

Designing an Activity and Resource Group-Disaggregated Cost Estimation Framework for Daily Floor Cleaning Services: A Time-Driven Activity-Based Costing Approach at Terminal 3 Soekarno-Hatta International Airport

Ardha Dimitri Akhsanulkhusna^{1*}, and Sylviana Maya Damayanti²

^{1,2} Institut Teknologi Bandung, Indonesia

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CORRESPONDING AUTHOR

29324402@mahasiswa.itb.ac.id

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ABSTRACT

Daily floor cleaning at Terminal 3, Soekarno-Hatta International Airport, is the largest item in the 2026 cleaning Owner Estimate (OE), at 41.58% of its value. The OE prices five activities across eight zones and three shifts with one productivity coefficient of 1,800 m²/hour. This explanatory single-case study designs an activity and resource group-disaggregated cost estimation framework using Time-Driven Activity-Based Costing (TDABC). The operator's Daily Activity of Cleaners (DAC) supplies planned minutes as the time input, which a Site Utilization Factor (SUF) compares with ISSA 612 benchmark times. Five Capacity Cost Rate (CCR) pools cover 24 resource groups, 19 of which plan fewer minutes than one full zone coverage at the benchmark pace. Unit costs range from Rp 8.76 to Rp 171.49/m²/frequency. The area-weighted TDABC costs of Rp 37.764 sits 30.64% below the normalized of Rp 54.4481, about Rp 450.98 million per month. Zone-level TDABC costs range from 83.07% below to 102.68% above the OE allocation, driven by area-based spreading of machine cost and zone differences in planned labor time. Reflecting cost construction and below-benchmark planned time, the gap is not presented as a cost saving. Eight zone-level line items for the owner's estimate price (HPS), backed by a 24-group derivation appendix, are recommended.

ABSTRAK

Pembersihan lantai harian di Terminal 3 Bandara Internasional Soekarno-Hatta merupakan item terbesar dalam *Owner Estimate* (OE) kebersihan 2026, yaitu 41,58% dari nilainya. OE menetapkan harga lima aktivitas di delapan zona dan tiga giliran kerja (*shift*) dengan satu koefisien produktivitas sebesar 1.800 m²/jam. Studi kasus tunggal eksplanatori ini merancang kerangka kerja estimasi biaya yang terdisagregasi per aktivitas dan sumber daya berbasis *Time-Driven Activity-Based Costing* (TDABC). *Daily Activity of Cleaners* (DAC) milik operator menyediakan menit terencana sebagai *input* waktu, yang dibandingkan dengan waktu acuan ISSA 612 melalui *Site Utilization Factor* (SUF). Lima kelompok *Capacity Cost Rate* (CCR) mencakup 24 kelompok sumber daya, dan pada 19 diantaranya menit terencana tidak mencapai satu kali cakupan penuh zona pada kecepatan acuan. Biaya satuan berkisar antara Rp 8,76 hingga Rp 171,49/m²/frekuensi. Biaya satuan TDABC tertimbang luas sebesar Rp 37,764 berada 30,64% dibawah OE yang dinormalisasi sebesar Rp 54,4481, atau sekitar Rp 450,98 juta per bulan. Biaya TDABC per zona berkisar dari 83,07% di bawah hingga 102,68% di atas alokasi OE, didorong oleh penyebaran biaya mesin berbasis luasan dan perbedaan waktu kerja terencana antarzona. Karena mencerminkan konstruksi biaya dan waktu terencana di bawah acuan, selisih ini tidak disajikan sebagai penghematan biaya. Penelitian ini merekomendasikan delapan item Harga Perkiraan Sendiri (HPS) per zona yang didukung lampiran derivasi 24 kelompok sumber daya.

1. Introduction

Over several decades, global aviation has followed a steady long-term growth path. Global passenger traffic is forecast to expand at a compound annual rate of 9.1% from 2023 to 2026 before settling near its pre-pandemic trend of about 3.6% per year through 2052 [1]. Asia-Pacific already holds the largest share of

world passenger traffic at 31.7%, while Indonesia is expected to climb from thirteenth place in 2023 into the five largest aviation markets by 2052. Higher passenger volumes raise the service demands placed on terminals, and customer experience is listed among five strategic priority areas for global airport development toward 2050.

