Beyond Electronic Flight Bag (EFB) Approval: Improving Crew Performance

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Electronic Flight Bag Operational Approval: Research Goal

The Federal Aviation Administration outlines the EFB certification and operational approval process in Advisory Circular 120-76A:

- FAA Advisor Circular specifies that an EFB needs to be as good as the existing paper system, and that it not result in "unacceptable flightcrew workload."
- **OUR GOAL**: Help crews working with EFBs not only to equal, but to measurably exceed, the performance of crews working with traditional paper documents.

Electronic Flight Bag Comprehensive Evaluation

The results being presented here are part of a comprehensive EFB evaluation that was divided into the following four phases with an emphasis on the Operational Evaluation:

- 1) Preliminary Design Evaluation
- 2) Prototype Evaluation
- **3) Operational Evaluation**
- 4) Procedure and Training Evaluation.

Electronic Flight Bag: Hardware Overview

EFB hardware was classified by the FAA as a Class 2 device consisting of:

- **Central processing unit** - (1.6 GHz Centrino CPU) with 512 MB of RAM, 40 GB hard drive, a lithium ion backup batter, connectors, and an On/Off button
- **Display** - a 10.4 inch touchscreen with more details provided in the next slides
- **EFB mount** - Round-A-Mount (RAM) attached to the side windows allowing for display adjustment.

Electronic Flight Bag: Display

The display consisted of a 10.4 inch touchscreen with standby and brightness controls and hardwired cable for connection to the CPU.

- Resistive touchscreen was a 10.4 inch color TFT LCD with a 1024 x 768 resolution when used in the landscape mode as evaluated
- The film-on-glass touch screen was engineered for direct sunlight readability with an illumination from 3 to approximately 500 nits
- The total dimensions of the touchscreen were 11” wide by 7.7” inches high and 0.63” thick.

Electronic Flight Bag: navAero t-Pad 1000 in a B-737 from Captain's Seat

Electronic Flight Bag: navAero t-Pad 1000 from F/O's Seat as Evaluated

Electronic Flight Bag: Display Specifications

navAero t-Pad 1000 Property	Specification
Display colors	256K
Standby button	Backlight on/off
Dimming buttons	3 - 500 nits Achieved with optical engineering that uses ambient light
Touchscreen type	Resistive
Touchscreen transparency	86-89%
Touchscreen surface	Anti-glare
Contrast ratio	250 : 1
Certification	DO160 Section 21, FCC

Electronic Flight Bag Software

The EFB software was classified by the FAA as Type A and Type B. The applications being evaluated on the EFB operating under Windows XP included:

- Operating manuals
- Airport operational information
- Minimum Equipment List (MEL)
- Airport ground, parking and facility charts
- SIDs, STARs and en-route charts.

Electronic Flight Bag Procedures and Training

The operator had developed extensive EFB Standard Operating Procedures (SOPs) including:

- General EFB procedures for each phase of flight
- Specific SOPs for EFB initialization, its use in the takeoff briefing, in approach planning, and in case of EFB failure.

The crew training for this evaluation included:

- Three hour home study session
- Two hour classroom session with an introduction to the EFB, to its applications, to its SOP as well as a set of navigation questions and problems.

Electronic Flight Bag Operational Evaluation

The Operational Evaluation data was collected from the following areas with the emphasis here on the Line Operational Evaluation (LOE):

- Home study quiz
- Classroom observation
- Classroom quiz
- Three hour LOE
- Exit questionnaire.

Electronic Flight Bag Line Operational Evaluation (LOE) Scenario

The LOE scenario is key to understanding the results and was developed to exercise the use of flight deck documents. The scenario consisted of six Event Sets:

- 1) Preflight Event Set
- 1) Engine Start Event Set
- 2) Cruise with Route Change Event Set
- 1) Divert Event Set
- 1) Low Visibility Taxi-In Event Set.

Electronic Flight Bag LOE Scenario Start and Stop Times

Event Set 1	Start: PDC Placed on Center Console
	Stop: Completion of Departure Brief
Event Set 2	Start: When GEN 1 OFF alert displays on EAD
	Stop: When crew pushes the DRIVE 1 disconnect switch
Event Set 3	Start: Last Word of ATC clearance to join an airway
	Stop: FMS NAV selected
Event Set 4	Start: ATC issues clearance change
	Stop: 12,000 foot restriction entered in FMS
Event Set 5	Start: ATC issues clearance
	Stop: 10,000 foot restriction entered in FMS
Event Set 6	Start: Ground Control issues initial taxi clearance
	Stop: Aircraft enters spot 6.

