Predicting how people will respond to a disruptive event: The human factors response framework

Richard Farry

QinetiQ, UK

ABSTRACT

System disruptions can have far reaching negative consequences. The extent to which a system can anticipate, absorb and adapt to a disruption is a characteristic of its resilience. As people are often fundamental to system resilience, an improved understanding of the people-related factors that underpin system resilience helps in predicting system vulnerability and the response to a disruptive event. The Human Factors Response Framework was developed to provide this improved understanding. The framework supports analysts in identifying relevant people-related factors within a system, and the prediction of the system's resilience and the likely dominant response from key personnel. This paper provides a high-level overview of the framework, its development, and future research direction.

KEYWORDS

Disruptions, resilience, human response

Introduction

Sooner or later systems, such as elements of critical national infrastructure, will suffer a disruption. Because system disruptions can have severe and far reaching effects – including loss of life and economic damage – it is important to be able to assess and enhance a system's resilience. Our focus in this research area has been to understand the role and contribution of people-related factors in system resilience.

The resilience of an organisation is its ability to *"anticipate, prepare for, and respond and adapt to incremental change and sudden disruptions in order to survive and prosper"* (BS 65000:2014). A resilient organisation is therefore one that is able to: prevent bad things from happening, prevent a bad situation from becoming worse, or effectively recover from a bad situation or event (Westrum, 2012). People will often play a fundamental role in developing and sustaining system, or organisational, resilience. To support understanding and analysis about how people will respond to a disruptive event, we have developed the Human Factors Response Framework (HFRF).

The HFRF

The HFRF provides support to analysts in predicting the resilience of a system or organisation and how the people within it will respond to a disruption. In addition to being exploited as part of the research programme that has developed it, it has also been used to structure psychology experiments and support cyber vulnerability investigations which identify areas of risk to military systems and platforms.

The HFRF's primary subjects of analysis are individuals, teams, groups, and organisations. From these building blocks the HFRF seeks to assess a system's propensity to respond effectively to a disruption. In particular it seeks to identify:

- If people can detect a change to the technological portion of the system that they are using or monitoring for.
- What factors will influence people's ability to gain an effective understanding of the situation.
- What people will decide to do and how they will act.
- The impact that these actions have on overall system performance – how quickly operating capability can be recovered.

