OBSERVING RESILIENCE: AIR TRAFFIC CONTROL CENTRE CONTRIBUTION TO EVERYDAY OPERATIONS

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Abstract

The paper proposes a concrete approach for observing resilience in practice translating the theoretical achievements (e.g. resilience themes and principles) into practical supporting material (i.e. a resilience observation sheet). This material is integrated in a high level experiment protocol for observing resilience through direct observations. In this perspective, resilience is an embedded feature of the system under analysis that should be taken into account in observing humans while they perform daily activities. If resilience belongs to the system, it is a part of it and evolves over time according to several elements and their combination. A deeper understanding and analysis of how humans can manage and adapt in a flexible manner to continue everyday operations is needed. Therefore, it is necessary to identify some practical indicators which can be used as early warnings to diagnose the system status and act timely in order to anticipate and prevent negative outcomes. Accordingly, the suggested protocol is exemplified through its practical application in an operational Air Traffic Control Centre (ATC) everyday activity, the missed approach procedure.

1 INTRODUCTION

As recognised by Theory Z (Hollnagel, 2008), Resilience Engineering (RE) aims at maintaining or improving safety looking at what goes right, as well as on what should have gone right. Theories, models, and methods aim to describe how things go right, but sometimes fail, and how humans and organisations cope with internal and external intractability and unpredictability. In this perspective, Socio-Technical Systems (i.e. an Air Traffic Control Centre which belongs to this class as it encompasses complex interactions involving humans and machines deeply influenced by environmental/organisational aspects) are considered safe and efficient. But a contributing factor to this is that humans learn to overcome the inevitable shortcomings, can adjust their performance to meet the actual demands of a situation, can interpret procedures and apply them to suit actual conditions, can detect when something fails or goes wrong, and can in many cases correct for it as well.

Consequently, humans play a preeminent role which requires further investigation in order to enable users to perform their everyday activities efficiently and effectively. However, due to the complex nature of a STS, task performance may be affected by an inborn variability. This is both normal and necessary and is the source of positive and negative outcomes – successes and failures – alike.

While some adverse events can be attributed to component malfunctions, others arise from unexpected combinations and/or non-linear interactions among normal performance variability of everyday activities. In order to prevent negative outcomes, an identification of the situations where normal performance variability may combine to create unwanted effects and to monitor continuously the status of the STS is needed.

Observing the users in everyday activities can support in identifying some indicators for detecting unwanted effects timely and in using these indicators as early warnings for monitoring the status of the system proactively.

This paper proposes an approach for accomplishing direct observations in an ATC centre during everyday operations. These observations can support in envisioning and detecting some resilience indicators related to performance variability of everyday activities (i.e. a missed approach performed through a go-around manoeuvre). These can be used for understanding the status of the system and to act timely. Due to the fact that an ATC centre can be considered a Socio-Technical System, these indicators cannot be isolated. But for the complex nature of the system under study, resilience indicators are interconnected. For this reason and for better understanding their role and interconnections, they are organised in patterns. Hence, a resilience pattern is a collection of resilience indicators. The patterns are constructed on the basis of current Resilience Engineering concepts as well as findings from the case studies investigated in the SCALES project (Herrera et al., 2014).

This paper outlines the suggested approach, its application through direct observations in an ATC and discusses preliminary findings regarding resilience in practice in terms of indicators and patterns. It starts with a short description of the protocol for observing resilience. Then, it introduces an everyday activity performed by Air Traffic Controllers (ATCOs), namely the missed approach procedure performed through a go-around manoeuvre. After, the protocol is further explained and applied to this case. Finally, results from this application are presented and discussed. The discussion reflects on added knowledge to identify resilience in practice and in daily activities, theoretical and practical implications.

2 OBSERVING RESILIENCE: A PROTOCOL

The ethnographic approach (Blomberg & Burrell, 2009) emphasises the understanding of behaviour in context through the participation of the investigator in the situation being studied as an observer of the team of users involved in the situation. Direct observation is a non-intrusive technique which allows participants to do what they normally do without being disturbed by the observer that is a "silent" actor "in situ".

This qualitative research answers questions about the complex nature of phenomena, with the purpose of describing and understanding the phenomena from the participants' point of view. Accordingly, multiple methods of data collection may be employed: video- and audio-recording, interviews, and surveys.

During direct observation, commonly the observer is sitting passively and recording as accurately as possible what is going on such as the behaviour of one or more persons, their interactions and the ones with different kind of artefacts. The observation is often supported by grids and guidelines to identify and capture relevant aspects/issues to be recorded.

Once having completed the observation, the observer provides a report, utilising a range of approaches, mainly informal interviews/debriefings and qualitative and quantitative analyses of the gathered information.

