Human-Centred Information Visualisation for Improved Situational Awareness and Critical Decision Making in Energy Control Rooms

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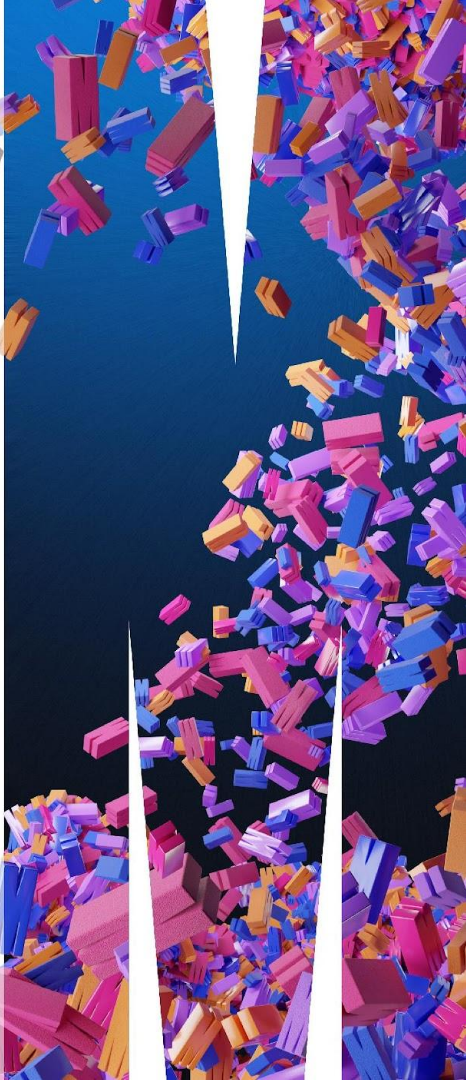
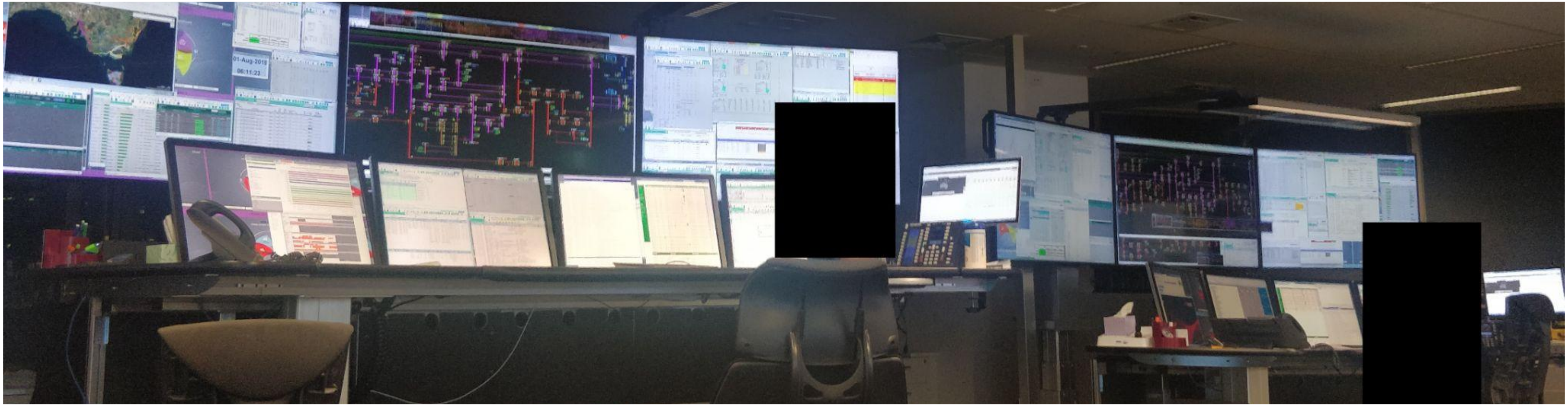


Future Energy Control Rooms...?

