Cranfield Digital Tower Research:
System Design and Monitoring Performance

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Overview: Cranfield Digital Tower Research

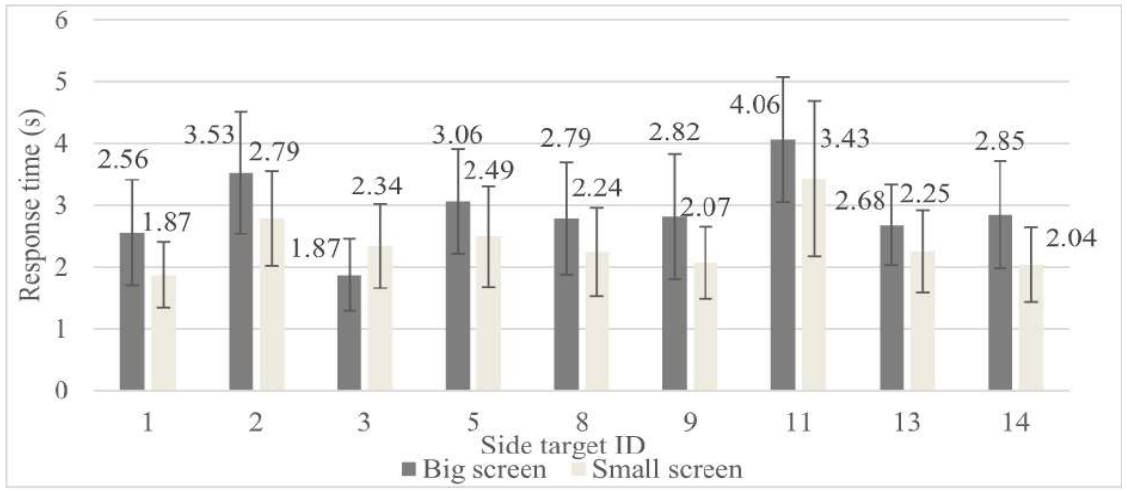
- What we have done?
- What we are keen to share?
- How can we learn from each other?
- How can we collaborate in future research?
- Q & A

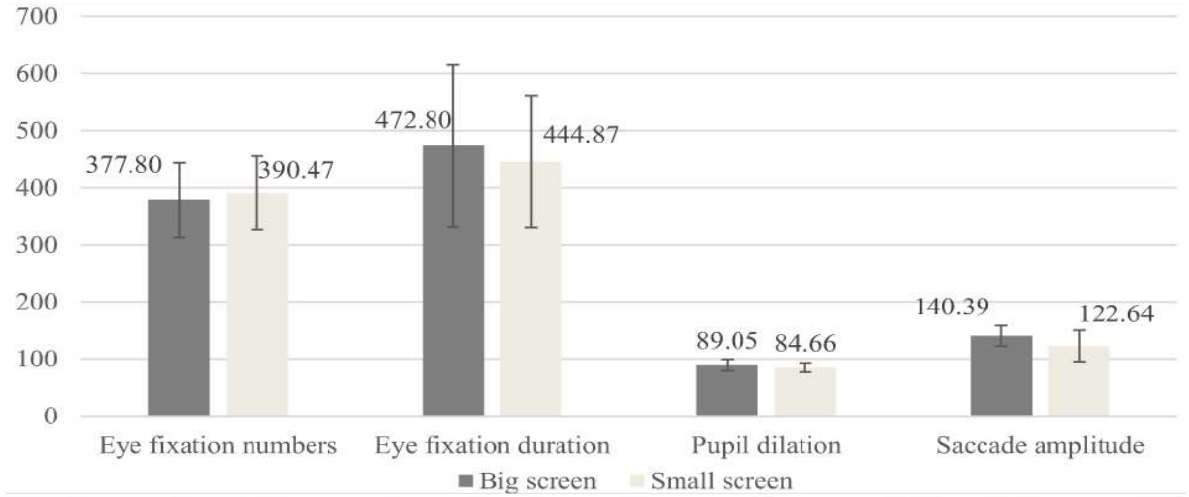



Contingency Tower Design and Human Factors Certification

(Ports of Jersey using Frequentis Systems)