In order to properly conduct direct observations, this paper suggests a high-level experiment protocol consisting of several steps. It can be adapted according to objectives and observers' needs as well as supporting materials.

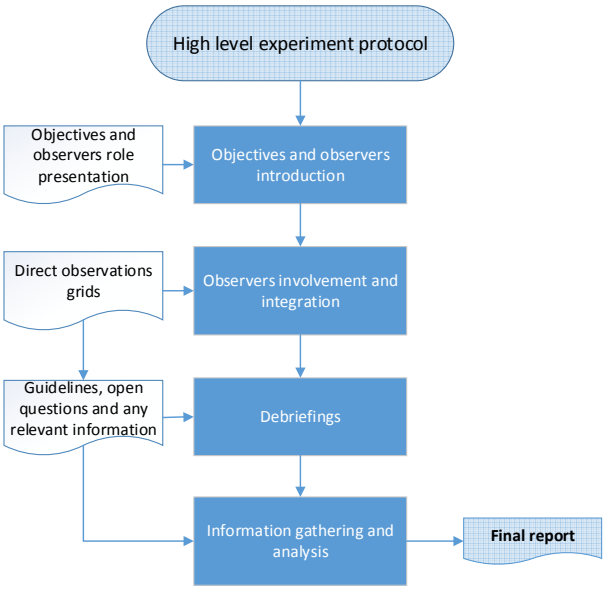

Figure 1. *High-level experiment protocol steps, supporting materials and output*

3 OBSERVING RESILIENCE IN PRACTICE: THE PROTOCOL APPLICATION

This protocol is exemplified through its practical application in an operational ATC everyday activity, the missed approach. It is a procedure followed by a pilot when an instrument approach cannot be completed to a full-stop landing (FAA, 2013). This must be flown in accordance with the published procedure stated for each runway or following the Air Traffic Control Operator (ATCO) instructions prior to the clearance for the approach. However, if the pilot believes that a missed approach may occur, s/he can make a specific request to ATCO including heading and altitude instructions to avoid in-flight delays and efficiently manoeuvre the aircraft into position for either its next approach, or a diversion to an alternate airport. Missed approach is a common operation but it involves many elements that should be taken into account and managed

simultaneously (Herrera et al., 2014a). For this reason, its development and outcome can be unexpected.

Through an extensive literature review and workshops with operational staff, several ATC elements which can contribute to the outcome of the operation have been identified and organised as follows[1]:

1. "COMmunication between pilots and ATCOs" (COM) consisting of:
    a. updating relevant information,
    b. the timing of issuing instructions,
    c. the language used.
2. "Management and Control of aircraft" (MC) which includes:
    a. separation and spacing,
    b. stabilised approaches,
    c. vectoring, etc.
3. "Design of Procedures and airspace" (DP) which consists of
    a. the degree of complexity,
    b. potential traps, etc.
4. "Awareness" (A) which includes
    a. information analyses,
    b. sharing information, etc.

These can be used as clues for guiding the observer while is performing her/his task and in filling the "Observation sheet"[2] (Fig.2). Indeed, they are reported in the sheet as "Topics of Interest". In the excerpt (on the right of the Fig.2), an example of the "Observation sheet" filled in.

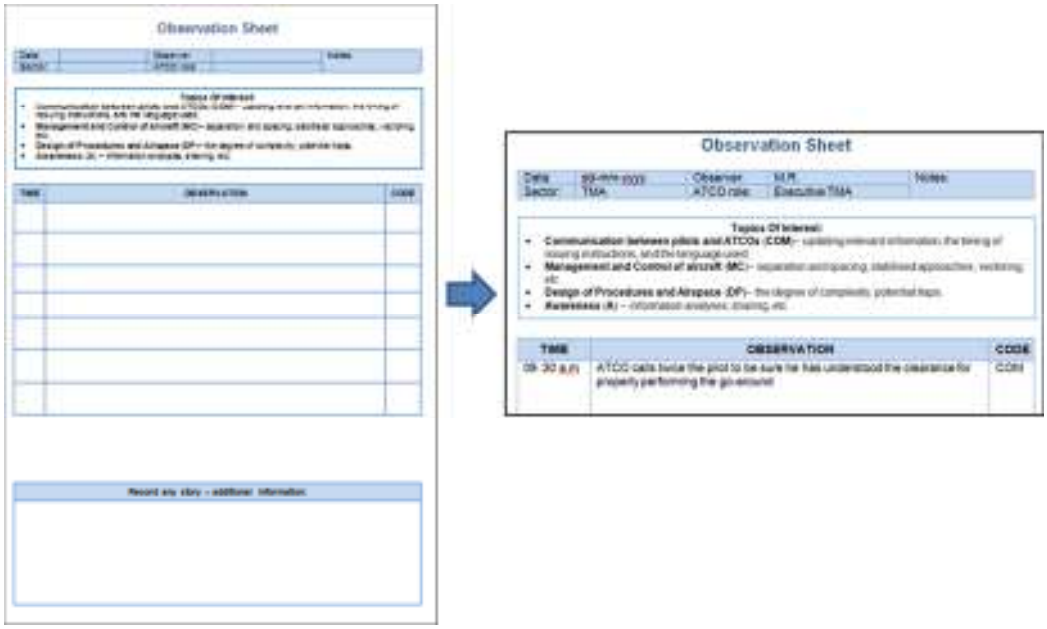

Figure 2. *On the left – "Observation sheet" for collecting information during direct observations – On the right, an excerpt of the "Observation sheet" filled in.*