Humans must be in-the-loop - to interpret the data as well as intervene when needed.

Data needs to be understandable - open, transparent and interpretable.

(Nearly) Current Operations



Multiple screens, many applications, different systems, inconsistent visual representations, many audio and visual alerts, and hundreds of different operator tasks and procedures…

Overview of the Human Visual System

The visual system has **three** main stages:

Stage 1: FEATURES - Extract low level properties:
colour, texture, lines and movement.

Subconscious, parallel processing.

Stage 2: PATTERNS - "Proto-object" recognition of surfaces, boundaries and relative depth:

Rapid serial processing divides the visual field into regions of similar colour or texture. This is driven both *top-down by visual attention* and *bottom-up by low level properties.*

Stage 3: MEMORY - Visual working memory:
Object recognition and attention.

This is under **conscious** control

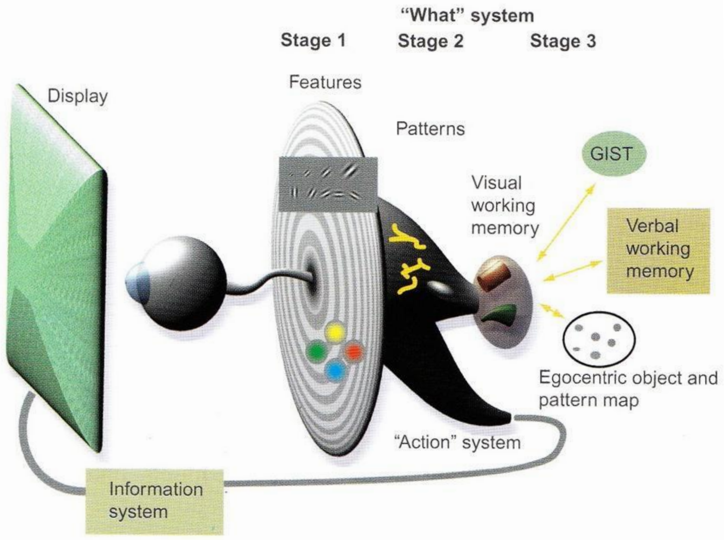


Figure 1.11 A three-stage model of visual information processing.

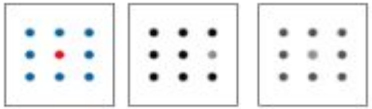
Ware, Colin. (2004). Information Visualization: Perception for Design: Second Edition.

Stage 1: FEATURES: Pre-attentive cues

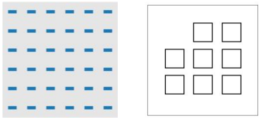
Highlighting (important/interesting/selected) objects use **pre-attentive cues.**

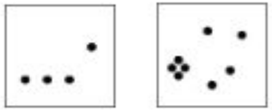
These cues fall into 4 broad categories:

Colour



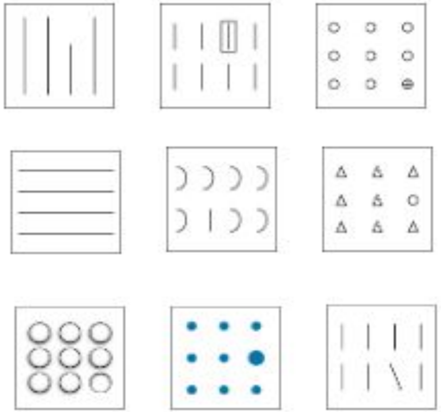
Movement





Spatial Positioning

Form



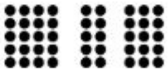
Stage 2: PATTERNS: Grouping / Gestalt Laws

The visual system uses a variety of heuristics to then group features into objects.

Many of these heuristics were identified by **Gestalt psychologists** at the start of the 20th century who were interested in how objects are perceived.

