Evaluation of Usability and Workload with Paper Strips as Compared to Virtual Flight Strips Used for Ramp Operations

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AHFE July 23 2018
What is ATD2?

Airspace Technology Demonstration (ATD) 2

Integrated Arrival Departure Surface traffic management developed at NASA. We are currently fielding the surface tool with AAL at CLT.
Paper Strips and Paper Map
at Charlotte Douglas International Airport

Paper strips and paper map limitations include
• Lack of digital updates to flight data
• Lack of Traffic Management Initiative data
Paper Strips and Paper Map at Charlotte Douglas International Airport

Paper strips and paper map limitations include:

- Lack of digital updates to flight data
- Lack of Traffic Management Initiative data

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Virtual Flight Strips
Ramp Traffic Console (RTC)

- Interactive moving map
- Digitally updated flight data
- Provide Traffic Management Initiative data
- Decision Support - metering pushback from the gate
Outline

- Background
- Evolution of Ramp Traffic Console and ATD2
- Objective of current study
- Ramp Traffic Console features
- Design of experiment
- Method
- Results
- Discussion
- Future Work
Evolution of ATD2
(Airspace Technology Demonstration 2)

HITL #5

6 HITLs

ATD-2

Ramp Traffic Console designed along with a new departure metering decision support tool

Evaluation and Design Evolution

Integration of Ramp Traffic Console with other tools used by the Air Traffic Control Tower and Center controllers

Current day field testing activities
Outline

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HITL 5 Objective

• Human in the Loop (HITL) #5 simulation experiment was conducted to evaluate usability and workload ratings of ramp controllers with the using paper strips as compared to virtual flight strips.

• During the HITL, post run and post study questionnaires were administered to assess ramp controller workload and usability ratings while using either Ramp Traffic Console or paper.
Current state of development of Ramp Traffic Console (RTC)
Design of Experiment

- Eight 90-minute data collection runs over three days
  - Four runs with Paper
  - Four runs with virtual strips

- Four ramp controller participants rotated through four sector positions

- Post-run and post-study questionnaires were administered to assess workload and usability

- Two-way repeated measures analysis of variance to determine effect of flight strip type on participant workload and usability
Post Run workload questions

- Four aspects of workload were assessed from NASA Task Load Index
  - mental demand
  - physical
  - temporal
  - frustration
- Response on a 10 point scale:

  ![Mental Demand Scale]

Example question:
“Please rate your workload during the last run”
Method
Usability-ISO definition

• **Effectiveness**: Asked Seven “Traffic Management Performance” questions
  Eg: I maintained sufficient separation among planes.
  (Always) 1 2 3 4 5 6 7 (Never)

• **Efficiency**: Six “Resources and Efficiency” questions
  Eg: The actions required the minimum number of steps.
  (Always) 1 2 3 4 5 6 7 (Never)

• **Satisfaction**: Eighteen Post study “Preference” questions
  Eg: Rate your preference for tracking aircraft status.
  (Prefer paper) 1 2 3 4 5 6 7 (Prefer RTC)
Results Summary

• Workload results:
  Lower mean workload for virtual strips

• Usability results:
  Trend toward increased mean effectiveness for RTC

• Satisfaction results:
  RTC preferred over Paper strips
Results
Workload

Mean Workload Rating

(High) 10
9
8
7
6
5
4
3
2
1

(Low)

Mental Demand
*Time Pressure
*Physical Demand
*Frustration

Mean workload lower for RTC for three aspects of workload assessed, where * indicates p<.05
Usability-Effectiveness Aspect
Mean Response (scale 1-7)

Mean effectiveness for RTC greater than Paper condition for three questions,
* indicates p<.05
Mixed results, with no statistically significant difference found between RTC and Paper.
Trend towards a preference for virtual strips across all questions
Discussion

- Results indicate potential for reduced workload and increased usability with RTC
- More research required
- Actively testing in the field now
Evolution of ATD2
(Airspace Technology Demonstration 2)

Ramp Traffic Console designed along with a new departure metering decision support tool

Evaluation and Design Evolution

Integration of Ramp Traffic Console with other tools used by the Air Traffic Control Tower and Center controllers

Current day field testing activities
Testing virtual strips as a part of the suite of ATD2 tools

HITL #5

We are here now

6 HITLs

ATD-2
Ramp Controllers
Some ATD-2 Field Data Results From November

Some ATD2 Colleagues are presenting some data collected from the field testing activities on Wednesday

- When active ramp controllers were asked, “Were the ATD2 tools helpful in this bank?
- Ramp controllers who used the ATD2 tools in a bank described them as helpful.
Questions?

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Extra
Data provided courtesy of Bonny Parke

Question Asked:
Were the ATD2 tools helpful in this bank? (Question asked only to those who used ATD2 tools actively or occasionally.)

Result:
Ramp managers who actively used the ATD2 tools in a bank described them as more helpful than those who used the tools occasionally.