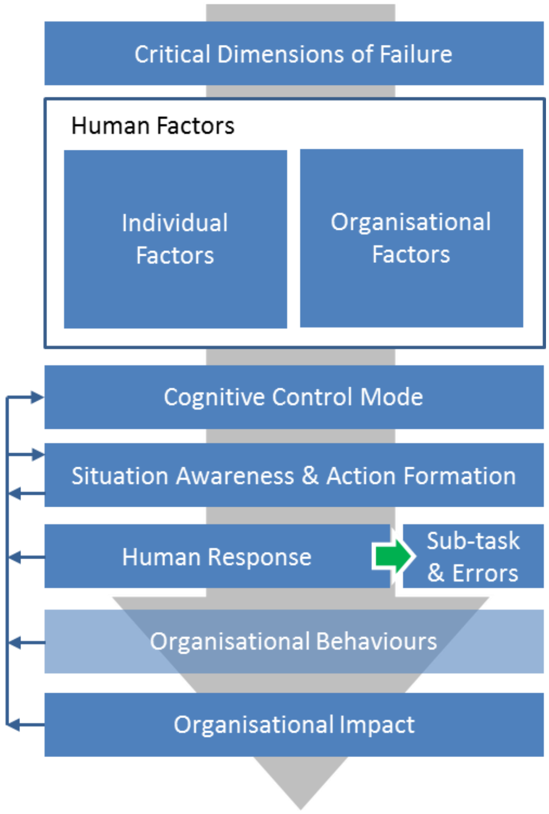

Figure 1: High-level overview of the HFRF

Figure 1, left, provides a high-level overview of the HFRF and its component elements. The **critical dimensions of failure** cover the nature of the disruption and the impacts it may have on the system. The **human factors** section features ninety-one individual and organisational factors thought to be relevant to the effectiveness of the human response to the system disruption. These are organised into seventeen categories covering aspects such as workload, organisational culture, the footprint of the organisation, and the organisation's adaptive capacity. The **cognitive control mode** is a mechanism to generate an indicator for the type of decision-making strategies that will be employed, which feeds into people's **situation awareness** and the **plans** that they formulate. The remaining sections of the HFRF relate to behavioural and performance outcomes. The **human response** characterises how key teams individually respond to the disruption on a scale that includes behavioural outcomes such as panicking and seeking external support. These responses then drive the **organisational behaviour**, and ultimately the **organisational impact** – what happens to the service or capability that the system is delivering.

Development and validation

Development of the HFRF is ongoing. It was originally developed through a subject matter expert workshop and literature review. Subsequently it has been further developed and validated through a variety of methods including case study analysis and experimentation. One of the validation experiments is described below.

Air traffic control experiment

One of the experiments we have carried out using the HFRF was based on an air traffic control (ATC) task. Sixteen teams of three people carried out a group task that required them to maintain an accurate air picture. Two of the participants were given the role of radar operator and had to track aircraft on their computer display. The radar operatives only saw half of the overall air picture. They had to communicate what they saw to the third participant, the team leader, who had to construct a single consolidated air picture based on the information provided. The participants could only see their own computer screens. The team leader was also responsible for setting status markers to indicate whether they thought their team was delivering a sufficiently accurate picture of the airspace on which to base traffic-directing decisions. Figure 2 gives a visual schematic of the experiment setup.

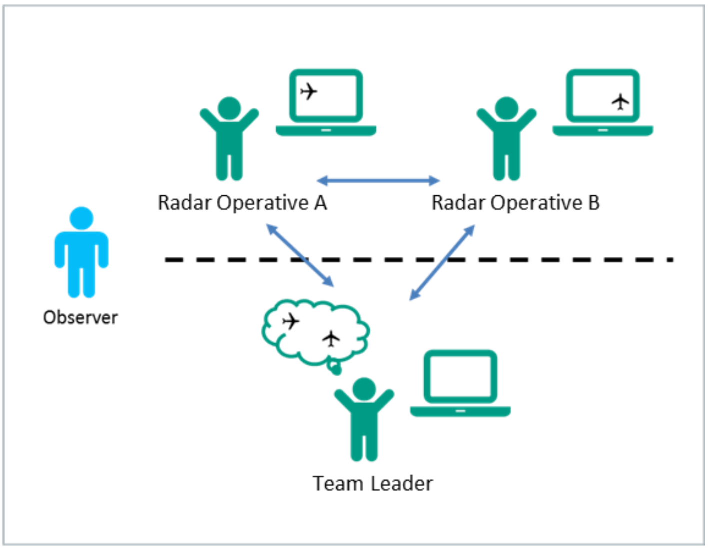

Figure 2: A schematic of the ATC experiment setup

There were various aids and equipment available to the participants, including backup procedures, whiteboards, and a telephone to use to contact technical support (run by the experiment team). Teams were randomly allocated to one of two communication styles and one of two human-machine interface setups. Each team had two one-hour long runs of the task and encountered a different (counterbalanced) system disruption on each run. One of the disruptions simulated a supporting information feed failing to update for a period of three minutes, the other simulated a computer freeze which blurred the computer screen and required a hard reset of the equipment to restore functionality.

The ATC experiment provided valuable data on system recovery times, information flow between personnel, and approach to developing recovery strategies.

Early predictive validity

One of the features of the HFRF is a mechanism to aggregate the individual and organisational factors that can have an impact on how people will understand and respond to the situation. The mechanism the HFRF uses is an adaptation of Hollnagel's (1998) cognitive control mode (CCM). The adapted CCM, like the original, places people and teams within a decision-making space, which has regions for strategic, tactical, opportunistic, and scrambled cognitive control modes.

