The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Mixed Reality Lab / School of Computer Science

Target Size Guidelines for Interactive Displays on the Flight Deck

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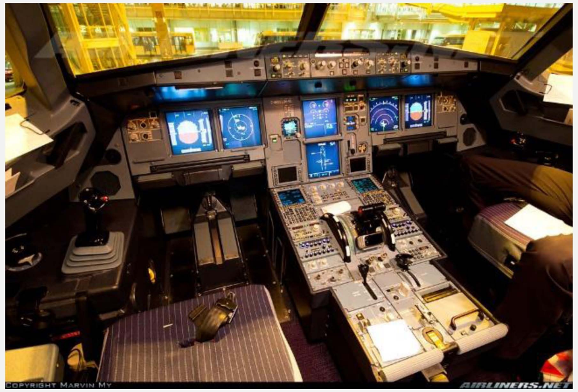
Content

Flight Deck Evolution:

Considerable changes have consolidated the number of inputs (e.g. buttons, switches and knobs) and outputs (e.g. displays).

Concorde (1)



Airbus A-320 (2)

Boeing 787 (3)

Future Flight Decks:

Suppliers for cockpit equipment have started to explore opportunities for the integration of touchscreens in and around the cockpit.

(4)

(5)

(6)

Advantages from perspective of…

Manufacturer: adaptable to any configuration by changing the underlying software, and they do not require removing and reconfiguring physical input devices

Air Carrier: reduced operational costs and crew workload (mobile device)

Crew: able to make performance calculations, create flight plans and utilise various formats of charts and checklists (mobile device). Faster and intuitive than other input devices

Challenges during operation…

The biggest drawbacks of soft buttons (i.e. interactive elements) compared to their physical counterparts are unwanted and accidental touches and absence of tactile feedback

! The size of interactive elements (e.g. buttons), called 'target size', has a significant impact on these errors.

? Why is it important…

- Use in safety-critical applications places a high demand on the operator to input data accurately.
- Pilots are likely to encounter stronger turbulences that could impede the usability of touchscreens in helicopters, especially when operating at lower altitudes.
- Two-thirds of fatal accidents are caused by human error , which makes designing a usable interface more important

General

- Mobile device suppliers have their own recommendations for target sizes, which are in general a compromise between acceptable error rate and available screen area.
- In academia, target sizes have been tested in many different conditions. Independent variables that have been studied include activity (*walking or standing*), mobility (*mobile devices or fixed devices*), usage (*one handed thumb or both hands*), feedback modality (*auditory and haptic*), target population (*older adults*) and task (*alphanumeric text entry, numeric text entry and tapping task*).

Aviation

- The Federal Aviation Administration (FAA) advised designers to demonstrate that integration of touchscreens should not result in unacceptable levels of workload and error rates.
- Dodd et al. published research performed in a flight simulator, and found that turbulence has a significant effect on error rates.

Aims and Objectives

The purpose of this research is to establish design guidelines and recommendations for target sizes on fixed and mobile touchscreens on a helicopter flight deck.

Approach

Salvamento Maritimo (SASEMAR)

Maritime Security and Rescue Society

SASEMAR Resources

(7)

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SASEMAR AW139

Don Inda Class tugboat

(9)

