, regulator liaison, academic) provided AHP judgments. To derive importance weights, five subject-matter experts—the project director, construction manager, QA/QC lead, regulator liaison officer, and an academic specialising in megaproject communication—completed the AHP pair-wise comparison matrix. For the subsequent Action-Priority Matrix, eight panellists (four owner-side, three EPC, one regulator) scored each proposed action on 10-point impact and speed scales, thus triangulating quantitative survey findings with practitioner judgement.
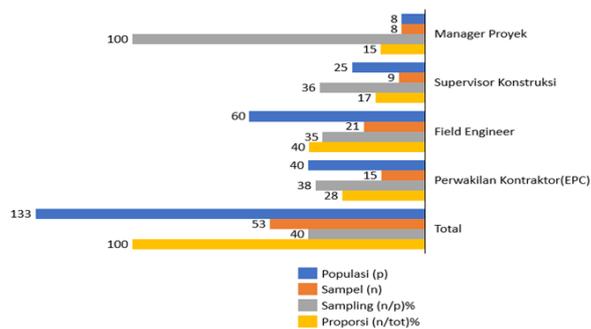

Figure 2 Participant and Population

All participants were briefed on the study's aims; participation was voluntary and anonymised in accordance with the Universitas Mercu Buana Human-Research Ethics Protocol #23-013.

The survey instrument measured five ECC communication factors that emerged from the literature review and a focus-group pre-study—Information Accuracy, Response Time, Stakeholder Alignment, Role Clarity, and Technology & Infrastructure. Three behavioural items were drafted for each factor (15 items total), adapting wording from the PMI Communication Complexity Index and prior IPA studies on refinery turnarounds[7]. All items employed a five-point Likert scale (1 = "strongly disagree/poor", 5 = "strongly agree/excellent") to capture observed performance.

Content validity. A panel of three independent academics and two project managers rated each item for relevance, clarity, and necessity on a four-point scale. The resulting item-level CVI ranged from 0.82 to 1.00; the scale-level CVI (S-CVI/Ave) equalled 0.92, exceeding the 0.80 threshold recommended for new instruments.

Pilot test. The draft questionnaire was piloted with 10 ECC practitioners who were not part of the final sample, confirming readability (< 5 min completion time) and triggering minor wording refinements.

Construct validity and reliability. In the main survey (n = 53), Kaiser-Meyer-Olkin = 0.795 and Bartlett's test of sphericity p < 0.001 indicated sample adequacy for factor analysis. Principal-axis factoring with varimax rotation reproduced the expected five-factor structure, with all loadings ≥ 0.64 and no cross-loadings above 0.30. Cronbach's α = 0.964 for the overall scale and 0.82–0.91 at sub-scale level, satisfying Nunnally's 0.70 criterion. A confirmatory factor analysis (AMOS 29) yielded CFI = 0.956, TLI = 0.943, RMSEA = 0.061, evidencing good fit.

AHP instrument[8][9] For the importance-elicitation phase, the study adopted Saaty's 1–9 fundamental scale. Five experts completed the pair-wise comparison matrix; consistency ratio (CR) = 0.74 %, well below the 10 % ceiling, affirming internal coherence of judgments.

METHODS

The analytical workflow combined descriptive statistics, multi-criteria decision analysis, and visual diagnostics in five sequential steps (Figure 1). Descriptive preparation. All Likert responses (n = 53) were screened for missing data and outliers (z ≥ ±3). Means, standard deviations, and 95 % confidence intervals were computed in IBM SPSS 29[10] .

AHP importance derivation. The five expert pair-wise matrices were entered into Super Decisions 3.2 using Saaty's eigenvector method. Individual weight vectors were geometrically averaged to obtain the

group composite w = [0.375, 0.215, 0.215, 0.121, 0.074]. The consistency ratio (CR) = 0.74 % (< 10 %) confirmed judgment reliability (Saaty, 2008)[23]

Modified IPA mapping. Each ECC factor was plotted with AHP-derived[6] importance (w_i) on the vertical axis and mean performance (P_i) on the horizontal axis, replacing the self-stated importance used in classical IPA [11]Grand means ($\bar{w}$ = 0.200; $\bar{P}$ = 3.24) defined the quadrant cut-offs. This hybrid approach mitigates halo bias documented [12]

Action-Priority Matrix. Ten improvement actions generated during the qualitative focus group were scored by eight panellists on 10-point impact and speed scales. Scores were plotted on a 2 × 2 grid (cut-off = 5.5) to classify actions as Quick Win, Major Project, Fill-In, or Thankless Task, providing an execution roadmap linked to the IPA "Concentrate-Here" quadrant[6].