Of the service dimensions passengers use to judge an airport, terminal cleanliness as a basic expectation rather than an optional attribute. Airports Council International treats it as a threshold requirement in the Kano Model of Customer Satisfaction, so its failure causes dissatisfaction, and that dimension explains 19.6% of overall satisfaction [2]. In the ACI Airport Service Quality framework, terminal cleanliness carries 23.2% and washroom cleanliness 32.1% of the infrastructure dimension of passenger satisfaction, and that dimension explains 19.6% of overall satisfaction. Cleanliness failure cuts the probability of a passenger becoming a promoter of the airport to 9.1%, whatever the performance of other attributes [3]. In survey of 356 passengers at five major Indonesian airports, it is found that airport service quality has a significant positive effect on passenger satisfaction ($t = 4.353$, $p = 0.001$) and airport image ($t = 8.258$, $p = 0.000$) [4].

In Indonesia, PT Angkasa Pura Indonesia (PT API, which trades as Injourney Airports, operates 37 airports that together served 155,986,328 passengers in 2024. [5]. Soekarno-Hatta International Airport (CGK), the country's main international gateway, handled about 35% of that traffic. In 2025 CGK served 54,953,109 passengers against a design capacity of 43 million, running at roughly 127% of capacity. Terminal 3 bears the heaviest share of this pressure, with the highest passenger volume in the network at 24,162,458 passengers in 2025. It also holds the largest floor area under daily cleaning at CGK, 227,959.23 m² in the *Lantai Harian Tipe B* (daily floor cleaning) scope of the 2026 contract [6].

Cleaning spending at CGK is both material and stable over time. It rose from Rp 156.09 billion in 2022 to Rp 231.97 billion in 2025 while staying within roughly 9.9% to 11.7% of total operating expense (excluding depreciation and amortization). In the 2026 Owner Estimate *Lantai Harian Tipe B* at Terminal 3 is valued at about Rp 5.73 billion per month, equal to about 81% of the Terminal monthly OE value and 41.58% of the total monthly OE value across all four cost packages [7]. The method used to set the unit price for this one work category therefore governs the reliability of the largest cost component in the contract.

In this study, the OE denotes the cost estimation document that Pasal 1 of PD.DU.27/PL.02.03/2025 formally calls the *Rencana Anggaran Biaya* (RAB), from which the *Harga Perkiraan Sendiri* (HPS) is prepared as the unit price output [8]. the current OE applies one implied productivity rate of 1,800 m²/hour to every floor cleaning activity, zone, and shift. Such a uniform rate holds only when outputs draw on shared resources in roughly uniform ways [9]. With five activities running across eight terminal zones and three shifts, the *Lantai Harian Tipe B* scope does not satisfy that condition. Research demonstrated that one overhead rate applied to outputs with different resource

consumption patterns yields systematic cost distortion [10]. In a hospital setting, study found that traditional costing placed the cost of a single MRI scan 53.28% below its time-driven activity-based costing (TDABC) cost [11].

The operator's own planning data make the issue visible. The OE does not document how the 1,800 m²/hour figure was derived, and the figure sits far above the productivity rates implied by the planned minutes in the Daily Activity of Cleaners (DAC), the operational planning document of PT Injourney Aviation Services Support (IASS) [12]. These implied rates, used here as context rather than as model inputs, run from 250 m²/hour for damp mopping with a mop set to 600 m²/hour for dry mopping with a lobby duster [13], so even the fastest floor activity reaches only one third of the OE assumption. Across shifts, planned machine floor cleaning is concentrated in Shift 3, at about 6,825 minutes against about 781 minutes in Shift 1, an 8.7-fold difference. Three of the eight zones plan no machine minutes in any shift, yet a uniform cost rate still assigns machine cost to them [10]. The machine component makes up 48.6% of the HPS, and its ride-on sweeper cost rests on theoretical capacity rather than the practical capacity that a study require [14].