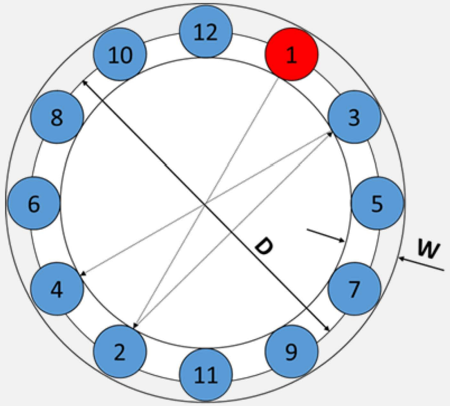
Apparatus

Experimental Setting

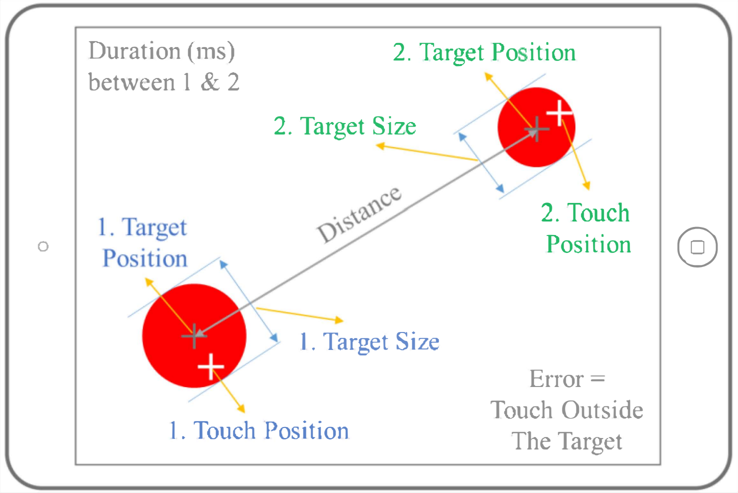
Vibration Measurement

Flight Recording

Task Design



ISO 9241 – Input Device Evaluation Task



Tapping Task and Recorded Variables

Experimental Design

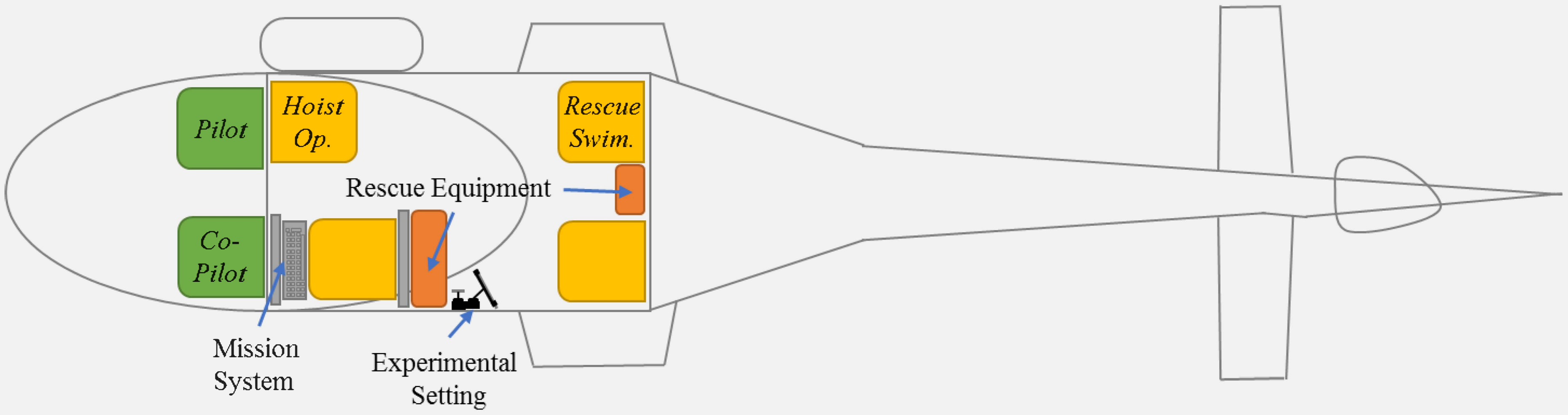
Hypotheses

- Vibration, placement and target size have a significant negative effect on error rates.
- Increasing target size will minimize the negative effects of vibration and placement.
- Participants make fewer errors when the device placement is mobile compared to when it is fixed.

Independent Variables (2x3x4 design)

- placement (mobile and fixed)
- vibration (cruise, transition and hover)
- target size (5, 10, 15, 20 mm)

