Implementation of Technology Assessment in Air Traffic Control System at Juanda International Airport using Technometric and MCDM Approach

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AIR TRAFFIC CONTROL SYSTEM
FLIGHT OPERATION PROCEDURE

Preparation stage

- Fill in flight plan form
- Flight plan data input (FDD, VHF)
- Pre-flight check (DVOR)

Departure stage

- Departure procedure prep (DVOR, NDB, VHF)
- Weather condition check (Radar, VHF)
- Runway/ground control check (Radar, VHF)
- Departure (DVOR, NDB, VCSS)

During Flight

- During flight guide (VCSS, DVOR, NDB)
- Information passing to destination airport (VCSS)
- Flight preparation to approach (VCSS, NDB, DVOR)

Approaching stage

- Approaching instruction information (DVOR, NDB, ILS, Radar, VCSS)
- Ready to approach/stand-by position (DVOR, NDB, ILS, VCSS)

Landing stage

- Landing stand-by position (DVOR, NDB, VHF)
- Weather condition check (Radar, VHF)
- Runway/ground control check (Radar, VHF)
- Landing clearance (VHF)
- Aircraft lands/touch-down (ILS, VHF, VCSS)

End of flight declaration

- Touch down (ILS, VHF, VCSS)
- Parking instruction (VHF, Radar)
- Turn off engine
Company’s existing assessment on ATC system is conducted at technological instrument and machines as maintenance routine, and quality assurance based on information accuracy.
Problem Identification

Technological gap of ATC System

Technology Assessment of ATC system

Alternative decision for technology improvement
1. To assess the use of ATC system technology performed in Juanda International Airport;
2. To figure out linkage inside the system that is insufficient;
3. To develop alternative decisions for ATC system improvement.
The research scopes are:

- The problem is viewed from the researcher’s point of view, by considering stakeholder’s;
- Technological components being observed are **Technoware**, **Humanware**, **Infoware** and **Orgaware**;
- The specified field of evaluation is the ATC system and management of technology of Juanda International Airport;

Research assumptions are:

- The ATC system being observed are all parts significant in assisting ATC controllers to manage flights;
- Expert judgments information necessary will be obtained through company’s experts in ATC technology.
## CRITICAL REVIEW

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Title of Research</th>
<th>Research Objectives</th>
<th>Year of Conduct</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dian Pusporini</td>
<td>Analisis Manajemen Teknologi pada Industri Kertas dengan Pendekatan TCC dan Benefit Cost Ratio (studi kasus: PT Kertas Leces (PERSERO))</td>
<td>Investigate technological transition in paper industry, benchmark to know the company’s position and developing alternative technology investment</td>
<td>2003</td>
<td>TCC, Benefit Cost Ratio</td>
</tr>
<tr>
<td>2</td>
<td>Evy Diah Prawestri</td>
<td>Implementasi Metode Teknometrik untuk Menganalisa Kandungan Teknologi pada PT Iglas (PERSERO)</td>
<td>Investigate gap between existing technology and state of the art technology for company’s improvement</td>
<td>2003</td>
<td>TCC, AHP</td>
</tr>
<tr>
<td>3</td>
<td>Xing, Jing; Manning, Carol</td>
<td>Complexity and Automation Displays of Air Traffic Control: Literature Review and Analysis</td>
<td>Investigate the impact of technology implementation in ATC display traffic control</td>
<td>2005</td>
<td>Human Reliability Assessment, Corporate performance</td>
</tr>
<tr>
<td>4</td>
<td>Dwi Kusumaningtyas</td>
<td>Implementation of Technology Assessment in Air Traffic Control System at Juanda International Airport using MCDM and Technometric Approach</td>
<td>investigate the existing ATC technology to improve its performance through developing alternative decision for technology investment</td>
<td>2010</td>
<td>MCDM (AHP, ELECTRE III)</td>
</tr>
</tbody>
</table>
STAGES OF DATA PROCESSING AND CALCULATION

AHP Weighting of Technology Component

TCC calculation

Technometric THIO Plot diagram

Establishing criteria and alternative improvement

ELECTRE III calculation of improvement preferences
AHP weighting stage

1. START
2. ATC system
   - Formulation: Identification of technology components
   - Experts judgment
   - Collecting data: 1. ATC system technology components 2. Air traffic volume 3. Airport Policy
   - Designing technology measurement questionnaire: - Technoware questionnaire - Humanware questionnaire - Infoware questionnaire - Orgaware questionnaire
3. Validation of result
   - YES: Data Analysis
     - Interpretation and generate alternative decision
     - Conclusion: Existing ATC technology and alternative technology investment
     - END
   - NO
4. Conducting Technology Contribution Calculation:
   1. Determining Company's degree of technology
   2. Determining state of the art
   3. TCC Calculation
5. Company's policy of ATC system and technology investment
Technology Component Weighting

In order to determine the weight of each ATC component, interview and discussion is conducted with 2 of the company’s ATC technology experts. Results obtained is then inputted into Expert Choice 2000 software to generate the technology component weight. For each technology element, the output shows only the first hierarchy criteria, with each subcomponent participate at lower hierarchy calculated in aggregation to form the first hierarchy criteria.