The issue bears on procurement governance because the HPS is the main output of the OE and the contractual basis for pricing. PD.DU.27/PL.02.03/2025 defines the HPS as an estimate prepared on data that can be accounted for (Article 1 number 18) and requires the HPS document to carry supporting data suited to the type of work (Article 18 paragraph (1) letter b) [8]. The same regulation list accountability as a procurement principle (Article 5 letter g). A single-rate area-based structure meets these requirements at the level of its own inputs, but it shows little of how the unit cost responds to activity-level and shift level conditions. This study addresses that gap with a TDABC framework that takes its time parameters from DAC planned minutes and compares them with ISSA 612 benchmark rates through the Site Utilization Factor (SUF), producing traceable unit costs for 24-zone-shift resource groups. Since the 2026 contract cannot be revised mid-period, the output is aimed at preparing the OE for the 2027 procurement cycle [15].

The study is guided by three research questions. First, how does the SUF vary across zones, shifts, and floor cleaning activity types at Terminal 3, and what does this variation reveal about the limitations of the single productivity coefficient in the existing OE for *Lantai Harian Tipe B*? Second, how is the TDABC framework constructed for *Lantai Harian Tipe B* floor cleaning at Terminal 3, using DAC planned minutes as the time input and the SUF to benchmark them against ISSA 612 rates, to produce traceable unit costs per resource group? Third, how does the unit cost output of the TDABC framework compare with the HPS structure in

the existing OE when applied to a normalized area basis, and what are the implications for the defensibility of cost estimation methodology in the 2027 procurement cycle? The study responds to two gaps in the literature. Methodologically, the SUF compares site-specific operational planning data with a published international benchmark through a derived benchmark ratio, so that time parameters drawn from planning data become comparable against an external reference, a combination not yet formalized in prior TDABC implementations for service operations. Contextually, the framework disaggregates cost at the zone-shift level, which makes TDABC applicable to continuous-area floor cleaning as a structurally distinct service typology that existing applications have not formalized.

2. Research Method

2.1. Research Design

This study adopts an explanatory single-case study design following by prior study [16]. The design fits “how” questions about a contemporary phenomenon in its real operational setting, where the researcher has no control over events. The single case is revelatory: the DAC records planned minutes per activity, zone, and shift, and as far as this study could establish, it has not been analyzed in published cost research [12]. Combined with the OE [7] and ISSA 612 [15], it allows planned cleaning workload to be costed by activity, zone, and shift. The data are quantitative and documentary. The DAC provides workload data, and the OE provides cost parameters and the comparison baseline. APPA provides the 420-minute practical capacity per shift, while ISSA 612 rates act only as the benchmark within the SUF, not as time inputs [17]. DAC time blocks often mix floor and non-floor work in free text, so a proportional decomposition extracts floor minutes with a verb weight for action time intensity and a material weight for cleaning effort (1.0 simple, 1.5 for detailed surfaces), giving 120 planned minute values. These planned minutes are treated as a planning-level proxy, following the TDABC applications built on documented or standard times [18], [19]. Construct validity rests on benchmark comparison rather than triangulation, with a row-level audit trail linking each minute to its DAC entry [16].

2.2. Unit of analysis and case boundaries

The case is the *Lantai Harian Tipe B* service at Terminal 3, covering sweeping (Sw), dry mopping (DM), damp mopping (DpM), ride-on sweeper (RS), and auto scrubber (AS) operation. Eight zones and three shifts form 24 embedded units, which are the resource groups of the framework. Glass, walls, and ceiling cleaning fall outside the scope because the OE prices them separately. Garbage collection belongs to a separate worker role and resource pool, so it is also excluded [9], [20]. The comparison uses the current-

condition analytical floor area 300,330.57 m², which includes former carpet areas the DAC already plans as hard floor. One frequency is one full coverage of a zone’s floor area within one shift, giving 90 frequencies per month (3 shifts × 30 calendar days).

2.3. Two contributions

The SUF carries the methodological contribution by comparing DAC planned minutes per unit area with time implied by ISSA 612 rates. The *five-pool CCR architecture* carries the contextual contribution. It separates labor wages, personal protective equipment (APD), manual cleaning equipment, and the depreciation of each machine type. It requires a separate rate when some activities use that others never touch [14], a principle also applied by different studies [21], [22]. At Terminal 3, manual and machine activities never share equipment, and planned machine minutes make direct tracing of both depreciation pools economically feasible [9].