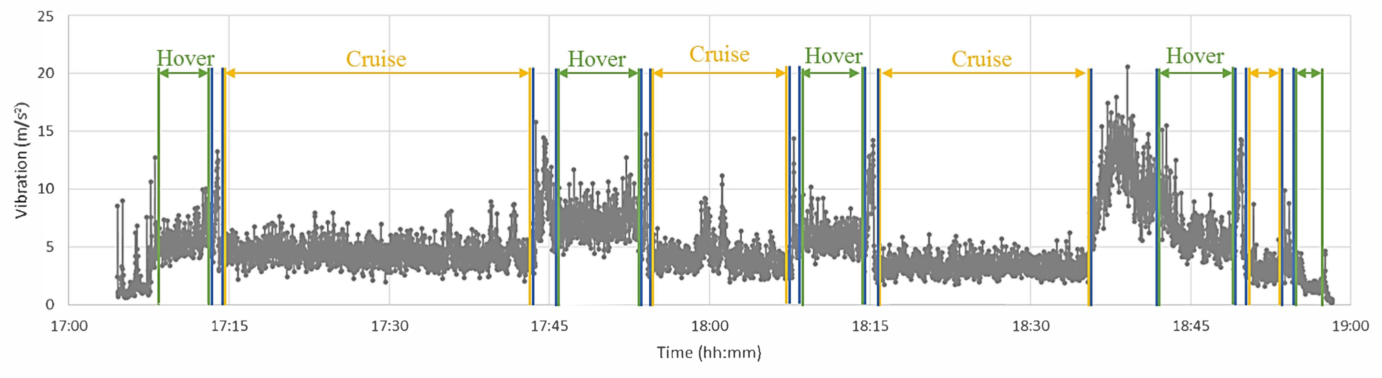
Procedure



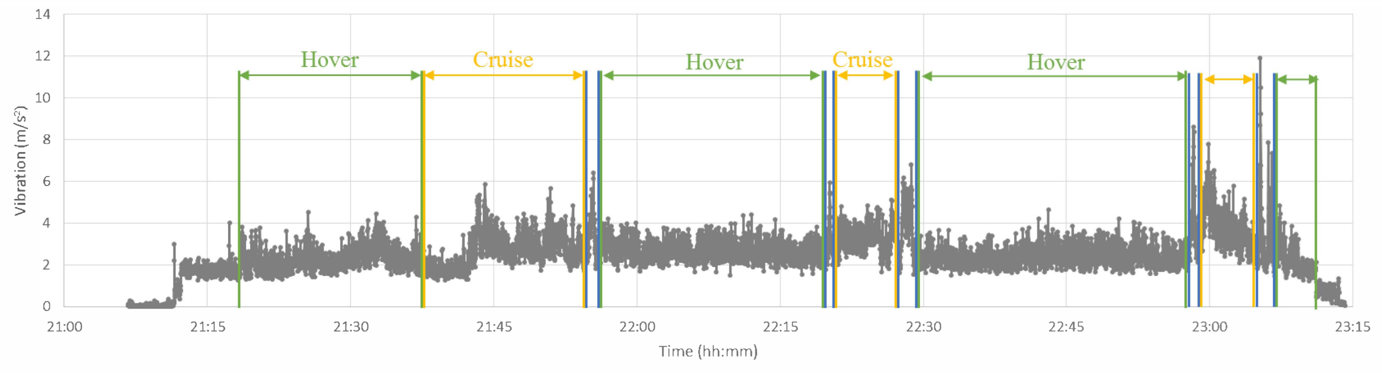
Vibration

Results

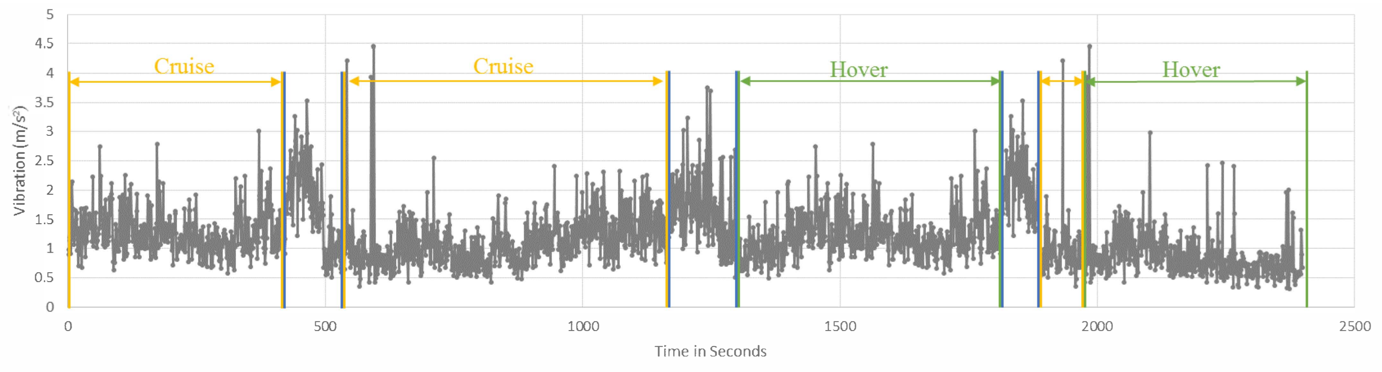
ANOVA revealed for all cases that the levels of vibration (cruise, hover and transition) are significantly different from each other.



