Inspiring Great British
Manufacturing

AREA AR Safety and Human Factors Framework

- “I think that developers and researchers of AR technology should be ambitious and continue to move forward, but proceed at a speed that allowed the appropriate time for cautious analysis.

- We’ve seen in recent news the affect that autonomous vehicles have had, the cost of human life, because the technology moved too quickly to allow adequate time for everyone else to catch up.

- We’ve got some exciting research to do, we just need to make sure we engage the appropriate stakeholders to make health and safety a priority.” – Boeing, Safety Advisor.

Image source: Stambol

Project Objectives

- **What are potential safety and human factors issues with AR? How do these impact the user?**
- **How can these be managed/mitigated?**
- **Current evaluation methods and metrics**

Research Outcomes/ Results

- **No consistent approach to measuring/assessing safety with AR in the workplace**
- ***Created a safety assessment framework that aligns with the project cycle including:***
  - **Supporting tools for device and design assessment**
  - ***Captured general and specific safety risks in industry***
- **Report –** *overview of research*
- **Manufacturing assembly case study**

Research Methodology

Primary research

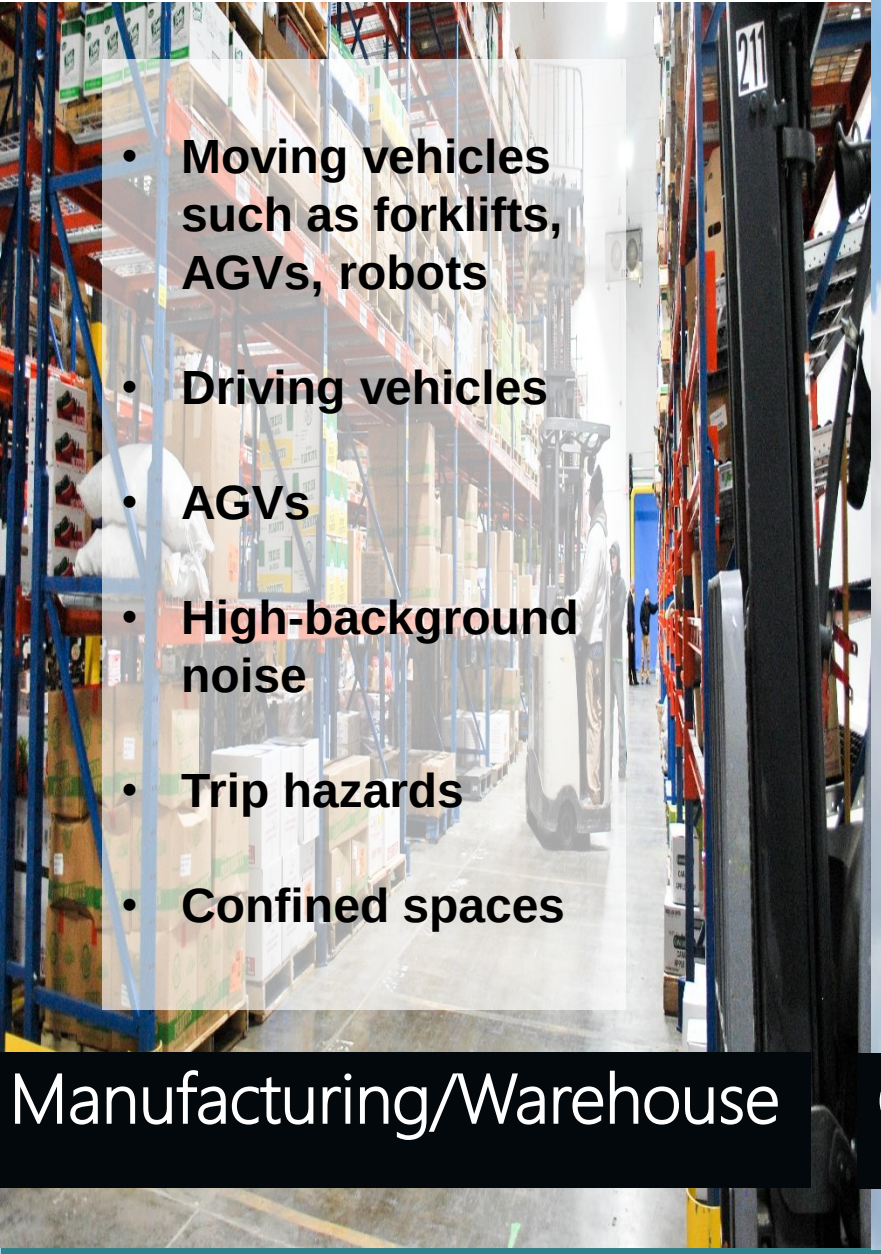
- **In person or remote interviews** were conducted with :
  - Safety/Regulatory bodies
  - Industries
  - AR Solution providers