2.4. Analytical procedure

Step 1 (RQ1) derives β as DAC planned minutes per unit area and the SUF as the ratio of those minutes to the ISSA 612 time for the full zone. Summing the SUF across activities tests planned minutes against one full coverage at the benchmark pace, assuming no overlap between activities. Step 2 (RQ2) combines β with the five CCRs into a total unit cost per resource group. Cleaner headcount is a ceiling function of total all-activity minutes over 420 minutes, with a contract-consistent team-leader ratio of 1:15. Machine CCRs spread daily depreciation over 1,080 calendar days across planned machine minutes carries one unit, and auto scrubber minutes count as operator minutes. Supervisory and overhead equipment costs are facility-sustaining, so they are split equally across zones as a simplification and multiplied by the floor cleaning share α . Step 3 (RQ3) compares TDABC output with OE_ADJ, a researcher-constructed baseline of Rp 54.448/m²/frequency. OE_ADJ removes four out-of-scope items (garbage collector manpower, bottle sprayer, push garbage bin, and caddy bag) totaling Rp 1.6613 from the gross HPS of Rp 56.1095/m²/frequency, a scope normalization rather than a correction of the OE. For zones, OE_ADJ is allocated by area.

3. Result and Discussion

The three subsections below build on each other. The time parameters (β) behind the SUF values in Section 3.1 feed the unit costs in Section 3.2, which form the TDABC baseline compared against OE_ADJ in Section 3.3.

3.1. Site Utilization Factor Analysis (RQ1)

The 120-value SUF matrix across eight zones, three shifts, and five floor cleaning activities answer the first research question. Three patterns emerge from the distribution.

3.1.1. Floor cleaning activity mix is not uniform across resource groups

Sweeping (Sw) SUF range from 0.0048 to 0.0222 across the 16 resource groups where it is planned, and dry mopping (DM) SUF from 0.0847 to 1.5160 across all 24. Where both are planned, DM SUF is roughly 22 to 150 times Sw SUF, reflecting the dominant share of DM in planned manual floor time. Because manual activities share the zone within a shift, a low activity SUF mainly reflects the small share of the zone covered, not a pace far above the benchmark. Machine floor cleaning follows a different pattern: ride-on sweeper (RS) appears in only five of 24 resource groups, and three zones (International Departure, International Boarding Lounge, and Domestic Departure) plan zero machine minutes in any shifts. A uniform rate across 24 resource groups therefore allocates machine cost to zones with no machine deployment.

3.1.2. International Boarding Lounge records the lowest SUF values across all manual activities

Its DM SUF ranges from 0.0847 to 0.1026 and its DpM SUF from 0.0453 to 0.0553, with no machine activity in any shift. IASS planned substantially less time per unit area for both activities than the ISSA 612 implies for standardized open-floor conditions. In contrast, Domestic Boarding Lounge DM SUF, at 0.2380 to 0.3811, is materially higher despite shared classification, a difference whose cost consequence is examined in Table 1.1 of Section 3.3.

3.1.3. Plaza zones show the widest SUF range and strongest machine concentration

Domestic Plaza Shift 3 records an AS SUF of 5.4916, the highest in the matrix, and International Plaza Shift 3 records 1.7100. Neither plaza deploys AS in Shifts 1 and 2, so spreading machine cost uniformly across three shifts assigns two-thirds of it shifts without machines. Domestic Plaza also records the only manual values above 1.0, with DM SUF of 1.1671 in Shift 1 and 1.5160 in Shift 2. In both shifts, IASS planned more DM time per unit area than ISSA 612 implies for standardized conditions.

The variation in SUF values demonstrates that planned time per unit area varies materially across zones, shifts, and activity types at Terminal 3. The single area-based rate of 1,800 m²/hour in the OE collapses this distribution into one uniform figure. This finding is consistent with study which found that disaggregated resource-center analysis reveals variation that aggregate analysis consistently conceals [23]. The summed SUF falls below one full coverage at the ISSA

pace in 19 of 24 resource groups, ranging from 0.13 to 0.16 in International Boarding Lounge and from 0.65 to 0.70 in both Departure zones. Only Domestic Plaza Shifts 1 and 2 and the Shift 3 machine shifts in International Plaza, Domestic Ground Floor, and Domestic Plaza exceed 1.0. Since the no-overlap assumption is the case most favorable to the planned minutes, most groups are planned below the benchmark for one full coverage. In International Boarding Lounge, the low sum may also reflect minutes spent on gate glass and wall cleaning or an area basis larger than the floor cleaned, which the DAC alone cannot separate. This variation forms the empirical basis for the resource-group disaggregated unit cost framework.