Vibration Measurement in Fix Position



Vibration Measurement on the Dashboard



Mobile Vibration Measurement

An ANOVA for mobile measurement was not performed because of few and intermittent measurements.

Error Rates

Results

Independent Variables.
I-III correspond to different levels of analysis.

I	Placement	Vibration	Target Size

II	Placement	Vibration	Target Size
	fixed (1)	cruise (1)	5 mm (05)
	mobile (2)	transition (2)	10 mm (10)
		hover (3)	15 mm (15)
			20 mm (20)

III			
1 1 05	1 1 10	1 1 15	1 1 20
1 2 05	1 2 10	1 2 15	1 2 20
1 3 05	1 3 10	1 3 15	1 3 20
2 1 05	2 1 10	2 1 15	2 1 20
2 2 05	2 2 10	2 2 15	2 2 20
2 3 05	2 3 10	2 3 15	2 3 20

T-Test for Placement

ID	Placement	M (%)	SD (%)
1	Fix	20	57
2	Mobile	15	45
t(13407)=6.74; p=<0.01 (two tailed)			

ANOVA for Vibrations

ID	Vibration	M (%)	SD (%)
1	Cruise	15	47
2	Transition	23	50
3	Hover	17	50
F(2,14403)=32.84, p=0.000			

ANOVA for Target Sizes

ID	Vibration	M (%)	SD (%)
5	5 mm	47	79
10	10 mm	10	32
15	15 mm	3	19
20	20 mm	1	12
F(2,14402)=777.24, p=0.000			

Error Rates (II. Level)

Results

Univariate ANOVA for Independent Variables

Placement	Vibration	M (%)	SD (%)
Fixed	Cruise	17	54
Fixed	Transition	25	64
Fixed	Hover	20	53
Mobile	Cruise	13	41
Mobile	Transition	21	55
Mobile	Hover	14	45