Gestalt Laws:

Proximity



Similarity

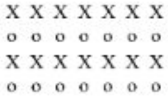
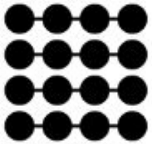


Figure Ground

Connectedness

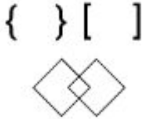


Common Fate

Continuity

Closure

Symmetry



Stage 3: MEMORY: Conscious Processing

Very **few objects can be held in visual working memory** and these are constructed from visible patterns and information in long term memory.

Must **avoid large changes**, where working memory is needed as this can cause **Change Blindness**

Cognitive Load can be defined as the **amount of information processed by working memory**.

Cognitive load

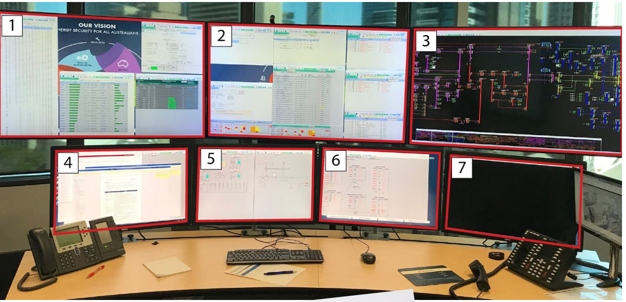
High cognitive load can lead to:

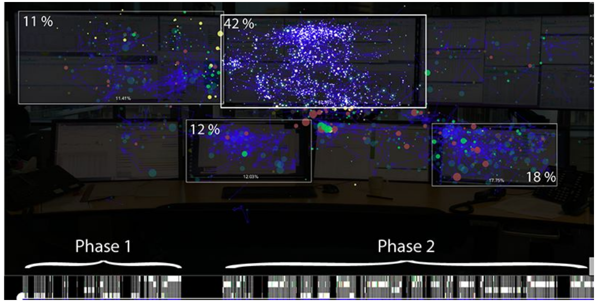
- **Mental fatigue:** This leads to sub-optimal cognitive performance and in the long term could lead to fatigue and burnout
- **Low situation awareness:** Situation awareness is the mental representation of the state of the system and its evolution.
- **Inattentional deafness:** Failure to hear audible sounds like alarms

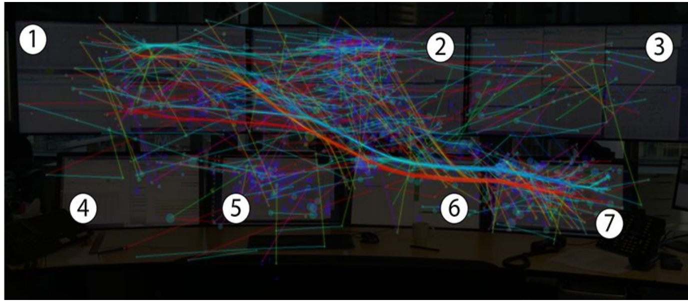
Cognitive load be measured by:

- **Subjective Assessment**, e.g. users assess their own cognitive load;
- **Biophysical Factors**, e.g. measuring users heart rate, brain activity or pupil dilatation;
- **Indirect Measures**, e.g. recording user activity, interaction, situation awareness or task performance rate.

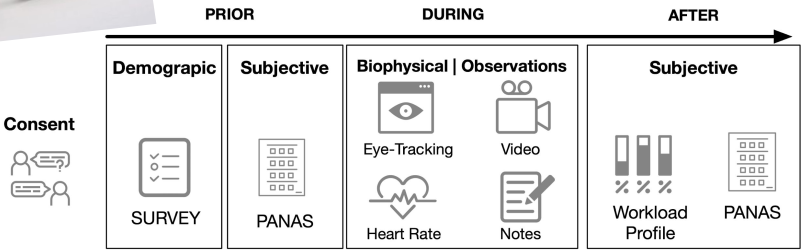
Operator Cognitive Load Study (2019)