3.2. TDABC Framework Output (RQ2)

3.2.1. Capacity cost rates

The labor CCR ranges from Rp 764.05 to Rp 815.50 per minute, and zones with larger cleaner headcounts carry lower rates because the same wage cost spreads over more capacity minutes. Machine CCRs follow the zone-level concentration of planned machine minutes. International Ground Floor carries the highest AS rate under the one-unit basis at Rp 178.09 per minute, owing to fewer daily machine minutes relative to acquisition cost, while Domestic Ground Floor records Rp 70.01 for AS and Rp 664.77 for RS. The one-unit basis fits the planned RS minutes but charges less AS depreciation than the plan implies. The APD CCR (Rp 5.28/min) and manual equipment CCR (Rp 8.56/min) are uniform across all resource groups because both pools scale with headcount.

3.2.2. Framework-implied headcount and floor cleaning share

Framework-implied headcount ranges from 10 to 20 cleaners and one to two team leaders per resource group. International Boarding Lounge records the lowest floor cleaning share (α) in every shift (0.1033 to 0.1256), so floor cleaning is about one-tenth of its total workload, with non-floor activities such as glass and wall cleaning of gate structures taking the rest. Domestic Plaza Shift 3 (0.6551) and Domestic Ground Floor Shift 3 (0.5232) records the highest α values, both consistent with concentrated night-shift auto scrubber deployment. Because the shared supervisory cost pool is split equally across zones and then multiplied by α , resource groups with lower α bear proportionally less supervisory cost per square meter. This keeps supervisory cost from being overstated where floor cleaning is a minor part of the shift.

3.2.3. Unit cost per resource group

The total unit cost (UC_{total}) ranges from Rp 8.76/m²/frequency at International Boarding Lounge Shift 1 to Rp 171.49/m²/frequency at Domestic Plaza Shift 3, a **19.6-fold range** across the 24 resource

groups. Two structural drivers produce this range. The first is machine deployment concentration within specific shifts. The machine cost component (UC_AS) is zero in Domestic Plaza Shift 1 and 2, where no machine operates, and most of the 2.4-fold difference in UC_total between Domestic Plaza Shift 3 and Shift 1 comes from planned auto scrubber time in Shift 3. Most of that cost is operator labor rather than depreciation (Section 3.3). The second driver is DAC planned time per unit area, captured in β , which the SUF compares with the benchmark. International Boarding Lounge records manual cost component (UC_manual) of Rp 7.70 to Rp 9.16 across shifts because its SUF values are far below the ISSA benchmark, while Departure zones record Rp 39.73 to Rp 43.46, driven by substantially higher DM and DpM SUF values. The area-weighted average unit cost across Terminal 3 is Rp 37.764/m²/frequency.

Table 1. Zone-level Comparison: OE vs TDABC Daily Cost and Unit Cost

Zone	Area (m ²)	TC _{OE/day} (Rp)	TC _{TDABC/day} (Rp)	Gap %	UC _{TDABC} (Rp/m ² /freq)
Int'l Dept	31,757.38	5,187,390.45	4,376,760.27	-15.63	45.940
Int'l BL	47,529.85	7,763,735.62	1,314,572.74	-83.07	9.219
Int'l GF	54,537.58	8,908,408.74	4,533,453.31	-49.11	27.708
Int'l Plaza	20,327.62	3,320,403.29	3,542,509.71	+6.69	58.090
Dom Dept	31,075.88	5,076,071.23	4,190,656.74	-17.44	44.951
Dom BL	45,485.07	7,429,732.34	4,978,054.01	-33.00	36.481
Dom GF	53,620.60	8,758,625.18	5,792,691.03	-33.86	36.010
Dom Plaza	15,996.58	2,612,952.22	5,295,997.67	+102.68	110.357
T3 Total	300,330.57	49,057,319.07	34,024,695.48	-30.64	37.764