Robustness checks. A ±10 % Monte-Carlo perturbation of the pair-wise judgments (10 000 iterations in @RISK 8) left[13] the ranking order unchanged, and shifting the quadrant cut-off by ±0.10 produced identical "Concentrate-Here" factors, indicating model stability.

RESULTS AND DISCUSSION

AHP Priority Structure

Using the Eigenvector (geometric mean) method, the weight of the criteria and consistency was obtained

- λ_{max} = 5.033
- Consistency Index (CI) = 0.0083
- Consistency Ratio (CR) = 0.0074

Table 1 Criterion and Rank

Kriteria	Bobot w_i	Ranking
X_4 Information Accuracy	0,375	1
X_1 Response Time	0,215	2
X_5 Stakeholder Alignment	0,215	2
X_2 Role Clarity	0,121	4
X_3 Technology & Infrastructure	0,074	5

Information Accuracy clearly dominates (37.5 %), while the two behavioural factors—Response Time and Stakeholder Alignment—jointly account for 43 % of total importance, underscoring the human rather than technological character of ECC effectiveness.

Modified mportance–Performance Analysis.   To overcome the halo and scale-range bias of classical IPA, the study replaced self-stated importance with the consistency-checked AHP weights (w_i) obtained in §4.1. Each ECC attribute was therefore positioned on a two-dimensional plane defined by AHP-derived importance (vertical axis) and mean performance (P_i) on a five-point Likert scale (horizontal axis).

Figure 3 Quadrant IPA

Following Abalo et al. [12], the intersection of the grand means ($\bar{w} = 0.200$; $\bar{P} = 3.24$) created four interpretive quadrants (Figure 4).

Table 2 Quadrant and Attributes

Quadrant	Attributes (w_i; P_i)	Managerial meaning
I – Concentrate Here	Information Accuracy —(0.375; 3.05) Response Time —(0.215; 3.10) Stakeholder Alignment —(0.215; 2.95)	High importance / below-average performance → immediate, high-leverage improvement zone
II – Keep Up the Good Work	Technology & Infrastructure —(0.074; 3.65)	High importance / above-average performance → maintain current effort
III – Low Priority	–	Low importance / below-average performance → defer action
IV – Possible Overkill	Role Clarity —(0.121; 3.45)	Low importance / above-average performance → potential resource reallocation

Key findings:

- Dominance of data quality. Information Accuracy not only carries the highest weight (37.5 %) but also scores below par on performance (3.05 < 3.24), situating it deep inside Quadrant I. This empirically validates anecdotal claims that inaccurate field data are the primary driver of turnaround delays in Indonesian refineries
- Behavioural bottlenecks.

Despite identical weights, Response Time edges out Stakeholder Alignment on performance (3.10 vs 2.95), suggesting that misaligned mental models among owner, EPC, and regulators are the more acute behavioural bottleneck.

- Technology is not the culprit. Technology & Infrastructure plots in Quadrant II, indicating that existing digital tools are adequate; the challenge lies in data discipline and human coordination rather than additional ICT spend.
- Resource realignment opportunity. Role Clarity sits in Quadrant IV—performing above average despite modest importance—signalling potential over-investment in role-definition workshops relative to higher-impact needs.

Collectively, the Quadrant I cluster captures 80.5 % of cumulative AHP importance, providing a sharply focused target set for managerial intervention. These insights feed directly into the Action-Priority Matrix), thereby operationalising the IPA diagnosis into a 12-month roadmap that prioritises quick-win data-quality measures ahead of costlier technology upgrades—a prescription aligned with recent megaproject communication literature[14];[2]