Secondary research

- Web-based/desktop

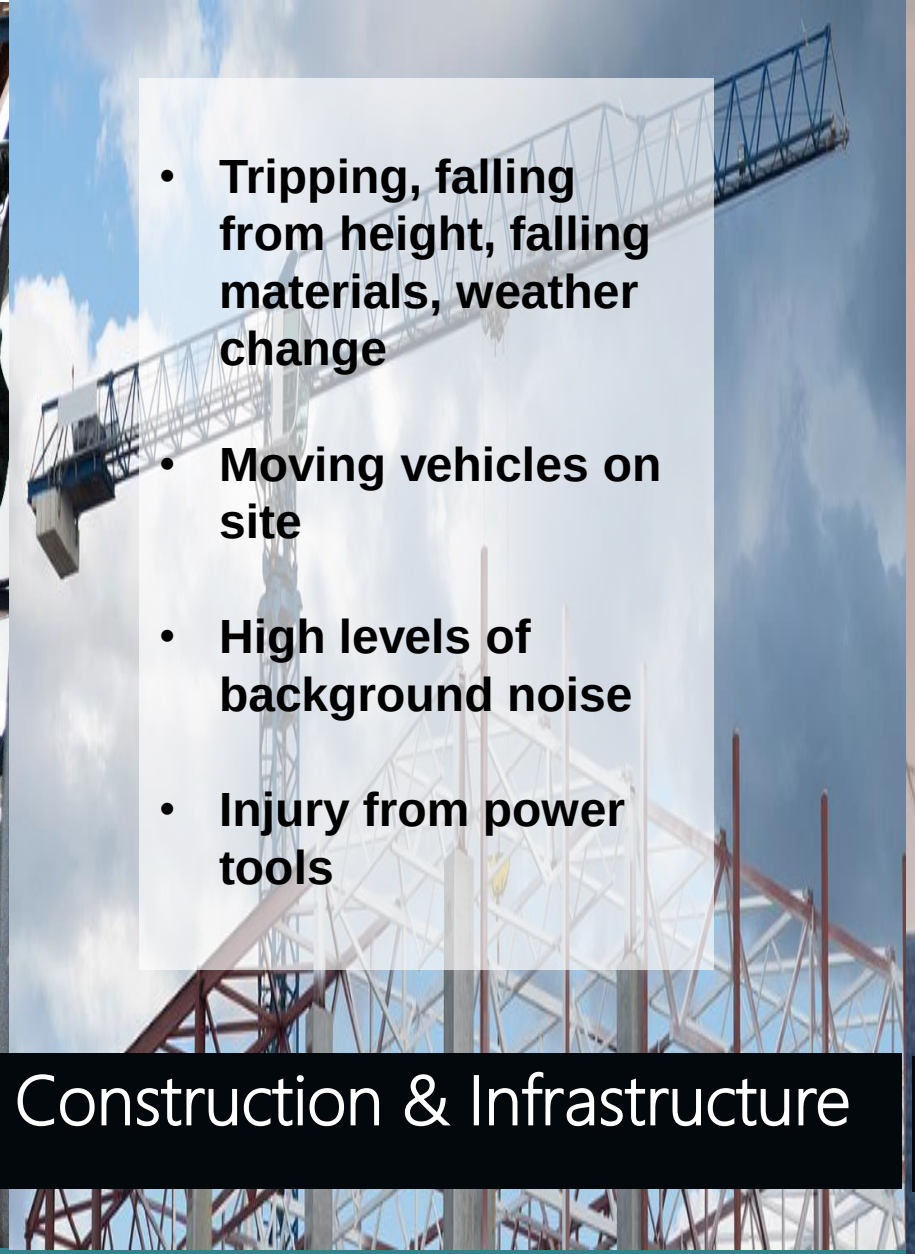
Collaboration with industry adopters and designers