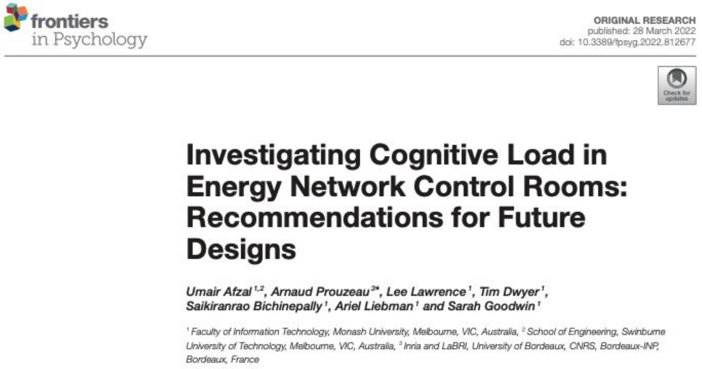






- Eye Tracking
- Heart Rate
- Workload ratings





frontiers in Psychology

ORIGINAL RESEARCH
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Investigating Cognitive Load in Energy Network Control Rooms: Recommendations for Future Designs

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- Afzal et al. (2022), Cognitive Load in Energy Network Control Rooms: Recommendations for Future Designs, Frontiers of Psychology Journal. 28 March 2022 | https://doi.org/10.3389/fpsyg.2022.812677
- Goodwin et al. (2022), VETA: Visual Eye-Tracking Analytics for the Exploration of Gaze Patterns and Behaviours, Visual Informatics, Vol. 6, Iss. 2, 2022, Pages 1-13, ISSN 2468-502X, https://doi.org/10.1016/j.visinf.2022.02.004

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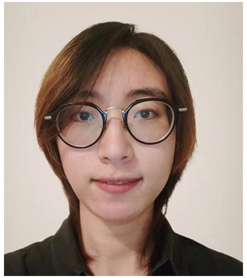

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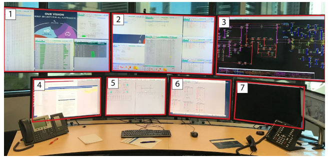
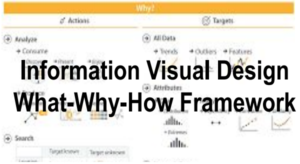
CROF Stage 4 Research 2024-2025

Understanding Current Practices and Future Needs and Ideas



Observations

AEMO Control Room



Information Visual Design
What-Why-How Framework

- Features
- Patterns
- Memory

FUTURE (AEMO) Control Room

Workshop 1

Creativity Workshops

What do you (really) want and need to
- **DO?**
- **KNOW?**
- **SEE?**

FUTURE Energy Control Rooms

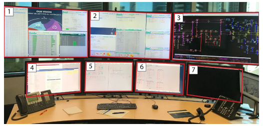
Workshop 2

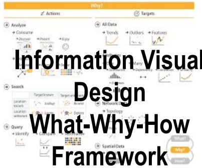
Interested?
Contact me!

E. Kerzner, S. Goodwin, J. Dykes, S. Jones and M. Meyer, A Framework for Creative Visualization-Opportunities Workshops, in IEEE Transactions on Visualization and Computer Graphics, vol. 25, no. 1, pp. 748-758, Jan. 2019, doi: 10.1109/TVCG.2018.2865241.

