

Cognitive Workload and Visual Attention Analyses of the Air Traffic Control Tower Flight Data Manager (TFDM) Prototype Demonstration*

Kiran Lokhande & Hayley J. Davison Reynolds

MIT Lincoln Laboratory

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Vis Attn & Cog Workload1 Lokhande/Reynolds 10/1/2012 *This work was sponsored by the Federal Aviation Administration under Air Force Contract No. FA8721-05-C-0002. Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the United States Government.



Motivation

- Multiple display technologies currently used at major US airports:
 - Paper flight strips
 - ASDE-X (Airport Surface Detection Equipment, Model X)
 - RACD (Remote Arts Control Display)
 - IDS (Integrated Display System)
 - etc.
- Desired from NextGen ATC tower:
 - System integration
 - Increased efficiency
 Decision support tools
 Automation
 - Safety & cost reduction



ASDE-X Display



RACD Display



Tower Flight Data Manager Prototype





Tower Flight Data Management (TFDM) Human Machine Interfaces

Tower Information Display System (TIDS)	Flight Data Manager (FDM)
Ground and air surveillance data	Electronic processing and distribution of flight data
Supervisor (SUP) Display	Scanning COHU Camera
Supervisor (SUP) Display	Scanning COHU Camera Fixed and tracking camera views for surveillance

Flight sequencing and scheduling support

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Tower Flight Data Management (TFDM) Human Machine Interfaces Analyzed in Study

Tower Information Display System (TIDS)	Flight Data Manager (FDM)
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TFDM Testing at Dallas-Fort Worth (DFW)

- DFW-1: 8/24-9/3 in 2010, focus was on surveillance validation and initial user feedback on interfaces
- DFW-2: 4/26-5/5 in 2011, focus on incorporation of decision support tools and camera usage
 - Participants:

Each day 2 controllers switched off between Ground Control (GC) and Local Control (LC) positions

Total: 12 ground, 12 local

- Shadow operation of East Tower
- Data collected:

Human performance data (audio, video) Questionnaires *(not reported here)* Technical performance data *(not reported here)*



Center tower and East tower locations at DFW



TFDM system at DFW airport MIT Lincoln Laboratory

Vis Attn. & Cog Workload-6 Lokhande/Reynolds 10/1/2012



Human Performance Data

 Video/audio of participants and East Tower Controllers (ETC) was compiled into one seamless video playback system

Measurements

- Verbal Command Analysis
 - Verbal control commands
 - Participant vs. ETC (control group)
 - Gap time & response rate

Causes of longest gap times

- Visual Dwell Analysis
 - Manual gaze evaluation
 - Individual dwell time & total dwell time

Causes of longest dwells



Video playback system for data analysis



- Appx. 72% of the time, GC and LC issued instructions before or within one second (neutral to) ETCs
- LC issued commands first more frequently than GC, t(9) = 3.30, p < 0.01
- Discarded from analyses:
 - Interacting with an observer
 - Incongruous operational strategy (2% of GC cases, 10% of LC cases)
- When issuing commands after ETC, participant controllers appeared to be distracted by operating the TFDM display





• Gap time plots created to investigate causes of high gap times for purposes of prototype design improvement





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 Gap time plots created to investigate causes of high gap times for purposes of prototype design improvement





 Gap time plots created to investigate causes of high gap times for purposes of prototype design improvement





- Specific issues found:
 - FDM field highlighting feature / FDM text changes
 - Confusion when transferring electronic flight strips to different controllers
 - ATIS code change

	Ground Control	Local Control
	(# of instances)	(# of instances)
Issued command after hearing ETC	7	12
Interacting with flight strip: Moving flight strip	7	2
Interacting with flight strip: Editing flight strip	4	1
Looking for flight strip	10	2
Using Search to find flight strip	2	0
Looked at RACD	0	3
FDE not sent in time by GC	N/A	3
Tracking flight on TIDS	1	2
TOTAL (all gap times over 3 sec)	54	37



Visual Dwell Analysis Results

Percent Total Dwell Time

- More time spent head-down (*M* = 81.9, *SD* = 12.8) than headup (*M* = 17.2, *SD* = 12.4), *t*(43) = 17.12, *p* < .001
- More time looking head-up out the window over "Other" dwell areas (*M* = 2.3, *SD* = 1.9), *t*(43) = -7.87, p < .001





FDM

- Ground Control
 - Forgetting to update FDE
 - Searching for flight strip
 - Editing flight strip
- Local Control
 - Confusion over flight strip not sent over to local control



- Viewing/Monitoring
- Using Picture in Picture camera view inside TIDS

	# of dwells	over 15 sec	% of dwells over 15 sec			
	Ground (#)	Local (#)	Ground (%)	Local (%)		
FDM	104	28	52	26.2		
TIDS	81	56	40.5	52.3		
Up	12	8	6	7.5		
СОНИ	3	5	1.5	4.7		
RACD	0	8	0	7.5		
Misc	0	2	0	1.9		
Total	200	107	100	100		



- Development of a quantified and non-intrusive behavioral measure of workload and gross visual attention in a field environment
- TFDM features requiring significant focused attention and resulting in spikes in workload identified for improvement

Issues Discovered Through:	Verbal Instructions	Visual Attention
Manually searching for flight strips on FDM	Х	X
Editing & updating flight strips	X	X
Moving flight strips	X	
Difficulty using "Search" function	X	
Tracking flight on TIDS		X
Forgetting to update a flight strip		X
Slow when using FDM keyboard		X
Adjusting TIDS camera view		X
Inconclusive cause	Х	X



Asterisk indicates difference in operational strategy

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Vis Attn. & Cog Workload-17 Lokhande/Reynolds 10/1/2012



* Asterisk indicates difference in operational strategy





Vis Attn. & Cog Workload-18 Lokhande/Reynolds 10/1/2012



* Asterisk indicates difference in operational strategy





Vis Attn. & Cog Workload-19 Lokhande/Reynolds 10/1/2012



* Asterisk indicates difference in operational strategy



Large gaps due to difference in operational strategy



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Vis Attn. & Cog Workload-20 Lokhande/Reynolds 10/1/2012



* Asterisk indicates difference in operational strategy



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Vis Attn. & Cog Workload-21 Lokhande/Reynolds 10/1/2012







Flight Data Manager (FDM)

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Ground FDM Display

Local FDM Display



Flight Data Entry (FDE)



Supervisor (SUP) Display

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COHU camera