Electronic Flight Bag Operational Evaluation Measurement

The evaluators, who provided most of the data, participated in 8 hours of standardization training to include:

- Overview of the Event Set I/E Training
- Usability Testing and EFB Operational Approval
- Design of the Scenarios and Event Sets
- Rating for the Event Sets
- Administering the Scenarios
- Using the EFB Evaluation Worksheet
- Rating Performance 1 - Practice and Discussion
- Rating Performance 2 - Practice and Discussion
- Refinements to the Observation Form
- Fly Part of the LOE and Administer Part of the LOE
- Final Standardization Check.

Electronic Flight Bag Operational Evaluation Pilots

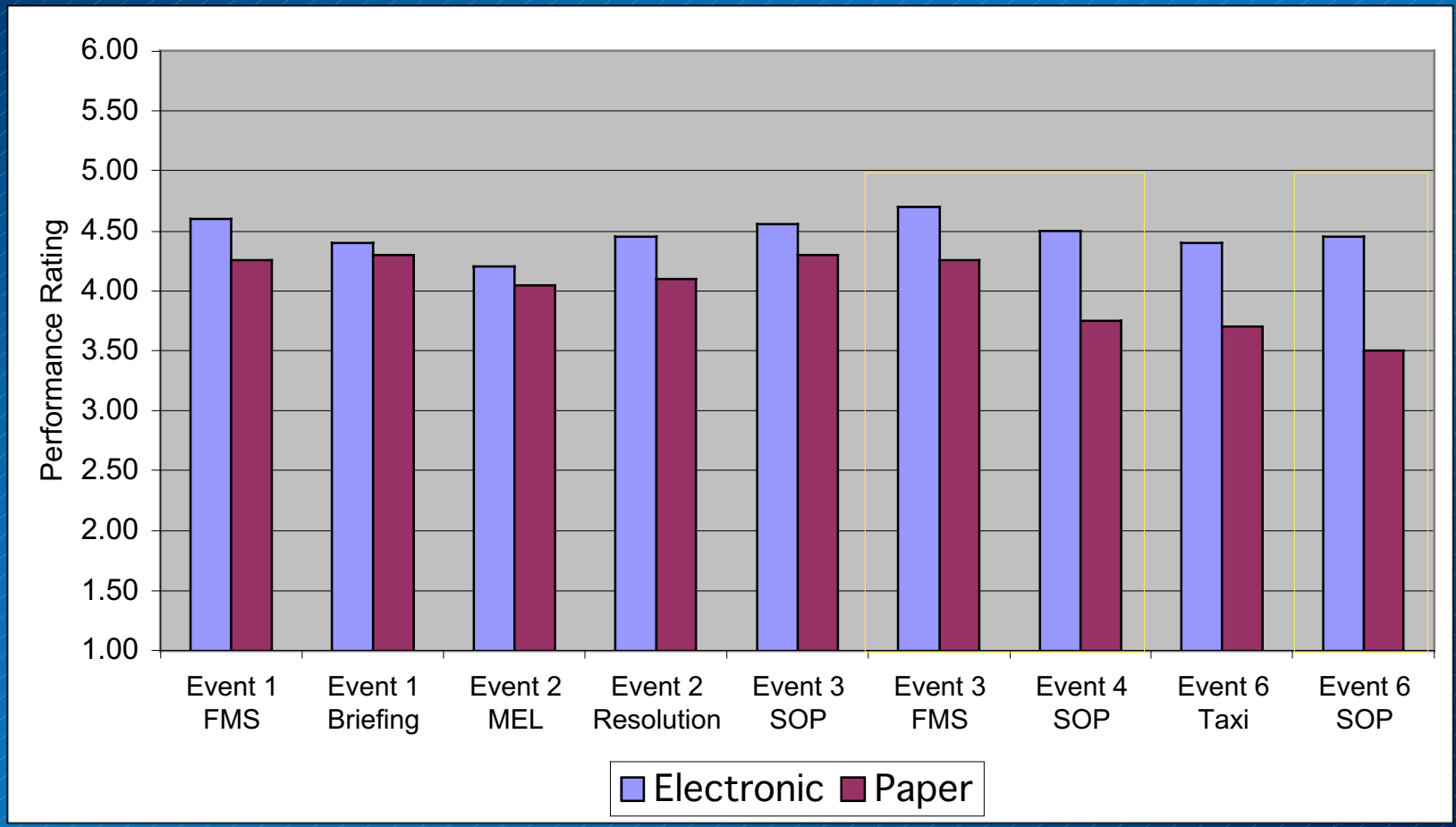
Forty volunteer pilots were solicited:

- Twenty volunteers were Captains
- Twenty were First Officers (FO)
- Twenty crews were formed made up of a Captain and FO and randomly assigned to the Electronic or Paper document condition
- Pilots had an average of 1,359 hours on fleet type with a range from 96 to 6,000 hours.
- Pilots had an average of 7,458 total flight hours with a range from 500 to 15,000 hours.