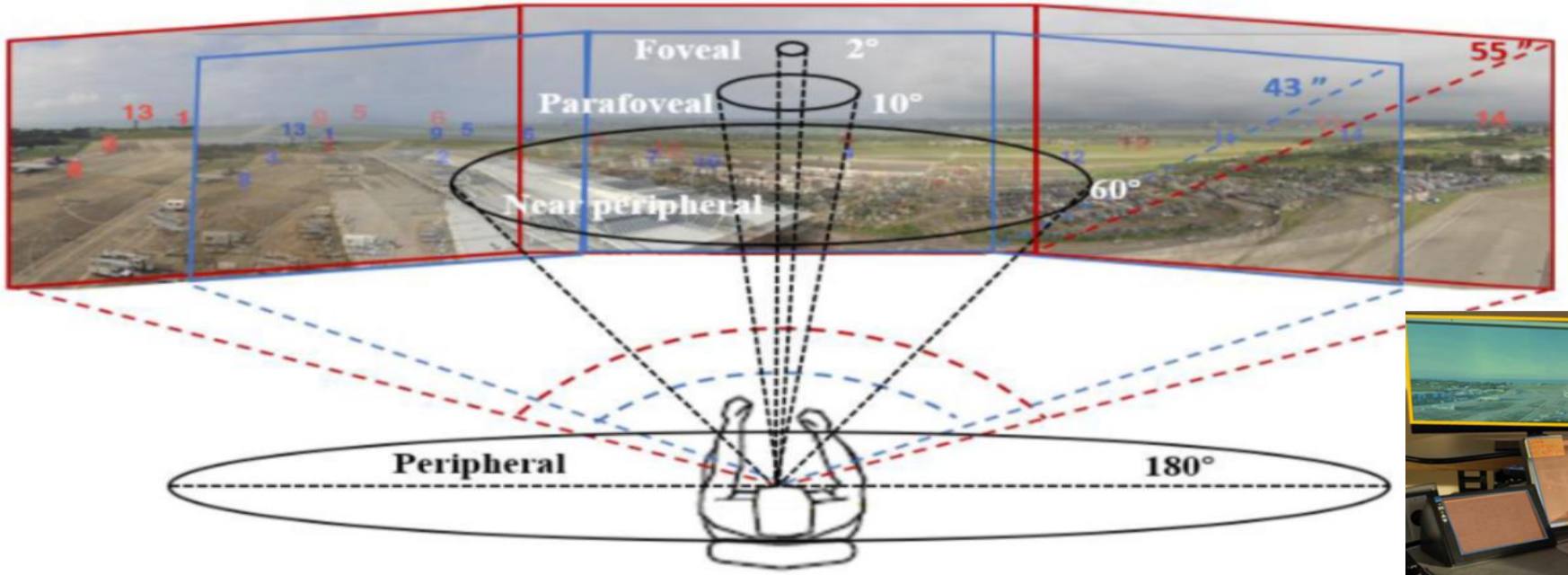
ATCO's Visual Behaviours, Workload & Response Time

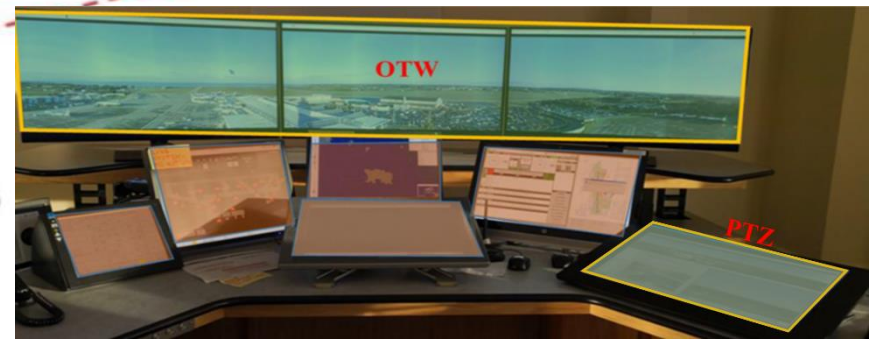




ATCOs have more fixation numbers, shorter fixation durations, and smaller saccade amplitude while interacting with a smaller-sized OTW display