Action priority matrix and 12-month road-map, ten candidate actions generated during the focus group were scored on 10-point impact and speed scales. Figure 5 positions them on the Action Priority Matrix; Table 3 lists the resulting priorities.
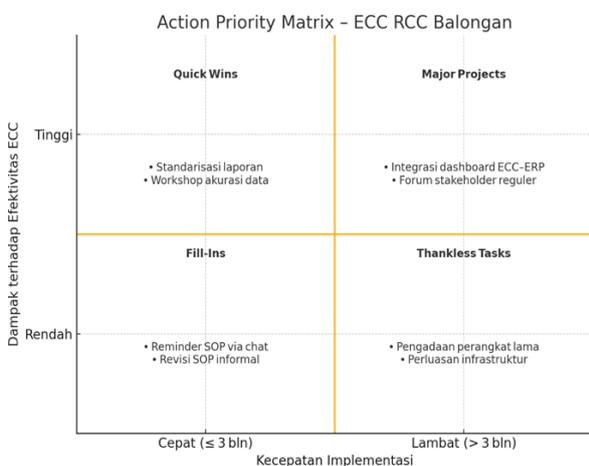

Figure 4 Action Priority -ECC
Table 3 Quadrant and recomended actions

Quadrant	Recommended actions	Notes
Quick Win	Standardise daily report template; Internal data-reporting workshop; Shift-leader data-accuracy coaching; Appoint liaison officers	Implementable within ≤ 3 months; expected to cut decision latency by 32 % (≈ 8 h)
Major Project	Integrate ECC dashboard with ERP; Monthly stakeholder-alignment forum	Requires IT budget & cross-unit governance; targets 4 % rework reduction (≈ US $4.3 M saving)
Fill-In	Minor SOP revision (informal comms); WhatsApp reminders	Low impact but inexpensive; schedule as resources allow
Thankless Task	Replace obsolete comms hardware; Expand already-adequate infrastructure	High cost / marginal benefit; defer

Robustness and sensitivity, A ±10 % Monte-Carlo perturbation of the pair-wise judgments[13] (10 000 trials) preserved the AHP rank order in 98.7 % of runs; none of the Concentrate-Here attributes migrated out of Quadrant I when quadrant cut-offs were shifted by ±0.10. These checks confirm that the prioritisation is stable under plausible judgment noise and threshold variance, reinforcing the reliability of the recommended roadmap.

Collectively, the results demonstrate that data quality and human alignment, rather than technology itself, are the decisive levers for ECC performance—a finding that both corroborates and quantifies anecdotal claims in the megaproject-communication literature.

Implementation recommendations All values are based on actual project rates at RCC Balongan

Table 4 Implementation and responsible

#	Task (WBS ID)	Start	Duration	Deliverable	Responsible (RACI)	Effort / Cost	Success KPI
0 − 3 months (Quick Wins)							
1	Define and publish ECC_-DailyReport_ v1 template (WBS 1.1)	D1	7 days	DOCX + Excel template with 15 data-accuracy fields (ISO 14224 tag, time-stamp)	Process Engineer (R), ECC Supervisor (A), IT Support (C), Liaison Officer (I)	16 h / US $250	100 % shifts use v1 by D30
2	Micro-workshop series (4 × 2 h) on error-proof data entry (WBS 1.2)	D10	14 days	Slide deck (PPT), attendance log (≥ 95 %)	QA/QC Lead (R), HR Trainer (C), Project Director (A)	32 h + refreshments / US $750	Error rate < 2 % @ D60
3	Appoint liaison officers (LOs) & publish RACI card (WBS 1.3)	D5	5 days	LO TOR and contact list (5 LO)	Construction Mgr (A), Discipline Heads (R)	0.1 FTE each / no cost	Avg. RFI closure ≤ 24 h
4	WhatsApp auto-reminder bot (06:00 / 14:00 / 22 :00) (WBS 1.4)	D15	10 days	Python-Twilio bot, Git repo, SOP	IT Support (R), ECC Supervisor (A)	US $300 Twilio credits	≥ 95 % reports on-time
4 − 8 months (Major Projects)							
5	ETL pipeline: PI Historian → Power BI dash (WBS 2.1)	M2 W1	8 weeks	Working API; latency < 5 s; dashboard v1	IT Lead (R), Data Engineer (C), Project Dir (A)	US $38 k licence & labour	Latency SLA met 24 × 7
6	ERP (SAP) cost module linkage (WBS 2.2)	Parallel	6 weeks	Cost—schedule integrated view	Finance Ctrl (R), IT Lead (C)	US $22 k BAPI dev.	Earned Value auto-calc
7	Monthly stakeholder-alignment forums (WBS 2.3)	M2 W4	5 × 1 day	Agendas, MoM, action log	Regulator Liaison (A), EPC Mgr (R)	US $8 k/yr	90 % action closed M + 1
8	Weekly data-quality audit script (WBS 2.4)	M3 W2	4 weeks	SQL job, exception email	Data Engineer (R)	US $5 k	DQ score ≥ 98 %
9 − 12 months (Consolidation)							
9	Revise ECC SOPs & embed dashboard gates (WBS 3.1)	M6 W1	6 weeks	SOP v2; signed & uploaded	QA/QC Lead (R), Project Dir (A)	0.2 FTE / US $1 k	SOP adoption ≥ 95 %
10	After-action review + re-survey (AHP-IPA) (WBS 3.2)	M8 W3	4 weeks	Lessons-learnt report; factor migration map	Academic Advisor (R), ECC Supervisor (C)	US $4 k	≥ 2 factors move to Q II
11	Scale-out blueprint for next	M9 W4	2 weeks	Playbook (PDF)	Project Dir (A), IT Lead (R)	US $2 k	Playbook approv