Placement & Target Size

F(3,14382)=10.29, p=0.000

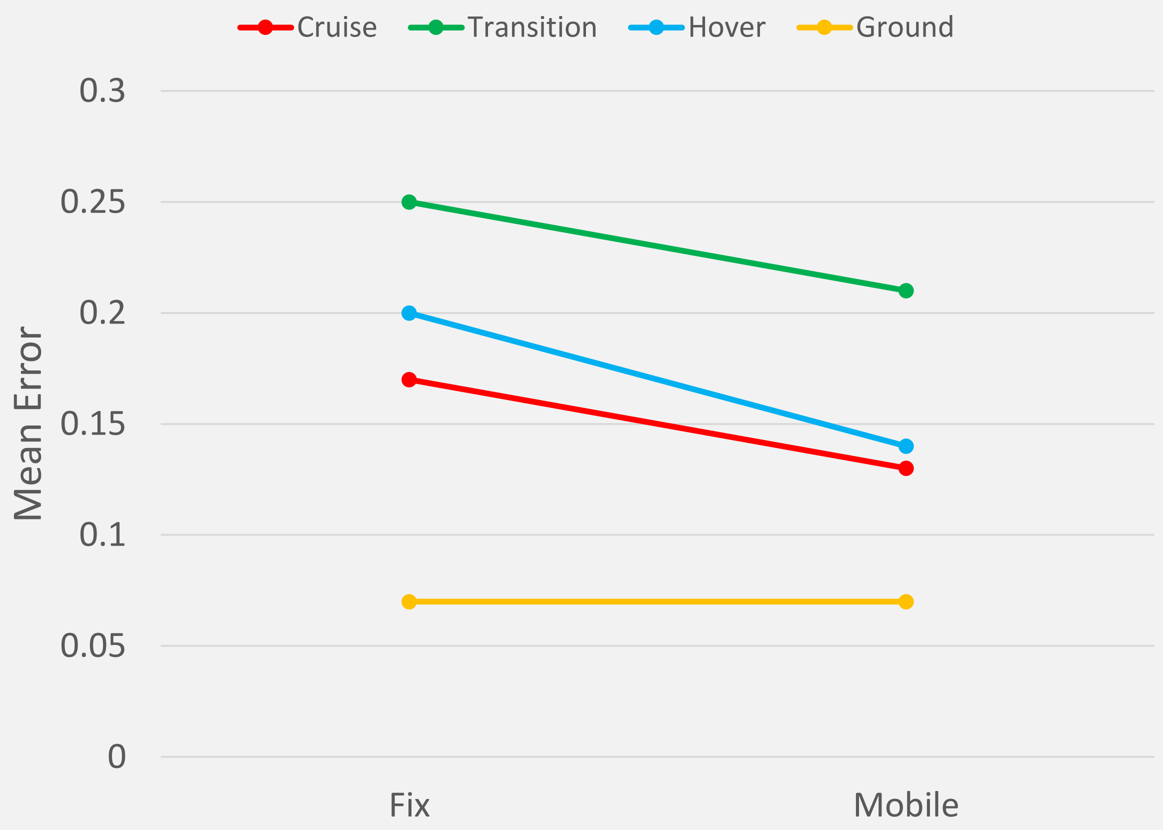
Vibration & Target Size

F(6,14382)=8.81, p=0.000

Vibration & Placement

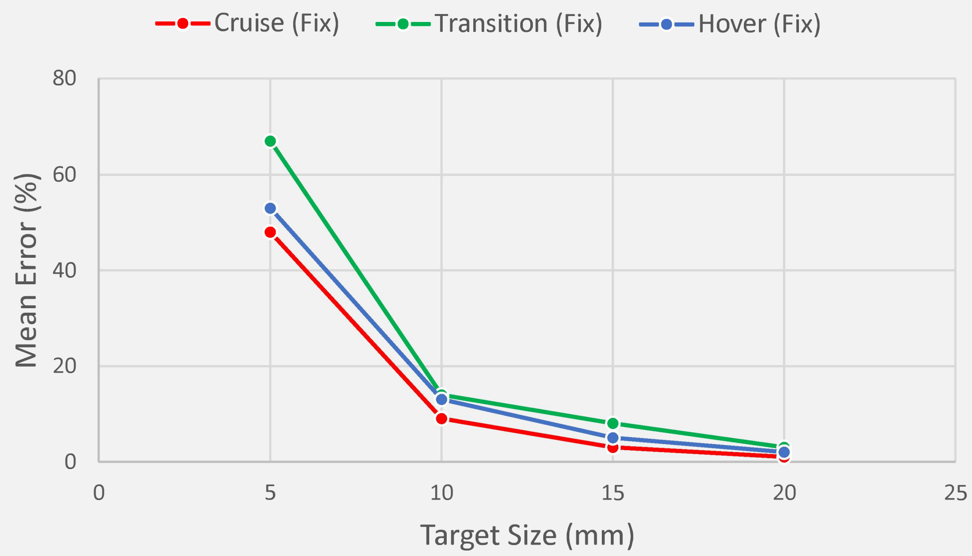
