

An Empirical Evaluation of the Integrated Tower Operations Digital Data System

Presented to: 2009 Integrated Navigation Communications and
Surveillance Conference

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Date: 13 May 2009



Federal Aviation
Administration



Introduction

- **Paper flight progress strips (FPSs) impose perceptual, cognitive, and physical loads on tower controllers**
- **Integrated electronic system should improve the efficiency and safety of tower operations**
- **Tower Operations Digital Data System**
 - Accommodate local and ground control positions
 - Increase controller awareness
 - Reduce cognitive and physical task load
 - Improve coordination between controllers and facilities
 - Increase airport efficiency
 - Reduce risk of incursions



Requirements Summary

- **JPDO *Concept of Operations for the Next Generation Air Transportation System* (June 13, 2007)**
 - **R-14** – ...Staffed Virtual Towers (SVTs) and Automated Virtual Towers...
 - **R-53** – ...surface operations in low visibility conditions...
- **JPDO *Next Generation Air Transportation System Research and Development Plan FY 2009-FY 2013* (July 6, 2007)**
 - **R-0120** – ...operator situational awareness for low-visibility terminal and airport surface operations...
 - **R-1430** - ...alternative aircraft/ground and human/automation roles and responsibilities...
 - **R-1040** - ...applied research on staffed and automated virtual tower options...
 - **R-1710** - ...applied research on risk-reducing systems interfaces, procedures, and training to reduce human error...



Background

- **FY04 – Literature Review**
- **FY05 – Design & Create Prototypes**
- **FY06 – Part-task Simulation & Usability Test**
- **FY07 – Enhanced Prototype Designs**
- **FY08 – Integrated TODDS vs. FPS**



Integrated TODDS - Overview

- **21.3” Vartech touch resistive display, 1600X1200 resolution, 85 degree viewing angle**
- **For use at airports with surface surveillance**
- **Integrates flight data management with real-time aircraft position, wx, and D-taxi**



ASH5215 P0000 HDG: 330
 CRJ1 • T0006 ALT: 120
 117 3111 E RWY: 33L
 BOS . .MALDY . .SWIGG . .PVD . .JFK

ATIS A TAXI 33L E@J HS 27 121 .01
 0

PENDING

◁ USA21	A333	27	0006	<input type="checkbox"/>
◁ DAL941	B752	33L	0001	<input type="checkbox"/>

OUTBOUND

○ ASH5215	CRJ1	MALDY	33L	0006
○ N6030N	PA28	MALDY	33R	0002
○ UAL653	A320	GARVE	27	E0016
○ UAL474	B763	GARVE	27	0002
▲ CH05582	E145	MALDY	33L	0000
▲ N8980F	PA28	MALDY	33R	0000

LOCAL

INBOUND

CAA2146	CRJ1
EGF5693	E145
NNA990	B752
AAL168	B752

RAMP



EDIT TAXIRAWS EDIT RUNWAYS

D-TAXI CANCEL

DCB ON/OFF
 OPER

WX
 A 29011614 2995
 33L: T56 M55 R54
 27: T59 M58 R57

HOLD SHORT

COAST/SUSPEND
 02/07/08
 0006/46

33R

33L

J1



AAL874 P0000 HDG: 330
 B763 ▲ T0000 ALT: 120
 108 0675 E RWY: 33L
 BOS .MALDY .SWIGG .PYD .JFK

DEPARTURE

▲ USA393	A319	MALDY 33L	0000	<input type="checkbox"/>
▲ SMA408	B738	MALDY 33L	0000	<input type="checkbox"/>
▲ DAL247	B752	MALDY 33L	0000	<input type="checkbox"/>
▲ AAL874	B763	MALDY 33L	0000	<input checked="" type="checkbox"/>
▲ USA447	A333	GARVE 27	0000	<input type="checkbox"/>
▲ EGF5986	E145	GARVE 27	0000	<input type="checkbox"/>
▲ COA254	B735	GARVE 27	0000	<input type="checkbox"/>
▲ AAL833	B738	GARVE 27	0000	<input type="checkbox"/>
▲ COA1068	B738	GARVE 27	0000	<input type="checkbox"/>

TRACON

ARRIVAL

USA236	B752	27
NHA101	A320	33L
TRS375	B712	27
N1553L	PA31	33R
N1858P	PA31	33R

GROUND



Datablocks & Flight Data Elements

- Unowned

PENDING				
AAL555	B757	04L	0000	<input type="checkbox"/>
AAL446	B777	04L	0000	<input type="checkbox"/>
DAL195	B757	04L	0000	<input type="checkbox"/>
USA306	B757	04L	0000	<input type="checkbox"/>

