Temasek Defence Systems Institute

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IMPROVING A KEY PERFORMANCE INDICATOR BASED REAL TIME COST MEASUREMENT SYSTEM FOR SMART MANUFACTURING

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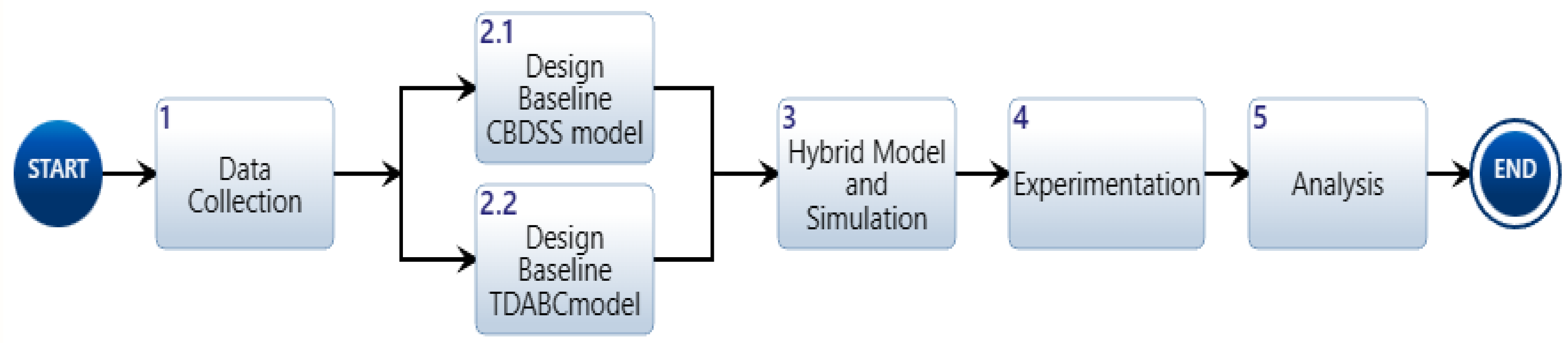
Background

Developed an integrated cost model combining a Cost-Based Decision Support System (CBDSS) with Time-Driven Activity-Based Costing (TDABC) to translate real-time key performance indicator (KPI) data into cost insights. Guided by Systems Engineering Vee model, the hybrid approach (CBDSS + TDABC) was implemented in an Excel spreadsheet using actual manufacturing data.

Research Questions

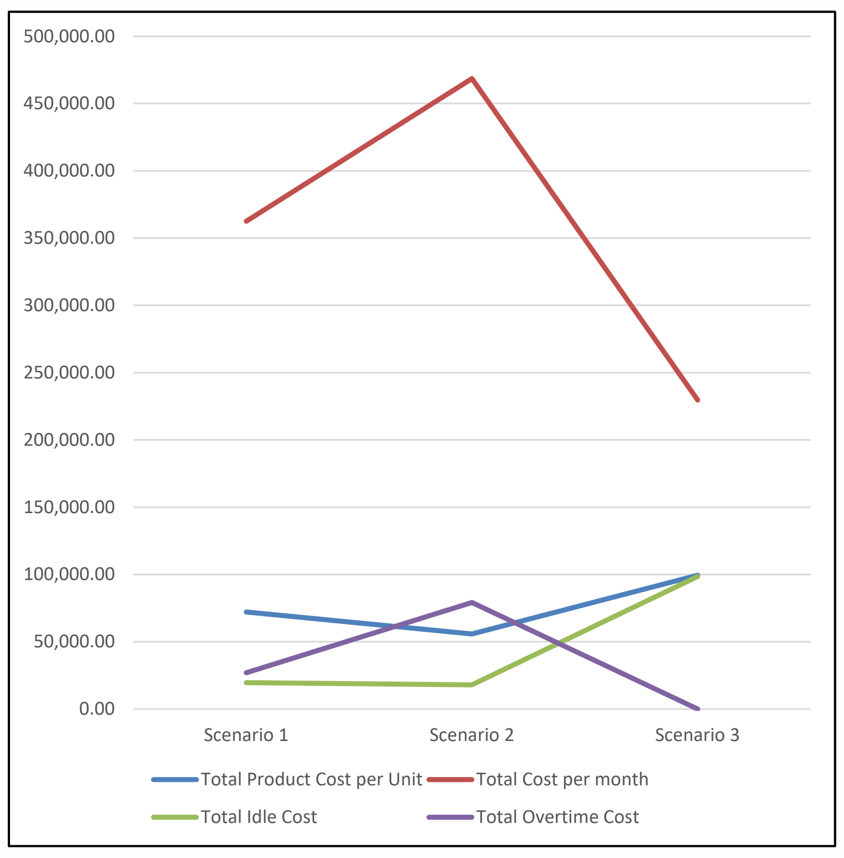
- RQ1: How can a KPI-based cost measurement system be improved to boost production efficiency and ROI?
- RQ2: What system architecture can significantly enhance KPI tracking in manufacturing?
- RQ3: Which KPIs most strongly impact cost visibility and decision-making?
- RQ4: Besides production efficiency, what other measurable benefits can be gained by improving a KPI-based cost system?