N = 8 active, 8 occasional use of ATD2 tools in banks; \( t(df\ 9.4) = 2.3, p = .04, \) equal variances not assumed; error bar = 95% Confidence Interval.
• 2-way repeated measures analysis of variance to determine effect of flight strip type.
• found effect of condition on workload and usability
• Independent variable: Scenario, scenario1 and scenario2
• Independent variable: Condition, the first level is paper and the second level is virtual strips
• Saw no effect of scenario
• most concerned with RTC vs paper results
## Results
(Workload)

### Mean Participant Ratings Across Four Aspects of Workload

<table>
<thead>
<tr>
<th>Aspect of Workload</th>
<th>Mean Response Paper</th>
<th>S.E. Paper</th>
<th>Mean Response RTC</th>
<th>S.E. RTC</th>
<th>F(1,3)=</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Demand</td>
<td>5.7</td>
<td>0.82</td>
<td>3.9</td>
<td>1.67</td>
<td>3.59,*p=.155</td>
</tr>
<tr>
<td>Time Pressure</td>
<td>4.9</td>
<td>0.57</td>
<td>2.4</td>
<td>.50</td>
<td>48.46,*p=.006</td>
</tr>
<tr>
<td>Physical Demand</td>
<td>4.6</td>
<td>1.32</td>
<td>2.8</td>
<td>1.43</td>
<td>84.26,*p=.003</td>
</tr>
<tr>
<td>Frustration</td>
<td>3.6</td>
<td>0.31</td>
<td>1.3</td>
<td>0.34</td>
<td>29.73,*p=.012</td>
</tr>
</tbody>
</table>
## Usability Results

### Effectiveness Aspect

<table>
<thead>
<tr>
<th>Effectiveness Question</th>
<th>Mean Response Paper</th>
<th>S.E.</th>
<th>Mean Response RTC</th>
<th>S.E.</th>
<th>F(1,3)=</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Maintained separation</td>
<td>6.7</td>
<td>0.157</td>
<td>6.9</td>
<td>0.125</td>
<td>9,p=.058</td>
</tr>
<tr>
<td>2. Maintained flow</td>
<td>6.1</td>
<td>0.373</td>
<td>6.6</td>
<td>0.295</td>
<td>12,*p=.04</td>
</tr>
<tr>
<td>3. Minimized delay</td>
<td>5.9</td>
<td>0.329</td>
<td>6.5</td>
<td>0.25</td>
<td>22.09,*p=.018</td>
</tr>
<tr>
<td>4. Avoided gridlock</td>
<td>6.6</td>
<td>0.161</td>
<td>6.9</td>
<td>0.063</td>
<td>6.82,p=.088</td>
</tr>
<tr>
<td>5. Maintained pressure on runway</td>
<td>5.9</td>
<td>0.258</td>
<td>6.7</td>
<td>0.237</td>
<td>54,*p=.005</td>
</tr>
<tr>
<td>6. Metered departures</td>
<td>6.2</td>
<td>0.493</td>
<td>6.6</td>
<td>0.12</td>
<td>.73,p=.456</td>
</tr>
<tr>
<td>7. Responded promptly</td>
<td>6.8</td>
<td>0.188</td>
<td>6.9</td>
<td>0.063</td>
<td>.33,p=.604</td>
</tr>
</tbody>
</table>
## Usability Results
### Efficiency Aspect

Resources and Efficiency Questions Mean Response with Standard Error and F values

<table>
<thead>
<tr>
<th>Efficiency Question</th>
<th>Mean Response Paper</th>
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<th>Mean Response RTC</th>
<th>S.E.</th>
<th>F(1,3)=</th>
</tr>
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<tr>
<td>1. Information was accessible</td>
<td>5.4</td>
<td>0.90</td>
<td>6.0</td>
<td>0.65</td>
<td>1.86, p=.26</td>
</tr>
<tr>
<td>2. Information available, but required work</td>
<td>3.3</td>
<td>0.753</td>
<td>3.4</td>
<td>0.74</td>
<td>.03, p=.878</td>
</tr>
<tr>
<td>3. Held aircraft information available</td>
<td>5.5</td>
<td>.729</td>
<td>5.4</td>
<td>0.582</td>
<td>.16, p=.718</td>
</tr>
<tr>
<td>4. Actions required minimum number of steps</td>
<td>5.4</td>
<td>0.439</td>
<td>4.9</td>
<td>0.161</td>
<td>1.85, p=.26</td>
</tr>
<tr>
<td>5. Collaborated</td>
<td>6.8</td>
<td>0.25</td>
<td>6.9</td>
<td>0.125</td>
<td>.27, p=.630</td>
</tr>
<tr>
<td>6. Others handled traffic as expected</td>
<td>6.9</td>
<td>0.125</td>
<td>6.9</td>
<td>0.125</td>
<td>0, p=1.0</td>
</tr>
</tbody>
</table>
Charlotte Douglas International Airport
Ramp Operations Tower
Ramp Traffic Console (RTC)
CLT