F(2,14382)=0.388, p=0.678

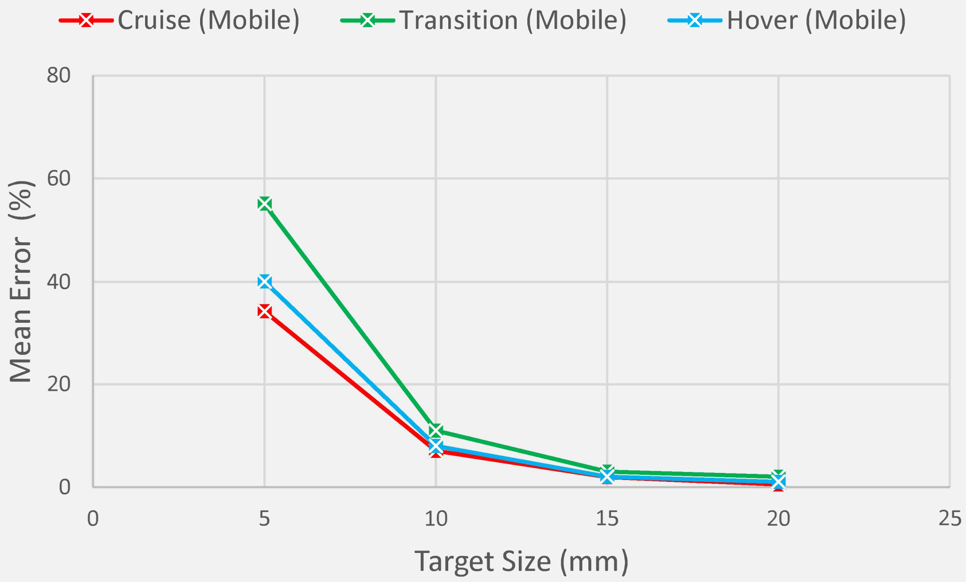
Mean Errors for Fixed vs. Mobile Placement by Vibration (including the Baseline).



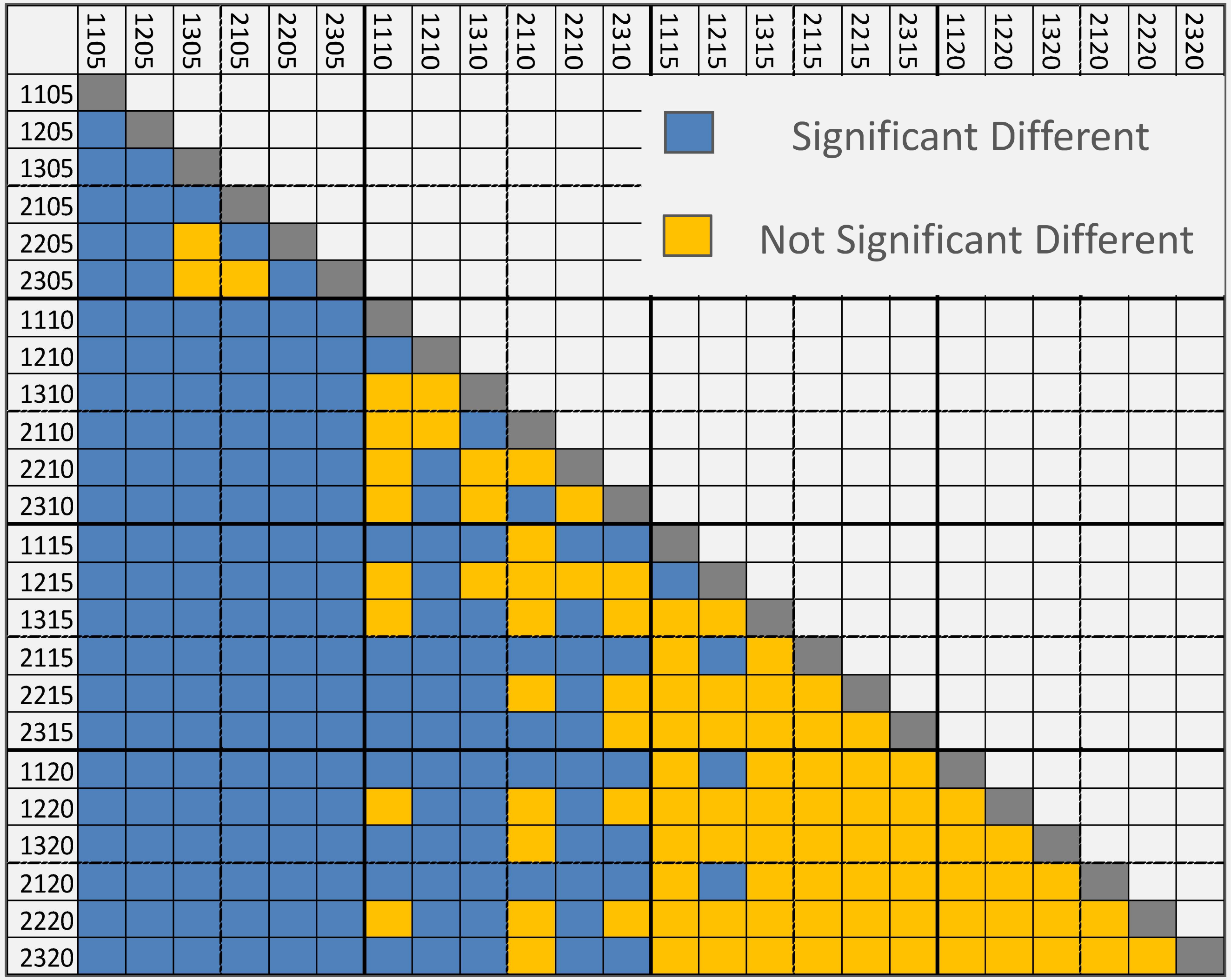
Error Rates (III. Level)