Methodology



Results:

Responses	Baseline Operation (Normal Conditions)	Improved Performance (High KPI)	Degraded Performance (Low KPI)
Total Product CPU ($)	72,146.12	55,803.76	99,439.57
Total Cost per month ($)	362,646.70	468,570.56	229,672.01
Total Idle Cost ($)	19,593.07	17,975.12	98,501.59
Total Overtime Cost ($)	27,033.09	79,186.04	0.00



- Scenario Testing:
- Improved: ↓ Unit cost by 23% but ↑ overtime cost due to capacity strain.
- Baseline: Balanced utilization and moderate cost.
- Degraded: ↑ Unit cost due to scrap, idle capacity, and inventory buildup.
- DOE Analysis:
- Dominant factors: Batch size & inventory ($p < 0.001$).
- Moderate factors: Repairability, quality yield.
- Negligible factor: Environmental efficiency within the tested bounds.
- Interpretation: Batch size lowers unit cost but increases overtime, while higher inventory directly raises total cost. Balancing both is crucial for optimal cost performance.

Research Objectives

- Evaluate the existing KPI-based cost framework (baseline) to identify its strengths and weaknesses for real-time cost visibility.
- Identify gaps in current KPI-based costing approaches that hinder effective real-time cost integration.
- Determine which operational KPIs most influence cost visibility and accuracy in smart manufacturing.
- Propose an improved KPI-driven real-time cost model and system architecture addressing the identified gaps.

Key Insights & Discussion

	Total Product Cost per Unit	Average Utilisation	Total Idle Cost	Total Overtime Cost
Model	0.000	0.000	0.000	0.000
Batch Size	0.000	0.000	0.000	0.000
Average Quality	0.930	0.017	0.243	0.966
Repairability	0.053	0.903	0.574	0.056
Environmental	0.962	0.469	0.413	0.880
Inventory	0.000	0.567	0.419	0.967

- Cost-Driver Sensitivity: Managers can reduce unit costs by optimizing batch sizes and controlling inventory levels, which emerge as the primary drivers of cost behavior.
- Trade-offs: Higher throughput lowers unit cost but increases overtime, while slower production avoids overtime but raises idle costs.
- Managerial Implications: By linking operational KPIs to real-time costing, the model provides a decision support tool that bridges engineering and finance perspectives.

Conclusion & Recommendations:

- Improved Cost Visibility: The hybrid model enhances real-time cost visibility by linking operational KPIs to financial outcome.
- Key Optimization Levers: Batch size and inventory management are the most influential factors; optimizing them reduces cost but requires balancing idle and overtime trade-offs.
- Implementation & Future Work: Integrating the model into Manufacturing Execution Systems (MES) enables live cost tracking. Future research should validate the model across diverse Industry 4.0 environments to ensure accuracy and scalability.

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