The largest divergence is at International Boarding Lounge, 83.07% below the OE allocation, where the TDABC weighted unit cost of Rp 9.219/m²/frequency is a 5.9-fold difference from OE_ADJ. The zone records the lowest planned time per unit area across manual activities and deploys no machines. About 60% of its gap (Rp 27.25 of Rp 45.23/m²/frequency) equals the machine component the OE spreads over every square meter, and the rest reflects lower planned labor time and related costs. At the opposite end, Domestic Plaza records sits 102.68% above the OE allocation through two mechanisms. Its Shifts 1 and 2 already exceed OE_ADJ without machines (Rp 70.39 and Rp 89.19/m²/frequency) because the DAC plans far more dry mopping time per square meter there. In Shift 3, its UC_AS of Rp 144.15 is mostly operator labor, since depreciation is about 6.9% of the per-minute auto scrubber rate under the one-unit basis.

3.3.2. Machine cost concentration

The zone-level divergence has two mechanisms. The first is machine cost: the OE spreads its machine component of Rp 27.245/m²/frequency over every square meter, while machines operate only in specific zones and shifts. The OE allocation therefore assigns machine cost to the three zones with zero machine deployment in proportion to their floor area, reproducing the distortion mechanism of the Plant I

3.3. Comparison with the Owner Estimate (RQ3)

Both cost structures are applied to the current-condition analytical floor area of 300,330.57 m², and the OE gross unit price of Rp 56.1095/m²/frequency is adjusted to OE_ADJ of Rp 54.4481/m²/frequency for like-for-like comparison.

3.3.1. Zone-level cost comparison

Table 1 compares the daily OE cost allocated by area (TC_OE/day) with the TDABC daily cost (TC_TDABC/day) for each zone. TDABC cost falls below the OE Allocation in six of eight zones and above it in International Plaza and Domestic Plaza. The terminal-level gap of 30.64% below OE_ADJ therefore contains zone-level gaps running in opposite directions, and neither direction is visible under the single-rate structure.

versus Plant II case [10]. The TDABC framework avoids this by dividing machine depreciation by total planned machine minutes per zone and assigning it through the β only to shifts where the machine operates, so shifts without machine minutes carry zero UC_AS and a zero ride-on sweeper component (UC_RS). The second mechanism, planned labor time per unit area, explains what the first cannot. In Domestic Plaza, the OE machine component exceeds the framework auto scrubber depreciation by about Rp 23.9/m²/frequency, yet the zone stays above OE_ADJ because its planned labor and operator time per square meter is the highest of all zones.

3.3.3. Terminal-level aggregation

Table 2 presents the terminal-level financial comparison. The TDABC weighted unit cost of Rp 37.764/m²/frequency is 30.64% below OE_ADJ, a monthly gap of Rp 450,978,708 and an annual gap of Rp 5,411,744,491. These figures show the financial magnitude of the methodological difference between a single-rate area-based allocation and an activity and resource group-disaggregated framework applied to the same scope at the same analytical area. They are not presented as cost savings, since the existing contract passed through PT API's formal procurement governance process and reflects a separately validated scope and pricing structure.

Table 2. Terminal 3 cost comparison: TDABC Framework vs OE Baseline

Metric	TDABC Framework	OE _{Adj}	Gap
Unit cost (Rp/m ² /freq)	37.764	54.448	(16,685)
Monthly total cost (Rp)	1,020,740,864	1,471,719,572	(450,978,708)
Annual total cost (Rp)	12,248,890,374	17,660,634,865	(5,411,744,491)

Two qualifications also apply. First, the TDABC unit cost prices the deployment IASS plans, and in 19 of 24 resource groups that plan falls short of one full coverage at the ISSA 612 pace, so part of the gap reflects planned time below the benchmark. Second, auto scrubber depreciation under the one-unit basis is about 2.33% of daily cost. More units would raise cost only in the five zones that deploy the machine and narrow the gap, so 30.64% is the upper end the planned minutes support, not a fixed value.

3.4. Discussion

The findings show that a cost estimate can reflect variation in resource consumption across activities, zones, and shifts only when its costing structure records that variation. Planned cleaning time per unit area differs substantially among resource groups, so floor cleaning activities do not draw on resources uniformly. The TDABC framework links planned time to the resource group that supplies it, whereas the single-rate approach folds heterogeneous activities into one productivity coefficient. This supports the view that a uniform allocation rate distorts cost when outputs consume resource differently [9], [10], and that wide averages distort the cost base on which managers are held accountable [24].