CROF Stage 4 Research 2024

Understanding Current Practice and Future Needs





Information Visual Design What-Why-How Framework

Observations

Workshop 1

Workshop 2

Analysis

Recommendations and Guidelines for CROF

Pain points

FEEDBACK

Recommendations

FEASIBILITY

Prototype Designs

EVALUATION

Results + Roadmap

Stage 4: Roadmap: CROF Operator and Human Factors

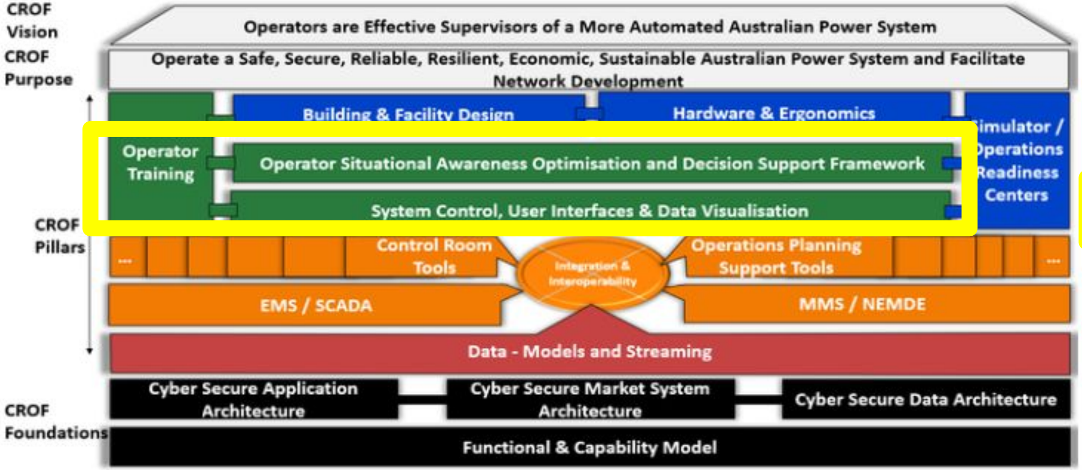


Figure 4-1 CROF model indicating the pillars and foundations. ***Note the color coding which is used the following maps as a way of differentiating the category groupings.***