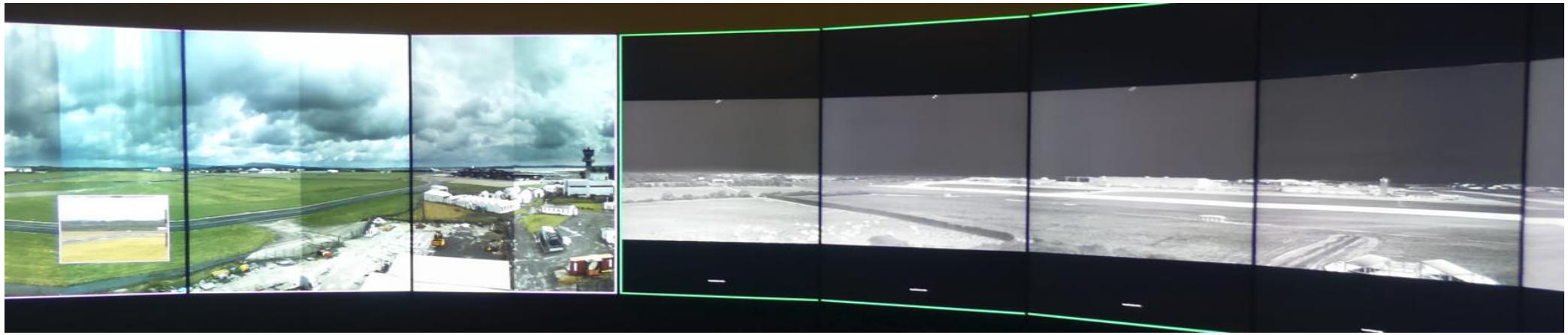
OTW Design Affecting ATCOs' Visual Behaviours & Response Time





1. Li, W-C., Moore, P., Zhang, J., Lin, J. & Kearney P. (2022). The impact of out-the-window size on air traffic controllers' visual behaviours and response time on digital tower operations. *International Journal of Human-Computer Studies*. doi:10.1016/j.ijhcs.2022.102880
2. Moore, P. & Li, W-C. (2018). The Optimal Visual Identification for Designing Contingency Digital Tower Module. In Proceedings of the International Conference on Human Factors in Aviation Safety, 12-13 November 2018, Gatwick Airport, U.K.

Multiple Digital Tower Research using SAAB Systems



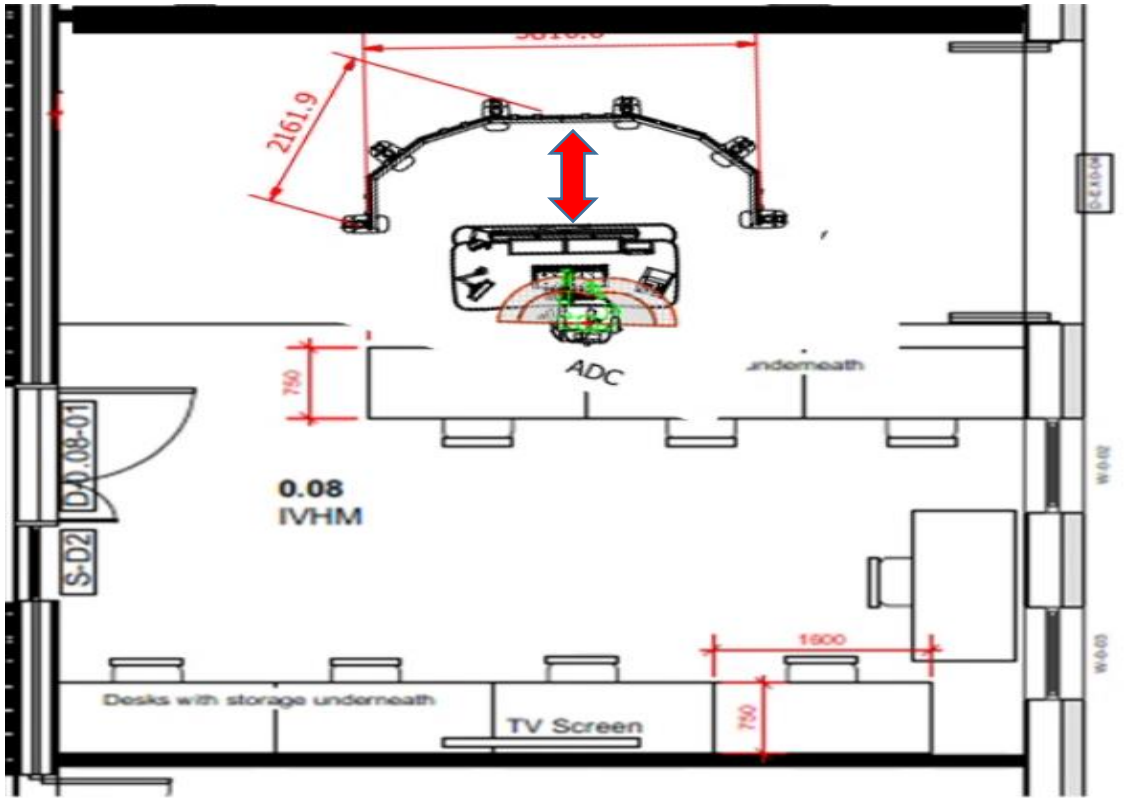
The comparison of cost-efficiency between traditional tower and remote tower.