[1] Due to space constraints the four main categories and correspondent ATC elements are just briefly summarised.

[2] Please note that this observation sheet is made for personnel involved in the SCALES project mapping ATC contributions to everyday operations

This sheet is the supporting material for the second step of the protocol. It helps in capture everyday operations, adaptations, ATC contributing elements, in documenting actions performed by controllers exploring individual, technical and organizational context and stories to illustrate how ATC services are delivered in practice.

Stories are important as a way to expand technical understanding of the behaviour of the ATC e.g. about how unusual things have happened and how the ATC deals with these (adapted from Hayes, 2013).

Once the observation session is ended, the observer can use the "Observation Sheet – Resilience themes & principles mapped to everyday operations" (Fig. 3) as guideline for setting up and leading the conversation during the debriefing in order to further explore the relevant insights with the controllers involved in the operations.

Thanks to the controllers and the observer collaboration, information can be structured and analysed in the RE perspective. Indeed, the sheet offers a preliminary resilience overview consisting of the four main capabilities, that are "Monitor", "Anticipate", "Respond", and "Learn", and boxes where some resilience patterns are further detailed into resilience indicators (Herrera et al. incoming).

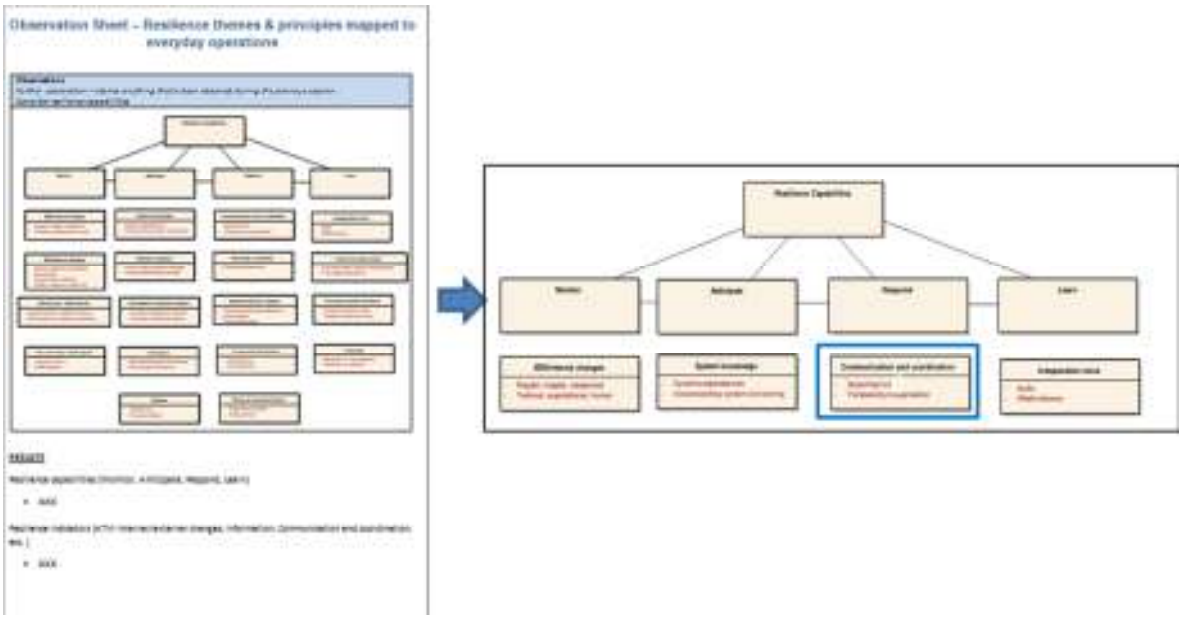

Figure 3. *On the left, "Observation Sheet – Resilience themes & principles mapped to everyday operations" for debriefing sessions – On the right, an excerpt of the sheet filled in.*

Through this sheet, the recorded ATC contributing elements can be translated into some resilience patterns/indicators. Indeed, the ATC contributing element identified during the observation, "ATCO calls twice the pilot to be sure he has understood the clearance for properly performing the go-around – CODE: COM" (see excerpt in Fig. 2), it is translated into an indicator belonging to "Communication and coordination" (as highlighted by blue box in the excerpt in Fig. 3). However, it can play a role in other linked patterns of the sheet, such as "Cross-scale interactions" and "Timing and synchronization".

