The Changing Role of the Control Room Operator in Metro Rail: Automation and the Challenge of Maintaining Situation Awareness

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INTRODUCTION

What is this presentation about?

How Human Factors techniques have been employed in control room system design in order to support the changes in the Control Room Operator Role in response to increasing automation of the Railways
Human Factors

Human Factors (HF) is concerned with the ‘fit’ between the user, equipment and their environments.

To assess the fit between a person and the system, HF experts consider:
Use of Human Factors in System Development

HF techniques can be used to evaluate the questions all Signalling Engineers ask themselves:

• **Is it safe?**
  • Is the system designed to minimise human error?

• **Does it work?**
  • Does the system provide the necessary functionality to allow the operator to maintain a good service?

• **Can you use it?**
  • Is the Human Machine Interface (HMI) designed to make it easy, efficient and effective to use?
  • Does it meet user expectations and match user capabilities?

Avoid Rework Involve Human Factors From Project Start-Up
Automated Control Centres: Signaller Role

**Signaller Goal: safe and prompt service in their area of control**

Signallers used to achieve this by being:
- Close to their area of control – providing direct line of sight monitoring
- In direct mechanical control

**Modern Control Centres cover Large Areas through use of Remote Monitoring and Automatic Control of Signals and Trains**

Signaller role changed from total control for all signalling actions to:
- Supervisor when system running to plan.
- Immediate Actor, Strategic Planner and Active Controller in degraded and emergency situations

**HF Challenge:**
Ensure operator identifies and responds appropriately to service affecting events
Maintaining Situation Awareness and Acceptable Workload

In order to ensure the Signaller identifies and responds quickly to service affecting events need to maintain situation awareness and acceptable workload

Key functionality:

- Alarms
- State of the Railway - Track Mimic Diagram
- Flexible allocation of control areas and role responsibilities
- Automatic Train Regulation
SITUATION AWARENESS
Alarms

Prompt correct response to alarms is vital for efficient and safe service

But
As level of automation increases trend is for number of alarms to increase

**HF Challenge:**
How to ensure that priority alarms are correctly identified and responded to quickly

**User Review is Key**

But
- Automated systems often have hundreds of alarms,
- Reviewing each alarm with users is time consuming,
- Often difficult to reach a consensus i.e. allocation to 3 priorities as suggested in EEMUA 191 guidelines
User Review - Affinity Diagrams

A simple and effective method for categorising lots of alarms quickly using post it notes and A0 sheets of paper:

• Divide users into groups
• Provide each group with all the alarms to be categorised on post it notes – 1 alarm per post it note
• Get each group to review each alarm and place it under the appropriate heading
• As a whole compare the output from each group and come to a meeting consensus
Using Affinity Diagrams makes review and re-review of data:
- Simple,
- Effective
- Quick.

Production of affinity diagrams has been used successfully to:
- Minimise number of alarms sent to each user
- Ensure all alarms received are of interest and role appropriate
- Ensure highest priority alarms attended to first.

Affinity Diagrams also used to:
- Prioritise information presented on mimic diagrams.
- Review allocation of function to role
Mimic Diagrams – Wall Overview Display

The objective of the mimic diagram is to:

Provide an overview of current state of service and enable instant location of problems.

Achievable only if information is minimised to task critical.

*But* when asked users always want a wall mounted mimic to display everything

**HF Challenge:**
Get users to identify what is really important and required
Focus Groups

**Objective:**
Get users to identify and prioritise requirements

**First Step:**
Focus groups early in the project provide guiding information
To ensure useful output focus groups need:
- Directed relevant questions
- Output reviewed for validity

**Suggested Questions for Focus Group**
- What confirms that a good service is being provided?
- What indicates that the service is becoming degraded?
- Which are the most important degraded events to be shown?
- What information is required to provide context?
Discussion

Results of Focus Groups provided a good basis for follow up prioritisation and design activities

Overview is clear, readable, understandable and presents an easily interpreted ‘snapshot’ of the service.

Information presented is minimised to:
- High priority service affecting events
- Infrastructure required for context
- Train Information
Operator Workload and Automation

Automation reduces workload hence staff levels are also reduced

But

In degraded and emergency states workload increases dramatically

HF Challenge:
How to design the system to manage the increase in workload?
Flexible Allocation

Spare operators are not always available so system needs to allow available operators to share the workload equally.

**Answer:** Flexible Allocation of Control Areas and Responsibility

**How:**
- Control areas can be subdivided into stations
- If Operator 2 workload too high (signalling problem at H) Operator 1 can help
- Line workload too high (fire at E) Manager can take control of E
Automatic Train Regulation

Operators optimise the service by minimising actual or predicted service disruptions

ATR supports this operational practice by optimising service against headway or timetable by:

1) Identifying disruptions
2) Automatically modifying train departure times and coasting speed

But

Previous experience shows operators distrust ATR and turn it off

**HF Challenge:**
Ensure users can understand, interpret and interact with ATR to develop trust
Paper Prototype Walkthrough

Purpose: Explore ATR requirements and behaviour early in design

Input: HMI requirements from System and Task Analysis used to produce a paper mock up of HMI

Method: Use Paper Prototype to do Scenario walkthrough with reference to how ATR could be used and could respond

Results:
- HMI amended by participants with information needs,
- Highlighted behavioural requirements as well as look and feel
- Emphasis on ATR as under user control with all proposed changes observable
Prototype Development

Paper Prototypes are just the beginning.
As the project develops the prototype will improve and change in-line with system development becoming closer to the end product.

From paper to computer HMI with limited interaction to developers rig.

Prototypes are useful for exploring designs throughout the project.

Using prototypes in workshops we can:
  - Explore different HMI design options
  - Evaluate usability
  - Investigate information required
Output – HMI Specification

HMI Specification for ATR:

- Details HMI visual and interaction design
- Records operational and HF rationale for design choices.

Used as useful communication tool between software engineers and HF specialists in conjunction with interactive HMI prototype

Production ATR system built to this specification and accepted by Users
DISCUSSION AND
CONCLUSION
Discussion

Automation of tasks previously done by operators is changing the operator role, increasing complexity, changing role to monitoring and strategic management.

Focus of design of human role in automated systems is on maintaining operator’s situation awareness and ensuring acceptable workload, particularly in degraded and emergency situations.

The methods used in this case to achieve this are applicable to multiple uses including the new challenges for rail e.g. introduction of ERTMS and consolidation of Traffic Management control in UK.
Conclusion

This paper:

- Demonstrates HF is vital in design of efficient and safe control systems that can be managed and used effectively by the operator.
- Highlights some of the most effective techniques being deployed in the key areas of control system design.
- Emphasises the necessity to include HF specialists from the start of the project.
- Emphasises the need to ensure the requirements are consistently understood by all stakeholders.
The Future – Meeting The Challenge

Increasing automation increases demands on Operators to:

• Monitor and maintain a highly detailed and complex system to a greater level of detail;
• Maintain vigilance when they are only monitoring the system and are effectively underutilised.

**HF Challenge:**
To balance operator workload and maintain operator situation awareness and vigilance

To meet the challenge we as professionals will need to:

• Innovate HF tools and techniques in this important area
• Work closely together as HF experts, Engineers and Stakeholders to ensure the systems of the future meet the changing needs of the control room operator.
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