	Build	Equipment	Manpower
Traditional Tower	Roughly cost £12 M to Build. To assume 10% annual running cost for the building is reasonable £1.2 M a year.	Usual Communications, Navigation, Surveillance and Flight Data Processing Systems.	Typical manning is 8–10 staff per H24 position.
Remote Tower	Build costs will reduce significantly as only a mast needed to house the cameras. Estimated cost of mast £2 M saving £10 M. To assume 10% annual running cost for the Mast is reasonable e.g. £200 K a year saving £800 K a year. In summary if the tower is depreciated over 30 years, saving is (12–2)/30 = £333 K in CAPEX, plus £800 K in OPEX so £1.33 M a year.	Additional CAPEX is £2 M. If the remote tower system is depreciated over 8 years, additional costs is 2/8 = £250 K in CAPEX, plus £200 K in OPEX so £450 K a year. There should be potential to save on some of the Communications, Navigation, Surveillance and Flight Data Processing Systems Costs via centralisation which will offset some of the increase in network costs.	Remote Towers will facilitate staffing efficiencies. The objective is to crew to workload such that operational staff are always busy within allowable safety limits. For the IAA example of Cork and Shannon controlled from Dublin we anticipated a saving of 4 ATCO's or £400 K a year.

OTW on R-TWR: Less is More? How much is too much?

14-Screen R-TWR Module

7-Screen R-TWR Module

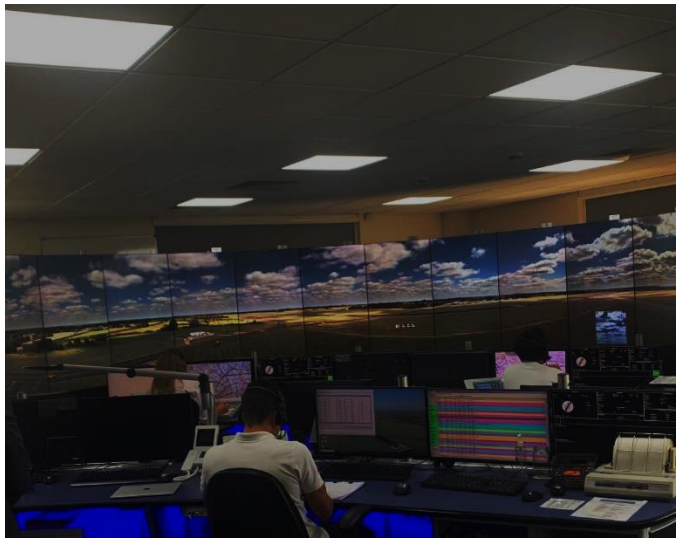


Future research

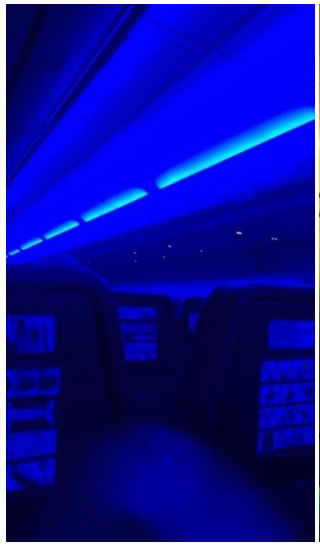
- Visual perception and response to Landscape v.s. Portrait presentation
- AI & AR application for Training and Operations