The study also extends TDABC to continuous-area cleaning services. The cleaning and hospitality applications reviewed define their cost objects as bounded transactions, such as hotel room visit or a room type [25], [26]. Here the cost object is a zone-shift resource group with its own activity composition and personnel deployment, a structure that existing applications have not formalized for this service context.

The SUF carries the methodological contribution. Existing approaches take time input from stopwatch observation [25], interviews and company documentation [18], or institutional records [27], but none links a published benchmark to site planning data through a derived ratio. The SUF does not calibrate the time parameter: β equals DAC planned minutes per square meter, and the ISSA 612 rate reaches the unit cost only through the small chemical term. Its role is comparative, separating β into a benchmark time and a ratio showing how far planned time departs from it.

From a managerial perspective, the framework gives PT Angkasa Pura Indonesia a traceable basis for preparing future Owner Estimates (OE). The current single productivity coefficient of 1,800 m²/hour is replaced by eight zone-level unit costs entered as HPS line items, each supported by a derivation appendix of the 24 resource-group unit costs behind it. Before

pricing, PT API should review the summed SUF of each resource group, because planned minutes fall short of one full coverage at the ISSA pace in 19 of 24 groups.

The framework also supports procurement governance. Each cost component traces to a documented source: the DAC for time parameters, the OE wage and equipment rates, APPA for practical capacity, and ISSA 612 for the external benchmark. Machine depreciation enters only the zones and shifts where the DAC records machine deployment. This chain is designed to support the requirement of PD.DU.27/Pl.02.03/2025 that the HPS rest on data that can be accounted for [8].

The implementation of the framework depends on how operational data is recorded. In the current DAC, cleaners work on floor, glass and wall surfaces within the same planned time blocks, so floor-cleaning minutes had to be extracted through proportional decomposition. A DAC format that records planned minutes for each cleaning activity and surface material separately would let floor minutes enter the framework directly as the time input, without that step. Such minutes would still be planning data, so the summed SUF review applies to them as well.

This study has several limitations. First, the time parameters are derived from DAC planned minutes rather than direct field observations, so the analysis reflects planning-level requirements. These minutes are also treated as normal time, which amounts to a performance rating of 1.00, whereas time study derives normal time from observed time adjusted by a performance rating [28]; this rating has not been validated at Terminal 3. Second, machine minutes follow planned deployment schedules, which may differ from actual utilization because of equipment downtime, and the DAC does not record how many units are deployed, so one unit per zone is charged (Section 3.3). Third, chemical consumption is taken from the OE because verified dispensing data were unavailable. Finally, the study covers only *Lantai Harian Tipe B* at Terminal 3, so other terminals or cleaning categories require recalibration of activity times and resource parameters.

Future research should develop field-validated standard times for each cleaning activity through work sampling, since TDABC studies combining direct observation with staff input report more reliable cost assessments [29]. Further studies may also examine how SUF values shift as passenger volume fluctuates across zone and shifts. Because time equations can be extended with new activity terms without rebuilding

the model [30], replication across most other work types and terminals within PT Angkasa Pura Indonesia would require new time parameters rather than a new cost architecture.

The proposed TDABC framework therefore offers a methodological alternative for improving cost estimation practices in airport cleaning services. By pairing DAC-derived time parameters with zone-shift resource groups, it makes cost differences traceable to their operational drivers and gives future Owner Estimates a more defensible basis.

4. Conclusion

This study developed an activity and resource group-disaggregated TDABC framework for daily floor cleaning services at Terminal 3 Soekarno-Hatta International Airport. Planned time per unit area differs by zone, shift, and activity, and summed SUF falls below one full coverage at the ISSA pace in 19 of 24 resource groups, so the single coefficient of 1,800 m²/hour cannot represent this variation. Using DAC planned minutes as the time input, benchmarked against ISSA 612 through the SUF, five CCR pools produce traceable unit costs with a 19.6-fold range. Under the one-unit basis, the area-weighted unit cost is 30.64% below OE_ADJ, while zone gaps run in opposite directions through two mechanisms (Section 3.3). The gap reflects a change in method and planned time below the benchmark, not a cost saving. The framework thus gives the 2027 Owner Estimate a more traceable and defensible basis.

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