Sources of Risks – Environment and Task



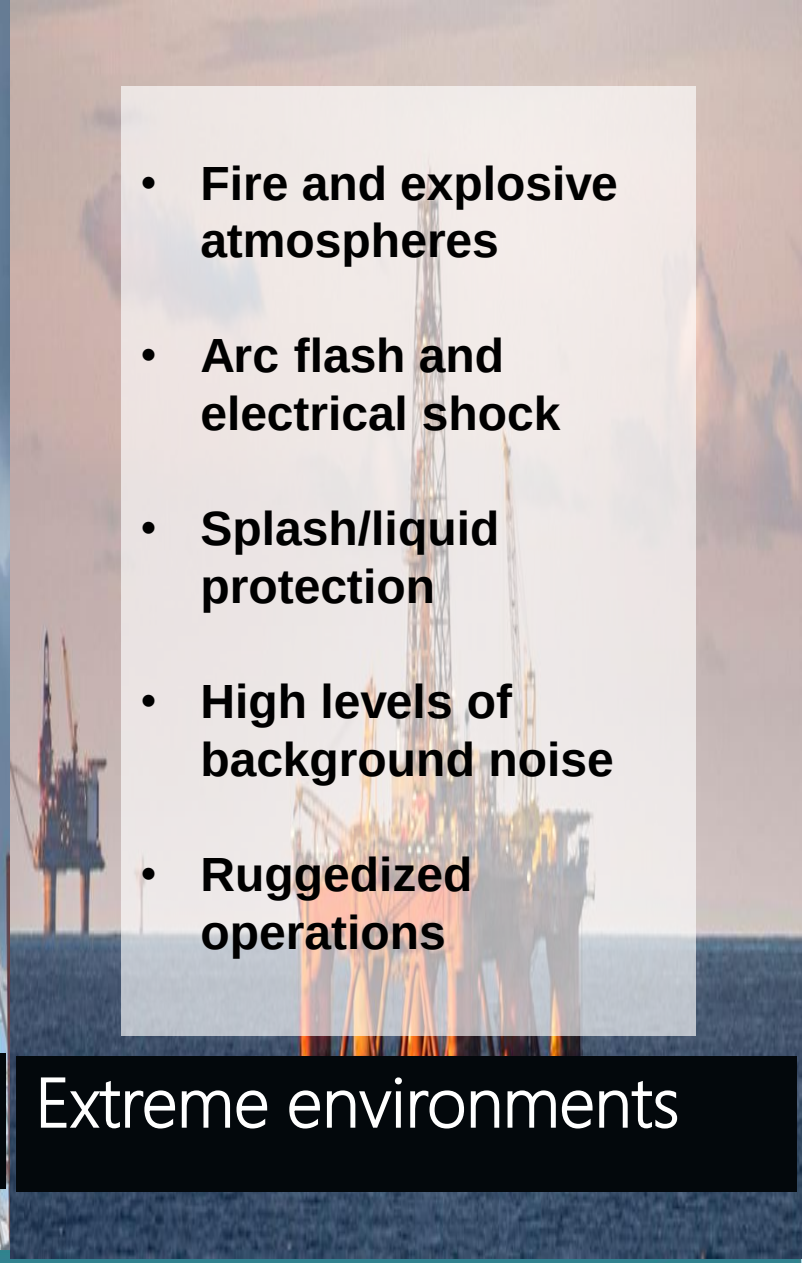
Manufacturing/Warehouse

- Moving vehicles such as forklifts, AGVs, robots
- Driving vehicles
- AGVs
- High-background noise
- Trip hazards
- Confined spaces