Working Environment Optimization

(Brightness, Colour, Saturability, and Temperature)



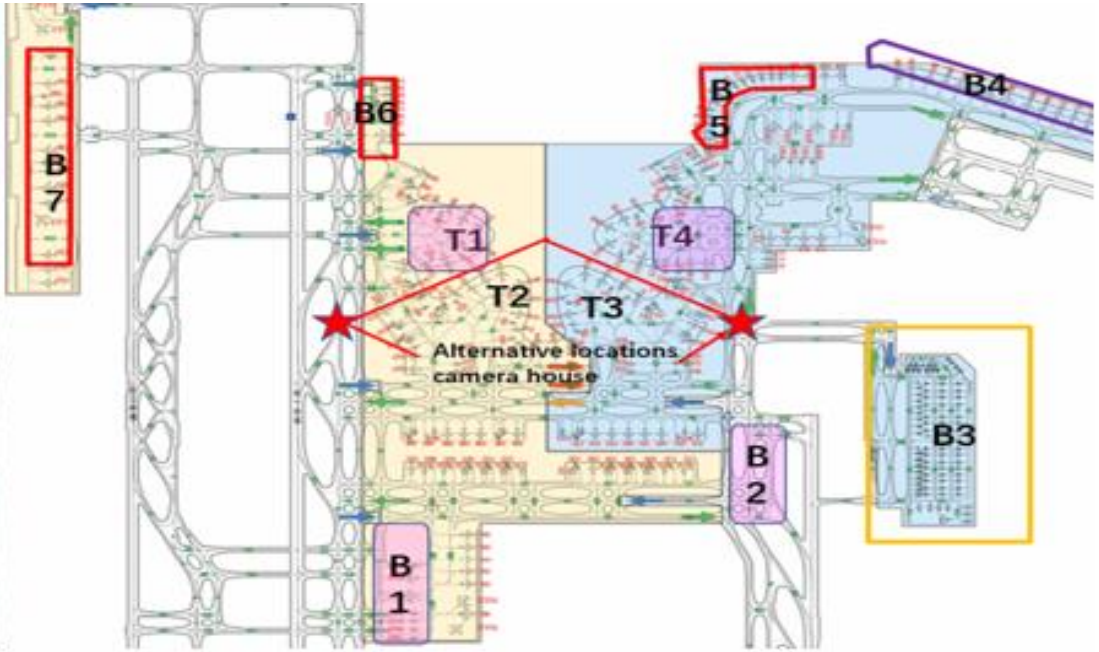
Brightness



Colour & Saturability

- **Circadian rhythm**
- **Visual fatigue**
- **Alertness level**
- **monitoring performance**
- **Response time**

Digital Tower for Apron Control (Beijing Daxing & Hong Kong airports)



There are some cultural differences (national, organizational, and professional cultures)