4.7. Roadmap for the CROF – Operator and Human Factors

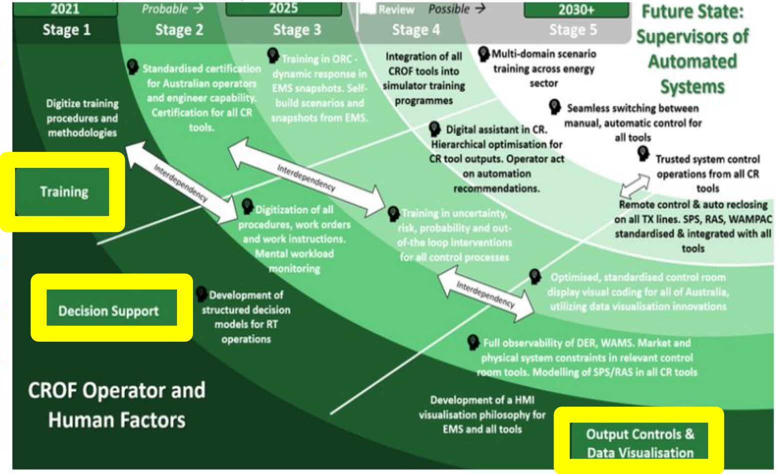
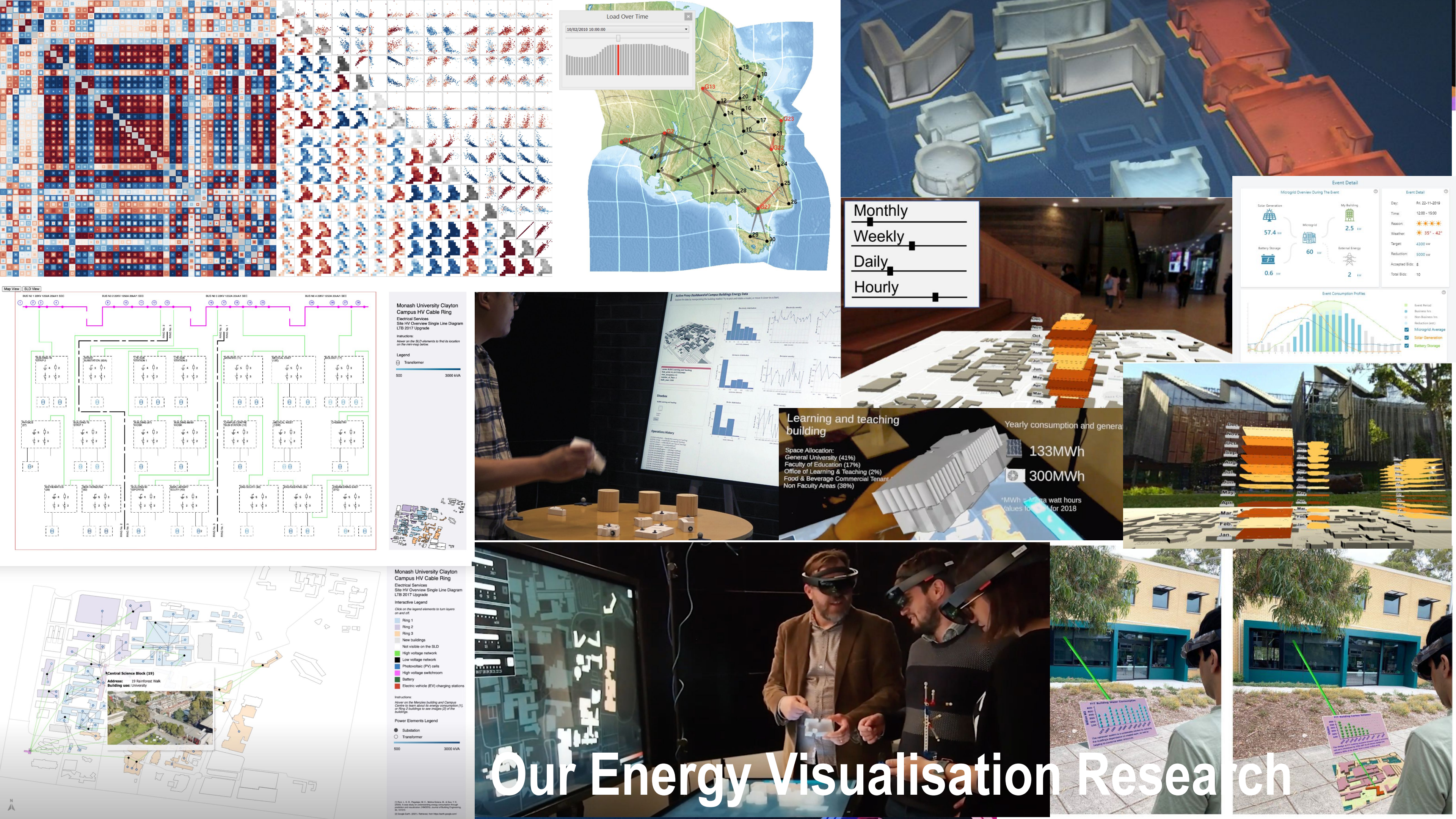


Figure 4-5 CROF Roadmap for Operator and Human Factors innovations


Load Over Time
10/02/2010 10:00:00
Event Detail
Monthly
Weekly
Daily
Hourly
Monash University Clayton Campus HV Cable Ring
Electrical Services
Site HV Overview Single Line Diagram LTB 2017 Upgrade
Legend
Transformer
Learning and teaching building
Space Allocation:
General University (41%)
Faculty of Education (17%)
Office of Learning & Teaching (2%)
Food & Beverage Commercial Tenant
Non Faculty Areas (38%)
Yearly consumption and genera
133MWh
300MWh
Interactive Legend
Ring 1
Ring 2
Ring 3
New buildings
Not visible on the SLD
High voltage network
Low voltage network
Photovoltaic (PV) cells
High voltage switchroom
Battery
Electric vehicle (EV) charging stations
Central Science Block (19)
Power Elements Legend
Substation
Transformer
Our Energy Visualisation Research

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