Consequently, once the recorded ATC contributing elements have been translated into some resilience patterns/indicators, they can be linked between them and with the capabilities. The drawn connections cause for reflection on interrelations, impacts and performance variability.

Through this illustrative example, we have explained in detail as the protocol and the supporting material described in "2 OBSERVING RESILIENCE: A PROTOCOL" can be applied in practice.

Fig. 4 shows the protocol in use, the supporting material needed for each step and the related output.

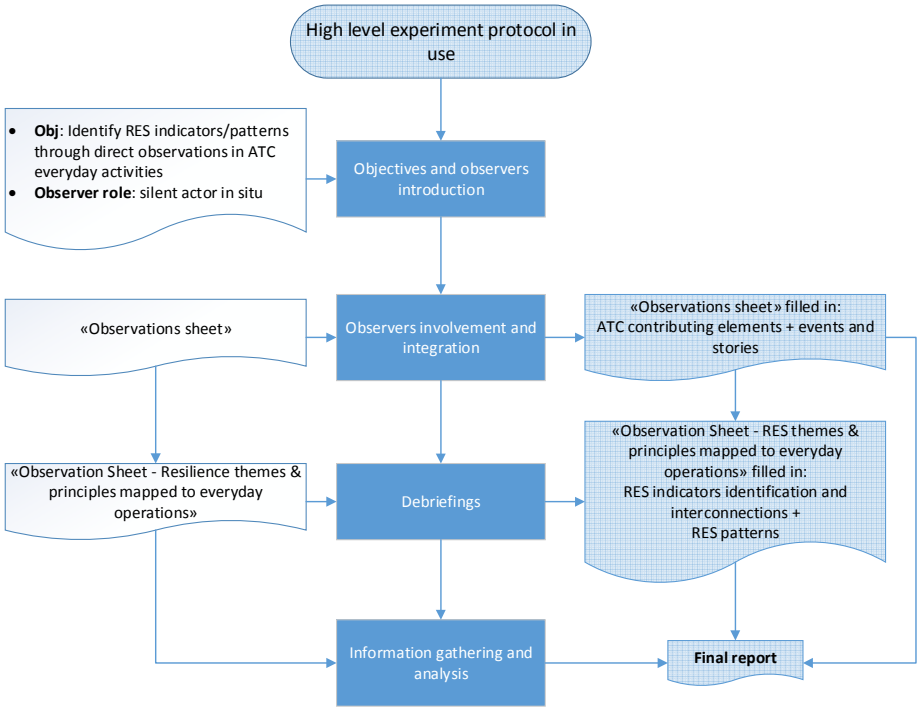

Figure 4. *High-level experiment protocol in use, supporting materials and outputs*

3 PRELIMINARY FINDINGS AND NEXT STEPS

This paper has presented a protocol for observing resilience in practice through direct observations of everyday activities. This has been thoroughly applied on the missed approach procedure, in particular on the go-around manoeuvre. The protocol and the supporting material presented in the paper represent a first step and the results are preliminary. However, from their application in the SCALES project, we conclude that they add significant value when observing resilience in daily activities and to promote a proactive approach.

Nowadays managing resilience is the result of lessons learnt from the past and their adaptation to todays' needs. Be adaptable and act proactively means to deal with the Socio-Technical Systems inborn performance variability. This requires not only speculative effort but also a practical, concrete and daily commitment in order to maintain and improve safety looking at what goes right and at what should have gone right. Theories, models, and methods aim to describe how things go right, but sometimes fail, and how to cope with intractability and unpredictability.

Direct observations can support in understanding how humans behave for adapting and dealing with situations where normal performance variability may combine to create unwanted effects.

In addition, the approach stimulates exchange of knowledge promoting the collaboration between operational staff and scientific community. The different perspectives offered by these complementary stakeholders can ensure a complete and concrete view of the system under analysis. Moreover, this fertile collaboration can support in identifying and analysing resilience patterns and related indicators. These can be used as early warnings to understand the status of the system and act timely in order to anticipate and prevent negative outcomes.

The proposed approach and these preliminary patterns/indicators can be used as example for continuing Resilience Engineering research in everyday activities in order to improve both these preliminary findings but also to investigate other ones.

Currently, the protocol has been applied only in the Air Traffic Management domain for observing resilience in different ATCs such as Fiumicino (FCO) and Ciampino (CIA) in Italy and Trondheim-Værnes (TRD) in Norway. However, thanks to its flexibility and customization, it can be adopted in different application domains.

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