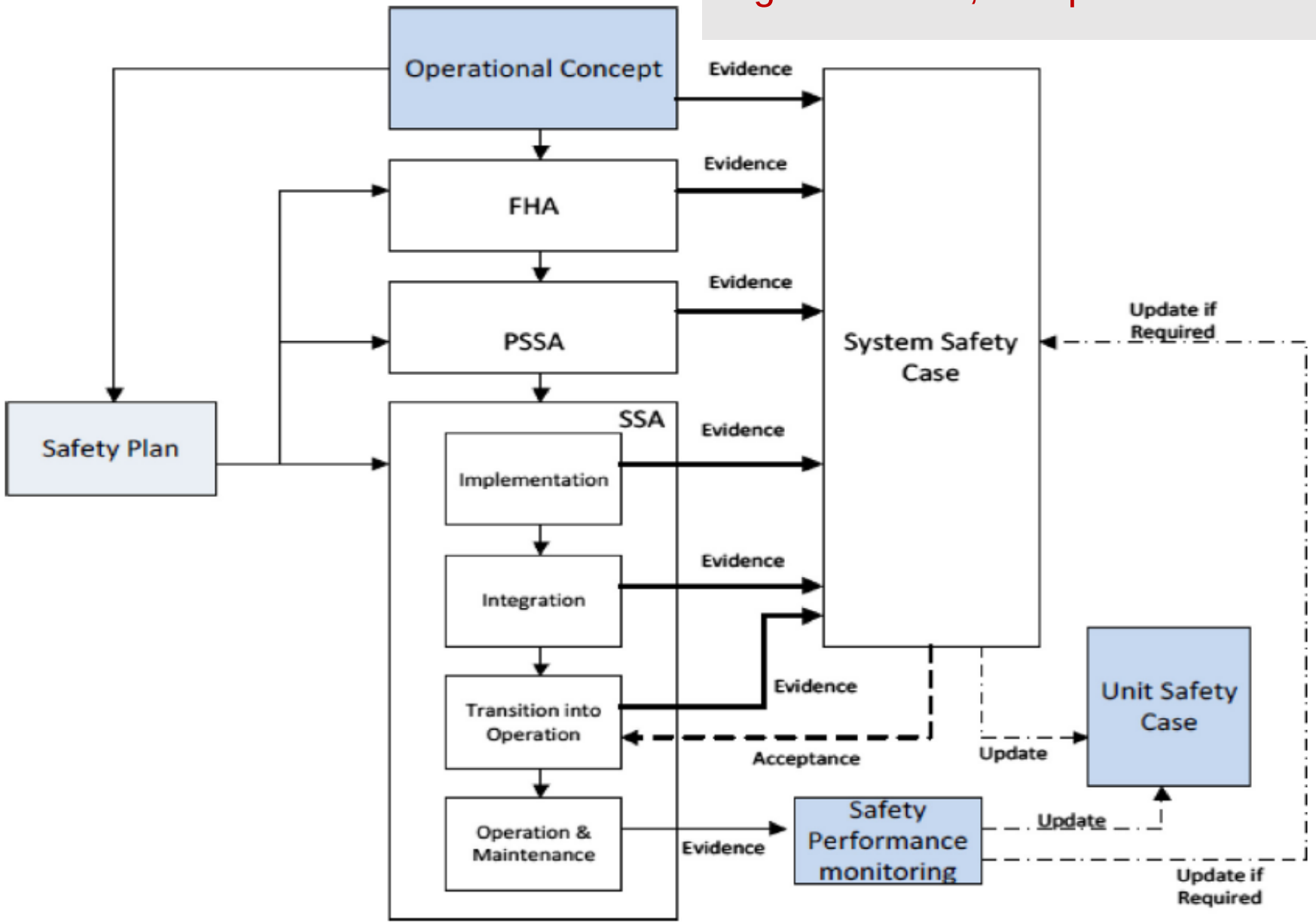


Fig. 2. Safety assessment Methodology applied by IAA Terminal Services.

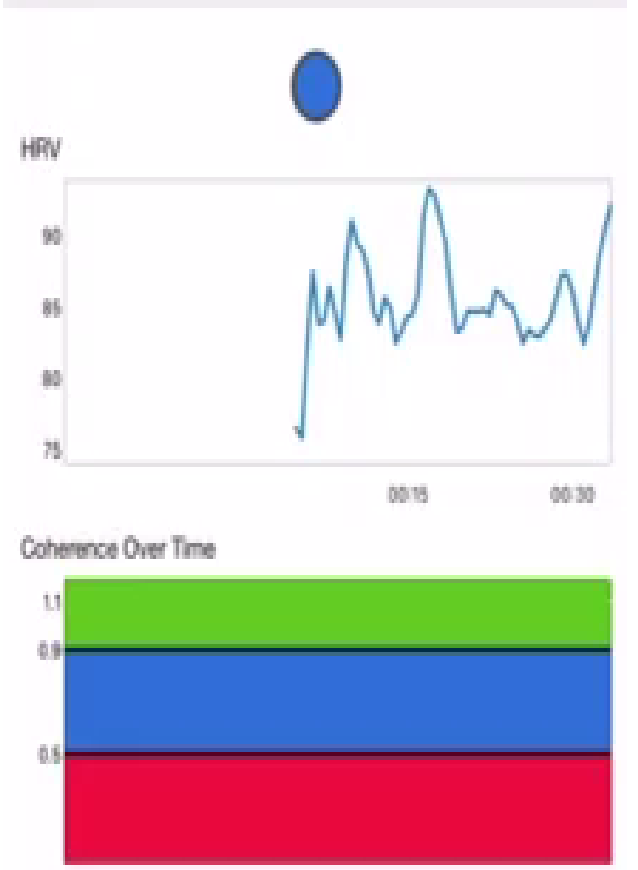
Augmented Reality (AR) in Flight Operations