Datablocks & Flight Data Elements

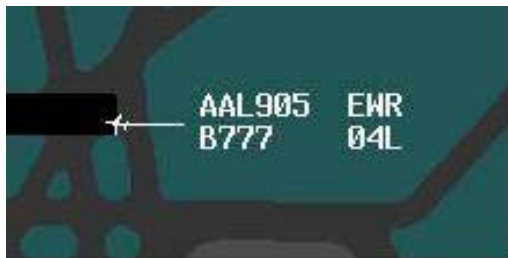
OUTBOUND					
DAL195	B757	EWR	04L	0017	<input type="checkbox"/>
USA306	B757	BOS	04L	0017	<input type="checkbox"/>
AAL445	B777	BOS	04L	0017	
AAL245	B777	EWR	04L	0016	
USA305	B757	EWR	04L	0016	
AAL246	B777	BOS	04L	0016	

DEPARTURE					
AAL916	B777	BOS	04L	0006	<input type="checkbox"/>
USA706	B757	BOS	09	0004	
AAL906	B777	BOS	04L	0003	
AAL915	B777	BOS	04L	0002	
USA705	B757	EWR	04L	0001	
AAL905	B777	EWR	04L	01:27	



ARRIVAL			
UAL3314	EA32	08	<input type="checkbox"/>
UAL3304	B737	04R	<input type="checkbox"/>
DAL2294	DC10	08	
AAL2004	B737	04R	
UAL3303	B737	04R	
DAL2293	DC10	04R	
AAL2003	B737	04R	


INBOUND	
UAL6003	B737
DAL2153	DC10
DAL2154	DC10
UAL2773	EA32
AAL7904	B737
AAL1014	MD82



Datablocks & Flight Data Elements

- Selected

OUTBOUND				
▲	N4942E	PA28	MALDY 33R	0000
▲	BTA7954	E145	MALDY 33L	0000
▲	NWA859	A333	GARVE 27	0000



Readout Area

```
AAL906      P0002      HDG: 040  
B777        T0004      ALT: 150  
137 2104   E          RWY: 04L  
BOS . .BOS036004 . .BLEAK . .VPBAY . .W0  
LFA . .PUGGS . .EWR  
  
REMARKS:
```

```
AAL906      P0002      HDG: 050  
B777        T0004      ALT: 140  
137 2104   E          RWY: 04L  
BOS . .BOS036004 . .BLEAK . .VPBAY . .W0  
LFA . .PUGGS . .EWR  
  
REMARKS:
```

```
DAL2293      HDG:  
DC10         ALT:  
129          RWY: 04R  
REMARKS:  
  
MISSED APPROACH
```


```
AAL906 B777 BOS 04L 0004 *
```



Datablocks & Flight Data Elements

- **ATIS Update Indicator**

AAL916	B777	BOS	04L	0005	
USA706	B757	BOS	04L	0004	
AAL915	B777	BOS	04L	0003	<input type="checkbox"/>
AAL906	B777	BOS	04L	0003	<input type="checkbox"/>



WX

A 29011G14 2995

33L: T56 M55 R54

27 : T59 M58 R57

- **Integrated Weather Information**

Datablocks & Flight Data Elements

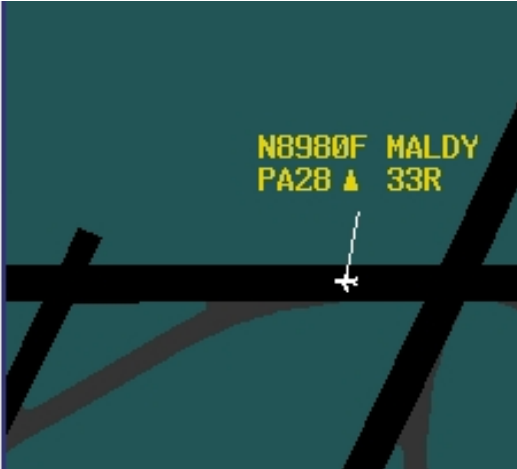
- **Generic Highlight**



Datablocks & Flight Data Elements

- Aircraft moving on runway surface

OUTBOUND			
▲ N8980F	PA28	MALDY 33R	0005
▲ EGF5986	E145	GARVE 27	0005
▲ CHQ5582	E145	MALDY 33L	0005



Datablocks & Flight Data Elements

- Aircraft stopped on runway surface/TIPH Highlight

▲ SWA970	B735	GARVE 27	0000
▲ DAL261	B738	GARVE 27	0000
▲ AAL14	B738	GARVE 27	0000



Datablocks & Flight Data Elements

- **Hold Short Indicator**



Digital Taxi-Out Clearance



The Experiment

- **Objective - Compare I-TODDS to current tower operations during zero-visibility conditions**
 - Does I-TODDS provide an advantage compared to FPSs with surface surveillance?
 - Did the most recent design changes improve the overall usability of I-TODDS?
 - Could I-TODDS support SNT operations?

