Human Factors in the Control Loop: A Case Study of the Use of STPA for a Rail Innovation Project

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The Railway as a Distributed Cognitive System

- Driver
- Signaller
- Controller
- Type of Train
- Location of Other Trains
- Weather Conditions
- Limit of Movement Authority
- Route Set
- Station Stop
- Level Crossing Users
- Drainage Condition
- Emergency Speed Limit
- Track Condition
- Next Speed Limit
- Train Location
- Current Speed of Train
- Current Speed Limit
- Signal State
- Track Workers
- Authority
- 50
- 100
- 20
External Disturbances

GB Rail Industry Control Structure

External Disturbances

Control
Feedback

Train and Freight Operating Companies

Rail Safety and Standards Board

Office of Rail and Road

Department for Transport

Rail Accident Investigation Branch

Network Rail

CFO, HR, Comms
Route Services
Technical Authority
System Operator
Regions and Routes

Train and Freight Operating Companies

System Development
System Operations

Project Management
Design and Documentation
Implementation and Assurance
Supply Chain
Maintenance and Evolution

Operations Management

Operating Process

Operator
Automation
Actuators
Sensors
Equipment

External Disturbances

Key
Control
Feedback

L-1
Financial loss

L-2
Loss of life or injury

L-3
Loss of trust or reputation

L-4
Loss or damage to property or the environment

L-5
Failure to deliver the rail service
Use human-centred design methods
Put safety first
Evoke trust
Reduce risk through digital engineering
Focus on the operational context
Designer deals with ideals or averages, not constructed system

Original design spec

Operational procedures, training

Manufacturing and construction variances

Evolution and changes over time

Operator’s continually test their models against reality

FUTURE SYSTEM

- Manufacturing and construction variances
- Evolution and changes over time

DESIGNER’S MODEL
- Architecture and requirements
- Processes, rules and operational realities

OPERATOR’S MODEL
- Goals, confidence and control
- Human information needs to drive improved decision making

Multidisciplinary design decisions to deliver benefits and manage risk

Spontaneous Synchronization
UCLA Department of Physics & Astronomy
Transactive Memory Systems in Product Development Teams


How did using STPA help?
- STPA control structures are useful *cognitive artifacts* that offer *decision making stability* in the face of *strategic uncertainty*.

- Blending STPA with *human factors methods* can surface *system vulnerabilities* and unlock opportunities for *creative decision making and innovation*.

- STPA provides *structure and processes* to consider *humans and machines as collaborative agents* during the *design of complex systems*. 
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In-Cab Technology

Driver

Competency
Experience
Situation Awareness
Distributed Cognition
Decision Making
Fatigue
Mode Confusion
Usability

Mental Workload
Expertise
Cognitive Tunnelling
Vigilance
Physical Ergonomics
Divided Attention
Cognitive Complexity
Stress
DMI Principles
- Consider the evidence
- Deliver the requirements

PROJECT

HUMAN FACTORS INTEGRATION

Risks, Assumptions, Issues, Dependencies and Opportunities (RAIDO)
- TOC & FOC
- Target Audience Description
- Lessons Learned

Scenarios

Cab Designs

Existing DMIs

Software Design Patterns

Operational Scenarios
- Goals
- Scenarios
- Tasks
- Decisions

DMI Market Scan
- Functionality
- Hardware
- Software

DMI: Human Factors RAIDO
- Analysis baseline of reference documentation
- Considerations register

Cab Design Survey
- Volumes
- Types
- Variables
- Edge cases
“The only way to know how a complex system will behave—after you modify it—is to modify it and see how it behaves.”

George E. P. Box
Network Rail Ergonomics

Human Factors-Centred Innovation

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