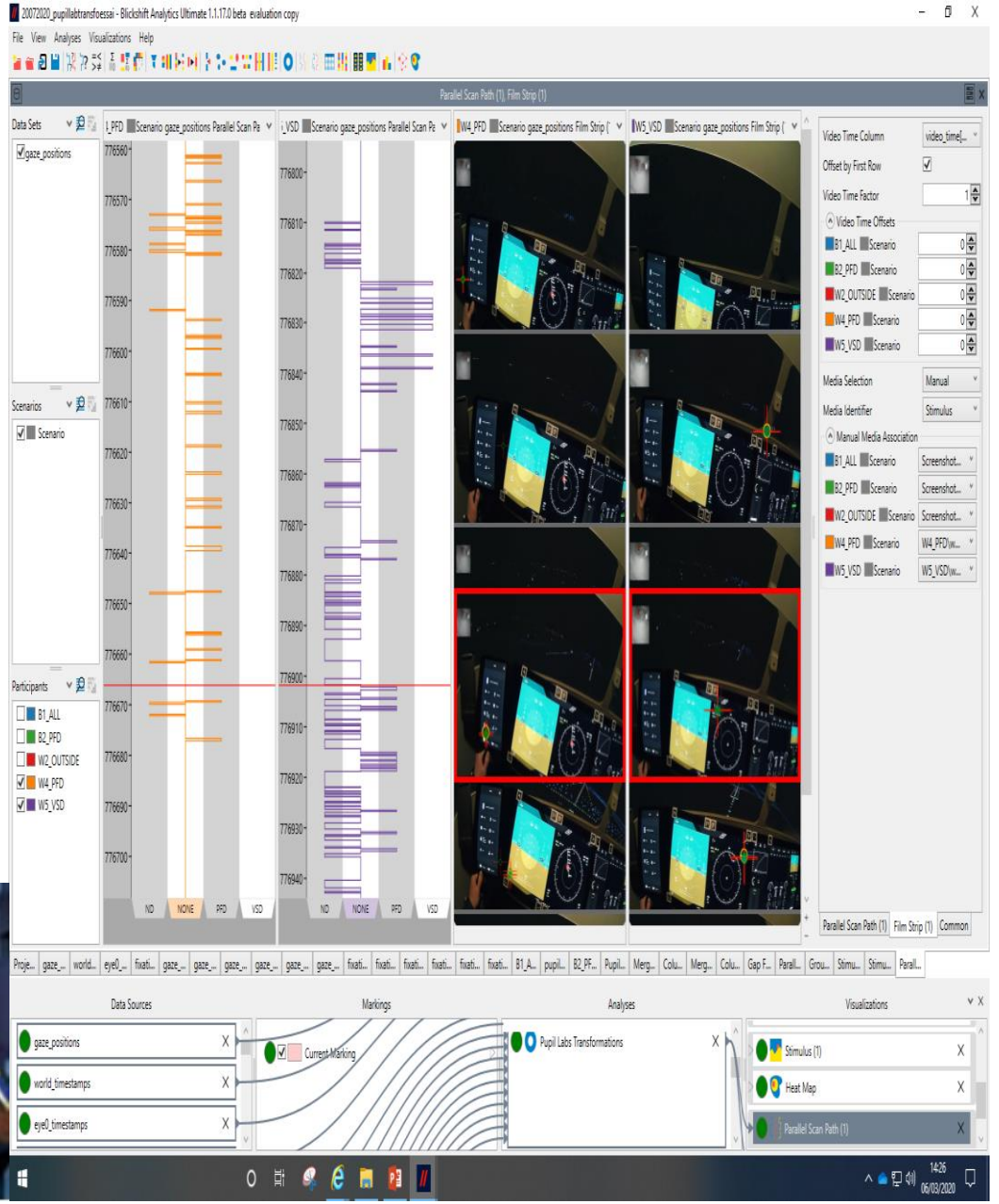
1. Li, W-C., Zhang, J, Court, S., Kearney, P. & Braithwaite, G. (2022). The Influence of Augmented Reality Interaction Design on Pilot's Perceived Workload and Situation Awareness. *International Journal of Industrial Ergonomics.* doi.org/10.1016/j.ergon.2022.103382
2. Li, W-C., Horn, A., Sun, Z., Zhang, J. & Braithwaite, G. (2020). Augmented Visualization Cues on Primary Display Facilitating Pilot's Monitoring Performance. *International Journal of Human-Computer Studies*. doi:10.1016/j.ijhcs.2019.102377
3. Li, W-C., Zakarija, M., Yu, C-S & McCarty, P. (2020). Interface design on Cabin Pressurization System affecting pilot's situation awareness: the comparison between digital displays and pointed displays. **Human Factors and Ergonomics in Manufacturing and Service Industries**. doi:10.1002/hfm.20826
4. Li, W-C., Zhang, J. Y., Minh, T., Cao, J. Q. and Wang, L. (2019). Visual scan patterns reflect to human-computer interactions on processing different types of messages in the flight deck. *International Journal of Industrial Ergonomics, 72,* 54-60. doi:10.1016/j.ergon.2019.04.003