At first level of technology element level, the result of AHP weighting is:

<table>
<thead>
<tr>
<th>Element</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technoware</td>
<td>0.255</td>
</tr>
<tr>
<td>Humanware</td>
<td>0.362</td>
</tr>
<tr>
<td>Infoware</td>
<td>0.272</td>
</tr>
<tr>
<td>Orgaware</td>
<td>0.111</td>
</tr>
</tbody>
</table>

Inconsistency ratio = 0.03

Complete list of technology component weight at APPENDIX B
SOA and TCC calculation

1. Formulation: Identification of technology components
2. Collecting data: 1. ATC system technology components 2. Air traffic volume 3. Airport Policy
3. Designing technology measurement questionnaire: - Technoware questionnaire - Humanware questionnaire - Informware questionnaire - Orgaware questionnaire
4. Construction of model tabulation
6. Data Analysis
7. Interpretation and generate alternative decision
8. Conclusion: Existing ATC technology and alternative technology investment
9. Company’s policy of ATC system and technology investment
State of the art values are extracted from questionnaire of comparison of company and SOA score, filled in by company’s experts. Then, to determine each technology component SOA score, calculation is conducted using equation:

$$ ST_i = \frac{1}{10} \sum_{k}^{t_i} \frac{t_i k}{k_t} $$

for Technoware technology element,

where $k =$ number of criteria $= 1, 2, \ldots, k_t$

$t_i =$ score for each criteria

Same calculation applies for Humanware, Infoware and Orgaware. Example of SOA score calculation:

Recap of SOA Score
Technology Contribution Coefficient

This model will measure the total contribution of the four components of technometric. This model is formulated;

\[ TCC = T^{\beta_t} \cdot H^{\beta_h} \cdot I^{\beta_i} \cdot O^{\beta_o} \]

Where:

\( T, H, I, O = \) technoware, humanware, infoware, orgaware contribution
\( \beta_t, \beta_h, \beta_i, \beta_o = \) contribution intensity of T, H, I, O to TCC.

Where contribution of each four technology element is calculated using:

\[
T = \left[ LT_i + ST_i (UT_i - LT_i) \right] / 9
\]
\[
H = \left[ Lh_j + SH_j (UH_j - LH_j) \right] / 9
\]
\[
I = \left[ LI + SI (UI - LI) \right] / 9
\]
\[
O = \left[ LO + SO (UO - LO) \right] / 9
\]
# Recap Table of SOA score and TCC calculation

<table>
<thead>
<tr>
<th>Technology Element</th>
<th>Upper Limit</th>
<th>Lower Limit</th>
<th>Weight ($\beta$)</th>
<th>SOA rating</th>
<th>Component Contribution</th>
<th>Total Contribution (TCC)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TECHNOWARE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation Stage</td>
<td>3</td>
<td>1</td>
<td>0.048</td>
<td>0.156</td>
<td>0.257</td>
<td>0.156</td>
</tr>
<tr>
<td>Departure Stage</td>
<td>5</td>
<td>1</td>
<td>0.127</td>
<td>0.167</td>
<td>0.519</td>
<td>0.153</td>
</tr>
<tr>
<td>During flight/ In travel</td>
<td>3</td>
<td>1</td>
<td>0.336</td>
<td>0.147</td>
<td>0.255</td>
<td>0.105</td>
</tr>
<tr>
<td>Approaching Stage</td>
<td>3</td>
<td>1</td>
<td>0.125</td>
<td>0.150</td>
<td>0.256</td>
<td>0.141</td>
</tr>
<tr>
<td>Landing Stage</td>
<td>3</td>
<td>1</td>
<td>0.281</td>
<td>0.150</td>
<td>0.256</td>
<td>0.114</td>
</tr>
<tr>
<td>Arrival Stage</td>
<td>5</td>
<td>1</td>
<td>0.083</td>
<td>0.167</td>
<td>0.519</td>
<td>0.158</td>
</tr>
<tr>
<td><strong>HUMANWARE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implementing Labour</td>
<td>6</td>
<td>1</td>
<td>0.584</td>
<td>0.275</td>
<td>0.708</td>
<td>0.273</td>
</tr>
<tr>
<td>Operational Labour</td>
<td>6</td>
<td>1</td>
<td>0.281</td>
<td>0.267</td>
<td>0.704</td>
<td>0.302</td>
</tr>
<tr>
<td>Technical Labour</td>
<td>6</td>
<td>1</td>
<td>0.135</td>
<td>0.458</td>
<td>0.810</td>
<td>0.324</td>
</tr>
<tr>
<td><strong>INFOWARE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infoware related to Technoware</td>
<td>4</td>
<td>1</td>
<td>0.105</td>
<td>0.450</td>
<td>0.483</td>
<td>0.309</td>
</tr>
<tr>
<td>Infoware related to Humanware</td>
<td>4</td>
<td>1</td>
<td>0.637</td>
<td>0.275</td>
<td>0.425</td>
<td>0.193</td>
</tr>
<tr>
<td>Infoware related to Orgaware</td>
<td>4</td>
<td>1</td>
<td>0.258</td>
<td>0.275</td>
<td>0.425</td>
<td>0.267</td>
</tr>
<tr>
<td><strong>ORGAWARE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work Organization</td>
<td>5</td>
<td>2</td>
<td>0.265</td>
<td>0.163</td>
<td>0.721</td>
<td>0.229</td>
</tr>
<tr>
<td>Work facilities</td>
<td>7</td>
<td>3</td>
<td>0.508</td>
<td>0.352</td>
<td>1.490</td>
<td>0.306</td>
</tr>
<tr>
<td>Job Evaluation</td>
<td>6</td>
<td>3</td>
<td>0.151</td>
<td>0.176</td>
<td>1.059</td>
<td>0.252</td>
</tr>
<tr>
<td>Modification of Work</td>
<td>7</td>
<td>5</td>
<td>0.075</td>
<td>0.308</td>
<td>1.180</td>
<td>0.253</td>
</tr>
</tbody>
</table>