Results





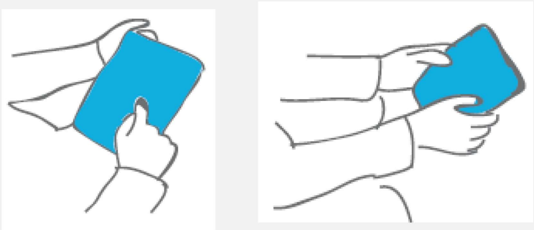
ANOVA for All Conditions



Discussion

Usage and Handling

- Interaction in the fixed placement condition was performed with one hand. Participants always used their preferred hand.
- Eight participants were observed to tend to hold on to the device from the side or above.
- In the mobile placement condition, four participants used both of their hands to hold the device, and used their thumb to tap the task. Ten participants held the device with their non-dominant hand and performed the experiments with their preferred hand's index finger



Tablet Hold Strategies used in the Experiment

Recommended Interactions Areas for Two Hands Holding, Thumbs Interaction

On Vibration

- In the fixed placement condition the smartphone and tablet were attached to the window via a suction cup fixture, which transferred the entire airframe vibration to the devices without absorption.
- Vibrations measured on the main instrument panel is lower, because it is installed on system which absorbs a certain amount of vibration
- The analysis of vibration measurements gathered in the mobile condition showed that the human body is able to absorb a certain amount of vibration

Error Rates

Discussion

- The study presented here confirms that without support this increases the likelihood to make more errors in a vibrating environment
- In the mobile setting the user was able to pull the device inside his “zone of convenient reach”, causing the device to vibrate similarly to the human body, ‘absorbing’ a certain amount of vibration, which is not the case in the fixed condition
- It is recommended to use 20 mm targets for fixed devices for which pilots have to extend their arms to reach, and for safety critical tasks. The expected error rate for 20 mm targets during transition phase with a fixed placement (worst case) is 3 %
- 15 mm targets for mobile devices may be sufficiently large. The expected error rate for 15 mm targets during transition when the device is held rather than fixed is 3%.

Conclusion

It was confirmed statistically that all flight modes are different in character. The potential impact of vibration, touch target size and placement was evaluated. All factors were found to have a significant impact. As shown in previous work the target size is the most significant factor, which may be utilised to minimise other degrading factors by selecting an appropriate target size. It was demonstrated that using touch-enabled devices that are fixed in place in vibrating environments produces significantly higher error rates than when the device can be held by the user.

Thank you for patiently listening!

? Any Questions ?

Image Reference.

- (1) http://www.airliners.net/photo/Air-France/Aerospatiale-BAC-Concorde-101/2381583/L/&sid=87bcc008c00be3110c03b70a4c2debda
- (2) http://www.airliners.net/photo/Air-Berlin/Airbus-A320-214/2050904/L/&sid=04712b6848613552a04f6fc81578440e
- (3) http://www.airliners.net/photo/Air-Canada/Boeing-787-8-Dreamliner/2663440/L/&sid=7dfb982e4972ee6d72f67ca0a37518a3
- (4) http://www.gulfstream.com/aircraft/gulfstream-g500
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