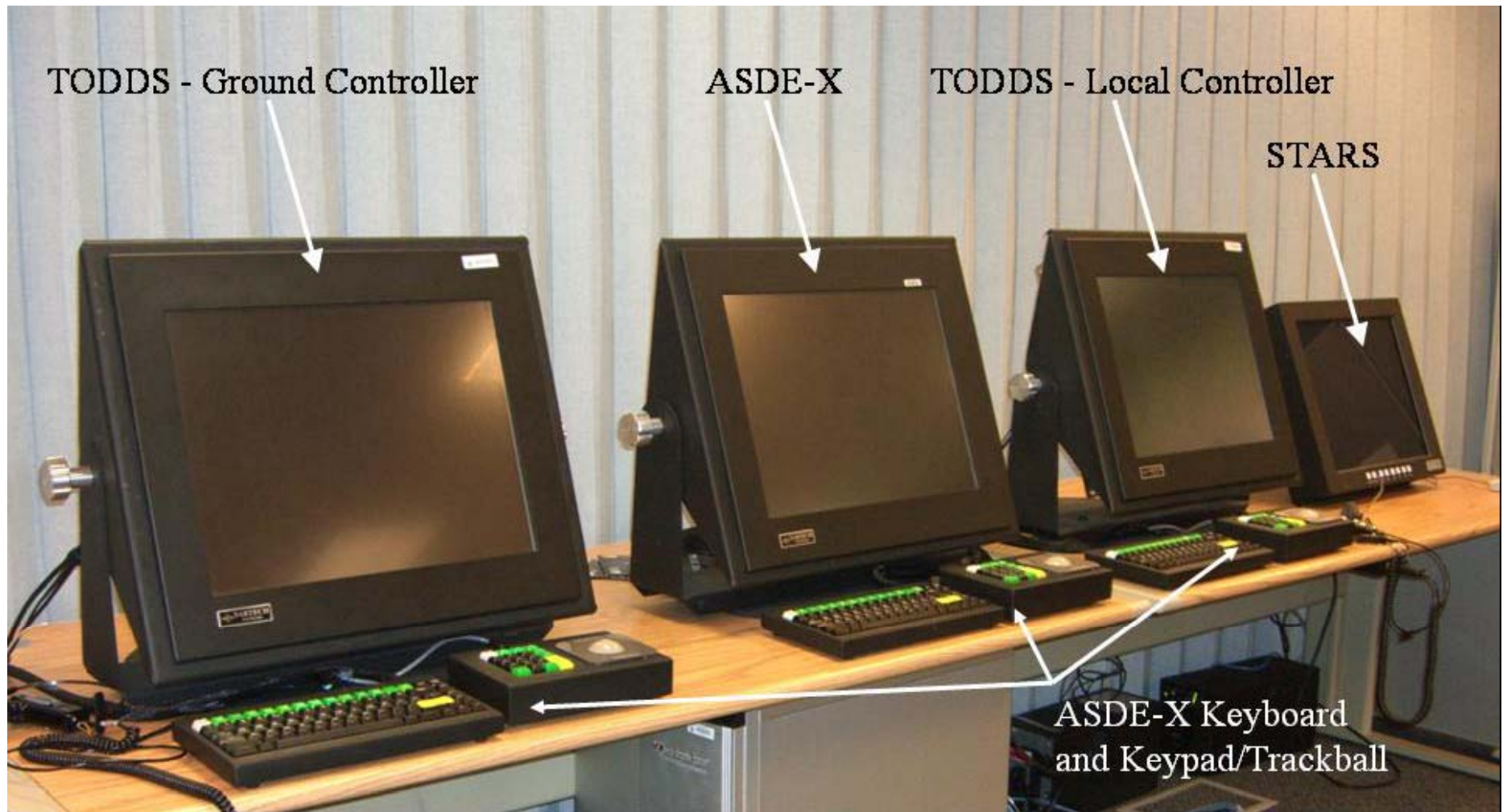


Procedure

- **Participants – 16 current controllers**
- **Touchscreen + TODDS training**
- **8 Practice scenarios + 8 Test scenarios**
- **40-minutes with high-volume airport traffic**
- **Arrivals & Departures on runways 27, 33L, & 33R**
- **No out-the-window view (i.e., zero visibility)**



Apparatus



Results

- **I-TODDS**

- Increased ramp-waiting time by 25 seconds (data comm. delay)
- Decreased the duration of taxi-out operations by an average of 106 seconds
- Decreased the duration of taxi-in operations by an average of 35 seconds
- Increased the number of departures by 2
- Reduced the number of departure delays from 6.6 to 5.3
- Reduced the duration of departure delays was reduced by 43 seconds
- The overall error rate decreased from 12% in the original design concept to 4%
- The participants reported that I-TODDS would be useful and thought it would have a positive effect on tower operations



Conclusion

- **The participants were able to control complex, high task load airport traffic without an out-the-window view at an unfamiliar airport using an unfamiliar system**
- **The participants were able to perform their tasks just as well or better with I-TODDS compared to using the current system of FPSs and surface surveillance**
- **Integrating the necessary information into a single display and providing new tools reduced the controllers need to shift their visual attention and resulted in an improvement in airport efficiency**
- **I-TODDS may be able to support the SNT concept**



Questions?

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Wake Turbulence Indicator