\[
TCC = T^{\beta_t} \cdot H^{\beta_h} \cdot I^{\beta_i} \cdot O^{\beta_o}
\]

For orgaware, total contribution equally divided by 4 organization components
What will the company decide??

Improvement alternatives developed based on company’s preferences for technology investment....
Improvement alternatives

ATC system

Formulation: Identification of technology components

Collecting data:
1. ATC system technology components
2. Air traffic volume
3. Airport Policy

Experts judgment

Designing technology measurement questionnaire:
- Technoware questionnaire
- Humanware questionnaire
- Inforware questionnaire
- Orgaware questionnaire

Conducting Technology Contribution Calculation:
1. Determining Company's degree of technology
2. Determining state of the art
3. TCC Calculation

Validation of result

Data Analysis

Interpretation and generate alternative decision

Conclusion:
Existing ATC technology and alternative technology investment

Company's policy of ATC system and technology investment

Secondary Data

Construction of model tabulation

END
## Company's Improvement Preferences

### Establishing Criteria and Alternative Improvement

<table>
<thead>
<tr>
<th>Name</th>
<th>Alternative Decision</th>
<th>Criteria Name</th>
<th>Definition</th>
<th>Degree of Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cr01</td>
<td>Level of service outcome</td>
<td>Cr01</td>
<td>With the level of service that is in line with the SK BP/284/X year 1999</td>
<td>0.659</td>
</tr>
<tr>
<td>A1</td>
<td>Renewed implementation of power distribution</td>
<td>Cr02</td>
<td>Effectivity of power distribution</td>
<td>0.185</td>
</tr>
<tr>
<td>Cr02</td>
<td>Overlapping of job description</td>
<td>Cr03</td>
<td>Indicate the overlapping job distribution when job dissemination conducted</td>
<td>0.156</td>
</tr>
<tr>
<td>A2</td>
<td>Improve work seniority</td>
<td>A1</td>
<td>Seniority in job dissemination is still considered, therefore improving seniority at work by developing work qualification</td>
<td>0.272, 0.091, 0.077</td>
</tr>
<tr>
<td>A3</td>
<td>Improving employee’s qualification</td>
<td>A2</td>
<td>To overcome the problem of lack of qualification for existing employees</td>
<td>0.272, 0.091, 0.077</td>
</tr>
<tr>
<td>A3</td>
<td>Improving employee’s qualification</td>
<td>A3</td>
<td>To overcome the problem of lack of qualification for existing employees</td>
<td>0.323, 0.03, 0.022</td>
</tr>
</tbody>
</table>

### Output analysis of company's improvement
CONCLUSIONS & SUGGESTIONS
Conclusions

• Technology assessment process was successfully conducted at ATC system unit at Juanda International Airport using AHP weighting method and technometric approach, Humanware holds the greatest weight for technology element contributing 0.362 for overall company's technology element and gaps 0.101 points to SOA score. While Orgaware weighted at 0.111 for overall technology element weight and is the lowest weight among other and gaps 0.740 points.

• Results indicate that Orgaware technology element is the company’s weakest element.

• Preferences for improvement is made by company’s experts, Alternative 1 is the most prefer among all alternatives.
Suggestions

• The company, PT Angkasa Pura I Juanda International Airport should maintain humanware technology element performance;

• Fully implementation of improvement preferences should be done if the company wishes to increases orgaware function and contribution to ATC system;

• Company has sufficient technology element based on SOA score that the company established;

• This research could be broaden into investigation of two ATC system in two different airports to compared each technological component contribution level and using other more advance methods of technology assessment and decision making.
REFERENCES


Free access paper, access on January 7th 2010 at 13.04.


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