Mean Crew Performance: Electronic versus Paper Documents

(1 = Unacceptable and 6 = Outstanding)

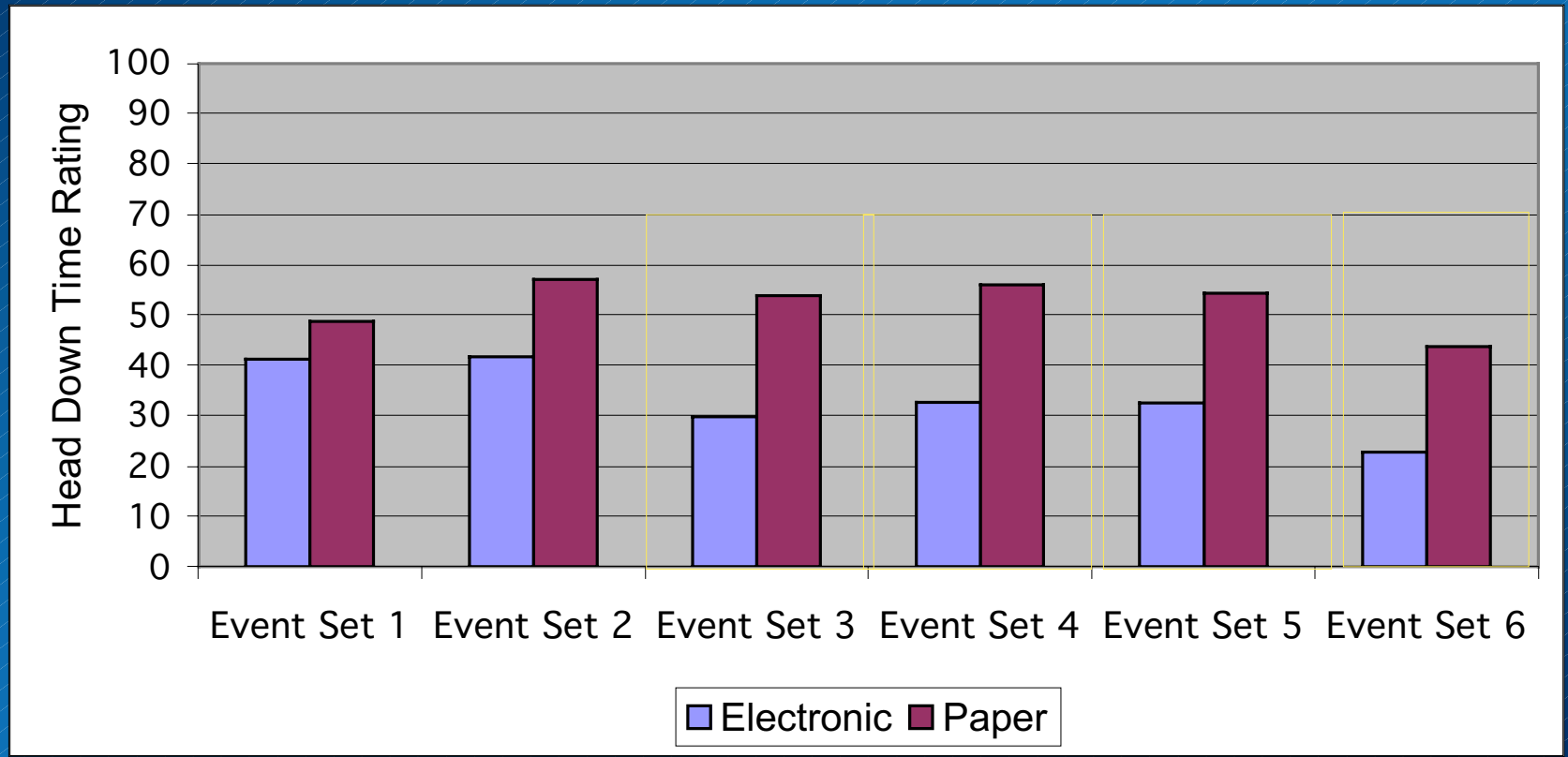
n=40, p <.05



Mean Pilot Head-Down Time: Electronic versus Paper

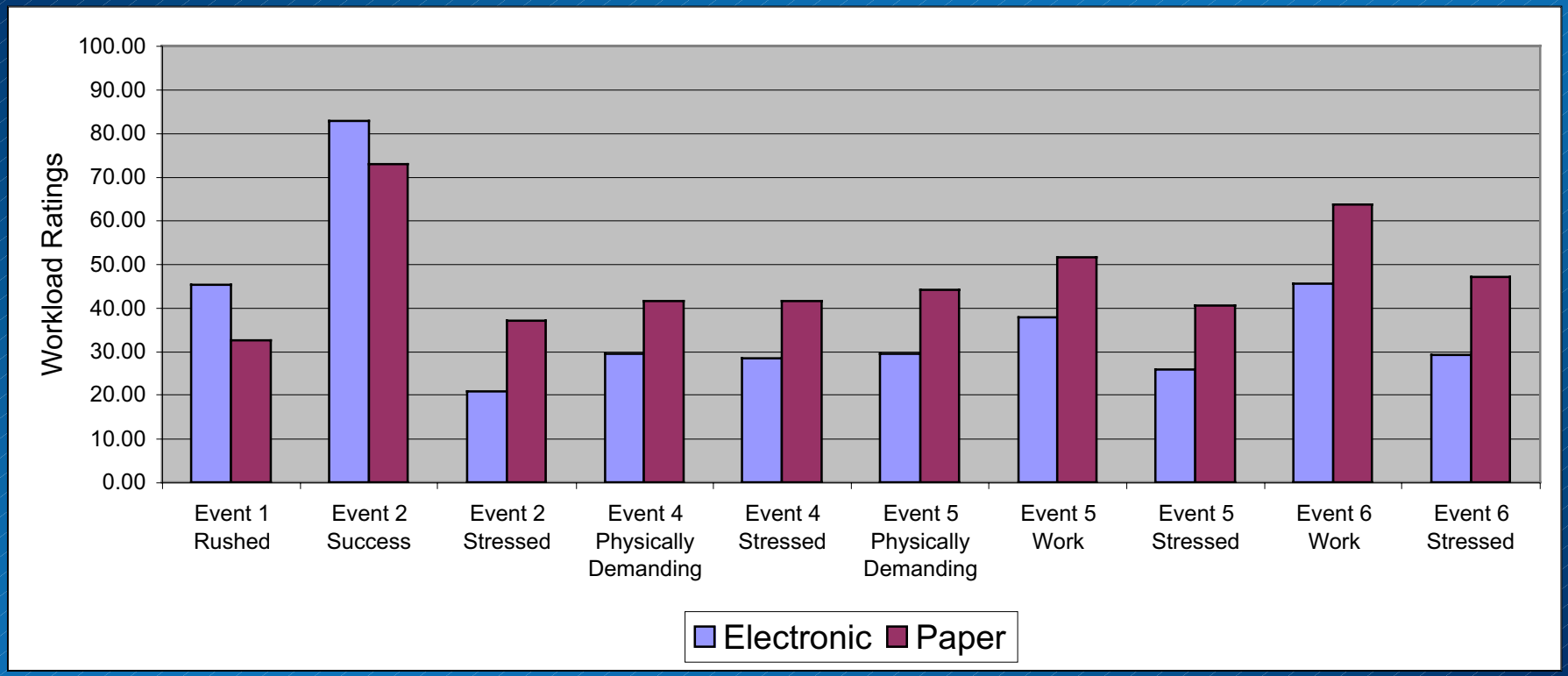
(0 = Minimal and 100 = Excessive)

n=40, p <.05



Significantly Different Crew Workload Ratings: Electronic versus Paper

(0 = Very Low and 100 = Very High) (n=40, p <.05)



Electronic Flight Bag Operational Approval: Interpreting the Results

A review of the significant differences combine to show that:

- When crews accessed the EFB for the very first time during Event Set 1, flightdeck setup, they felt more rushed than crews working with paper documents.
- As the LOE progressed, crews with the EFB felt significantly lower workload along several workload dimensions as compared to crews under Paper.
- Data from Head-Down Time and Crew Performance also support this pattern of improved EFB usage as crews gained greater familiarity with the new system.

Electronic Flight Bag Operational Approval: Recommendations

The results establish that the EFB can improve crew performance while reducing head-down time and workload suggesting:

- **From the display side**, that screen touch sensitivity is critical to fully utilize the different touch modes
- **From the software side**, that the different EFB applications need a common user interface
- **From the SOP and training side**, that crews be shown best practices to maximize the use of the EFB
- **From the overall evaluation side**, that precise measures are essential to obtaining a clear understanding of how EFBs improve crew performance.

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THANK YOU!