PF & PM's Visual Behaviours and Attention Distributions

iF Design Award: Cranfield Future System Simulator

Synchronization System Performance and Human Performance



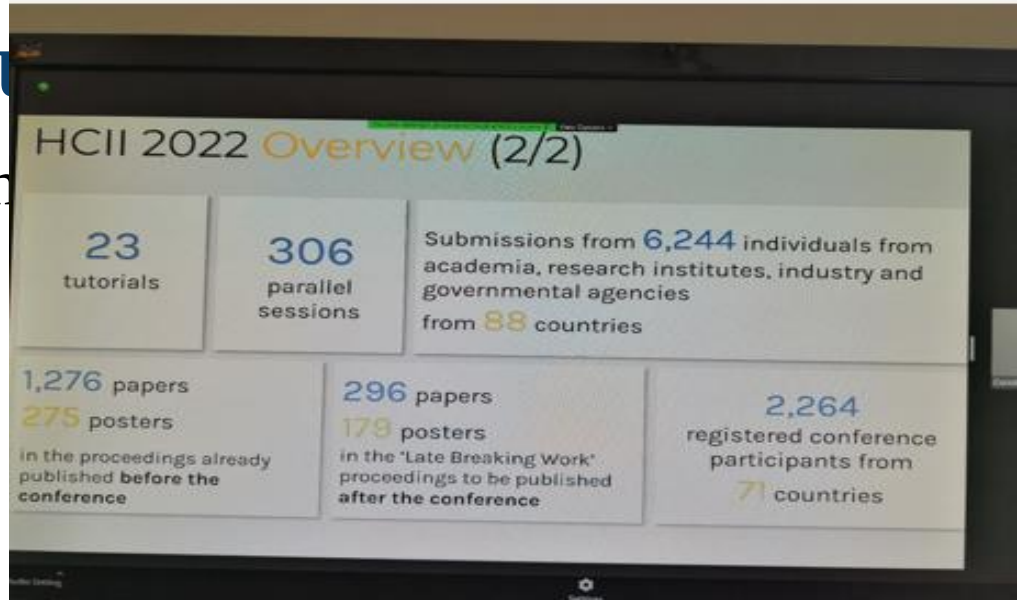


How can we learn from each

- Trustworthiness AI Decision Support Syste
- Collaborative Training Framework for Next
- Human-in-the-Loop Automatic Digital Tow

How can we collaborate on f

- Share research findings to avoid reinventing the wh
- Share research facility and expertise
- Share data for developing research papers
- Develop research proposals for research funding
- Organize international conferences to increase impacts (HCII, EAAP. CIEHF…)



Summary: something extra …

- Technology is there, but sometimes human operators are relevant to use it.
- Human factors research can facilitate human operators' understanding of the benefits of the proper use of technology.
- User's satisfaction is the driver of the success of implementing innovative technology.
- Integrated visual, aural, and psychophysiological characteristics in system design can facilitate safety, cost-efficiency, human performance, and wellbeing

Cranfield is looking forward to collaborating with you in an innovative way

Thank you!
Q & A

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