A retrospective exploratory analysis of the ATC experiment was conducted to check the predictive validity of the new CCM mechanism. Each participant team from the experiment were categorised according to a set of HFRF factors aligned to the original CCM's inputs. This created four ranked groups. Each group's mean performance at maintaining an accurate air space picture was then plotted (see Figure 3). The system disruption occurred early on in the session for each team and is marked in Figure 3 with a red line.

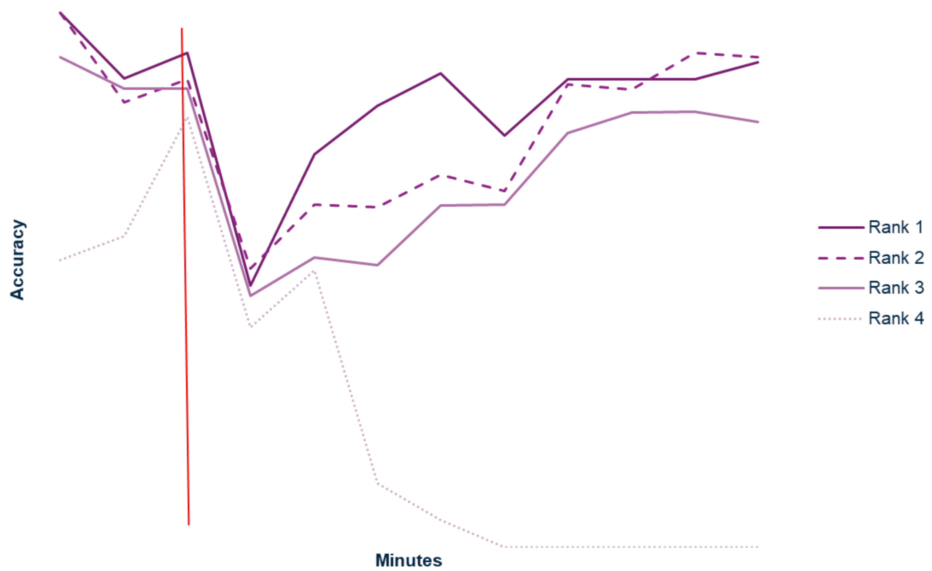

Figure 3: Air picture accuracy over time for groups of teams categorised by their predicted CCM

The figure shows that the predicted CCM rank ordering reflects the recovery curves of the teams. Unfortunately, we cannot draw significant conclusions from the outcome of this retrospective analysis, because the experiment was not designed to test the validity of the new approach. Even if it had been, the size of some of the resulting treatment groups is not sufficient to support a robust statistical evaluation of the relevant hypotheses. However, the results are highly suggestive that with a few simple criteria we can predict recovery outcomes between groups, which provides strong grounds for carrying out a follow up experiment to verify the finding.

Discussion

The HFRF has been developed to support analysis and thinking around system resilience. Its focus is on the people involved in the system, and whether and how they can detect, consider, and effectively respond to a disruption to the overall system of which they are a part. Recent work on the HFRF has been aimed at supporting analyses when only relatively sparse data is available, and equipping analysts with supporting guidance to be able to carry out an analysis with limited human factors expertise. Future research efforts will be focused on providing automation aids to analysts, including remote assessment of an organisation's resilience.

Acknowledgements

The work described in this paper was funded by DSTL and would not have been possible without the support of David Ball. Other people have contributed to the HFRF research programme in various ways over the years, and as such I would also like to thank Stephanie Appleyard, Darryl Croft, Victoria Doherty, Sonny Gates, Gemma Huddy, Karen Newell, Barney Petit, Hannah State-Davey, William Twiney and Rachael Way.

References

British Standards Institution. (2014). BSi 65000:2014 Guidance on Organisational Resilience. BSI Standards Publication.

Hollnagel, E. (1998). Cognitive Reliability and Error Analysis Method. Elsevier.

Westrum, R. (2012). A Typology of Resilience Situations. In Hollnagel, Woods, and Leveson (Eds.) Resilience Engineering: Concepts and Precepts. Ashgate.