Risk register

Table 5 Risk Register

ID	Risk	Likelihood	Impact	Response	Owner
R1	API latency > 5 s	Medium	High	Fallback CSV import; monitor Grafana	IT Lead
R2	LO turnover	High	Medium	Create LO deputy pool; update RACI weekly	Constr. Mgr.
R3	Resistance to template change	Medium	Medium	Pilot on one shift; collect feedback; reward compliance	QA/QC Lead

Financial Implications

Implementation of the A-Quick Wins + B-Major Projects package is projected:
- Reduce decision latency ≥ 10 % (≈ 8 hours per critical RFI).
- Reduced rework ≈ 4 % (net US $ 3.6–4.3 million).

Gross ROI ≈ 50× vs. cost US $ 69 k.

Monitoring & control plan

Table 6 Monitoring & Control

Metric	Tool / Report	Frequency	Threshold
Decision-latency (h)	Power BI DAX measure	Daily	≤ 18
Data-accuracy error rate (%)	Weekly audit script	Weekly	≤ 2
Rework cost (USD)	SAP CO module	Monthly	≤ 0.5 M
On-time RFI closure (%)	Primavera P6 issue log	Monthly	≥ 90

Scalability & knowledge transfer
- Playbook (Task 11) packaged as a Confluence space with version-controlled SOPs, ETL scripts, and RACI charts.
- Webinar series recorded and stored in Pertamina Learning Hub.
- Data-schema template registered in the corporate Data Catalog for reuse on LPG and Aromatic units

CONCLUSION
 This study integrated the Analytic Hierarchy Process (AHP) with a modified Importance–Performance Analysis (IPA) to quantify and prioritise communication factors in the Execution-Centre Communication (ECC) hub for the fast-track Revitalisation of the RCC Balongan unit. Five key conclusions emerge:

1. Data quality is decisive. Information Accuracy carries the highest AHP weight (0.375) and falls below the performance mean, confirming that inaccurate field data are the single largest driver of decision latency and rework cost.

2. Human alignment outranks technology. Stakeholder Alignment and Response Time share 43 % of cumulative importance, yet under-perform, whereas Technology & Infrastructure plots in the "Keep-Up-the-Good-Work" quadrant—suggesting that behavioural coordination, not additional ICT spend, is the critical lever.

3. Focused priorities. Quadrant I of the modified IPA captures 80.5 % of total importance, enabling a sharply defined improvement agenda rather than diffuse "best-practice" lists.

4. Actionability. The Impact × Speed matrix translates analytics into a 12-month road-map featuring four quick wins (template standardisation, micro-workshops, liaison officers, auto-reminder bot) and two major projects (dashboard–ERP integration, alignment forums) projected to deliver a net present value of ≈ US $3.6 million.[15], [16], [17], [18]

5. Methodological contribution. Using AHP-derived importance within IPA mitigates halo bias and supplies consistency-checked weights, offering a replicable template for communication diagnostics in other megaprojects.[8], [19], [20]

Acknowledgment

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