Construction & Infrastructure

- Tripping, falling from height, falling materials, weather change
- Moving vehicles on site
- High levels of background noise
- Injury from power tools



Extreme environments

- Fire and explosive atmospheres
- Arc flash and electrical shock
- Splash/liquid protection
- High levels of background noise
- Ruggedized operations

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Safety by Design

Figure 1 Risk Assessment Cycle (adapted from HSE 'Risk – Controlling the risks in the workplace and CSM for risk evaluation and assessment) (Health and Safety Executive, 2018) (European Commission, 2013)

What risk does AR present? Construction example

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Current Process/Risk → **Potential AR Risk** → **Design Considerations**

Sources of Construction Risks	AR Risk	AR Safety Considerations
Trip hazards, Falling	• Reduced situational awareness/distraction can cause user to spot hazard	• Hazard notification using AI/machine learning • Safety Prompts
Noisy environment	• Voice interaction may not be possible	• Alternative/multi-modal interaction methods e.g gesture, eye-gaze, clickers
PPE	• Device form fitting i.e. discomfort • Device interaction whilst wearing safety gloves	• Comfortable fit with PPE e.g. hardhat and ear-defenders or integrated safety rated device • Device interaction (buttons, gesture tracking, clickers) compatible with PPE such as safety gloves

Occlusion of vision
– Limited field of view (FOV)
- **Occlusion of hazards in environment**

Heat from device
– User discomfort

Form Factor (size, shape, and weight)
– Discomfort/distraction

Dynamic/Travelling
- Occlusion of hazards in environment

Limited battery life
– Loss of data or safety critical alerts

Sources of Safety Issues – Device

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Poorly design UX/UI

- **Noisy**
- **Cluttered**
- **Unclear**
- **Too much/too little detail**

- **Over-stimulation**
- **Obstruction of FOV**
- **Visual distraction**
- **Incorrect perception/judgement – of distances/speed**

Sources of Safety Issues – App Design

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- **Distraction**
- **Situational awareness**
- **Cognitive load/stress**
- **Eye strain**
- **Ergonomics and musculoskeletal strain**
- **Habituation**

Impact on user

Please Select Role

Developer	The developer's role is primarily to develop and maintain the software that is running on the AR display device
Project Manager	Project manager plans and oversees the project and ensures on time and on budget delivery. This tool is focused on the client's side i.e. the adopter of the AR solution
Safety Manager	Safety Manager ensures risks are analysed, assessed and benchmarked to compliance standards. This role can be within the client's or solution provider's team.
Solutions Provider	Integrators develop the full AR solution according to the client's requirements. This may include hardware, software and and also an implementation/delivery plan. Depending on the internal and external resources, the solutions provider can also serve in the role of developer

Findings

- **Education/Training safety issues for AR/MR for industry**
- **More engagement with safety managers**
- **Lack of congruent metrics for evaluating AR**
- **More studies required to push towards standards/regulations for safer and more robust AR solutions**
- **User should be centre of design – UX/UI is key!**

How can AR improve safety?

- ✓ **Improve situational awareness in pilots**
- ✓ **Assist in audits and inspections**
- ✓ **Hazard awareness and identification**
- ✓ **IoT networked – health monitoring**
- ✓ **Improve training and reduce human error**
- ✓ **Reduce visual discrepancies (in the future!)**