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# Situational awareness as an instructable and instructed matter in multi-media supported debriefing: a case study from aviation

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**Abstract** Debriefing is an important practice for learning from experience especially in high-risk industries, including the medical field and aviation. Although it might be assumed that tools aiding in representing the events to be debriefed will improve the learning outcomes, meta-analytic studies appear to show that there is no advantage to debriefing sessions that use videos. Simultaneously, such meta-analytic studies are calling for process-related investigations of debriefing generally and those focusing on representational tools more specifically. In this study, we provide an exemplary interaction analysis of debriefing meetings in aviation that immediately follow 4-hour examination sessions. We examine how situational awareness—a crucial feature of aircraft piloting performance—becomes an instructable and instructed matter in and through the meetings. We exhibit the anchoring role of the tool, the opportunities for distinguishing knowledge from performance components, and the opportunities for anchoring third-person perspectives of performance to embodied knowing.

**Keywords** Tool mediation · Situational awareness · Debriefing · Technology-rich workplace · Learning · Embodiment · Re-presentation · Memory

## 1. Introduction

> I was the flying pilot . . . where the normal uptrim and autofeather didn't work. I knew it hadn't autofeathered but I had no idea the engines hadn't spooled up properly. I never realized until we were shown on that [debriefing tool] . . . So it just highlights to me how [we], as the crew, are not going to be able pick up all the events. (Experienced airline captain after debriefing of a simulator-based examination)

Successful performance in high-risk workplace environments—e.g., military, surgery, or aviation—depends upon agents being aware of crucial situational aspects, which in the fields of aviation and human factors is known as *situation(al) awareness* (SA). Broadly defined as "knowing what is going on around you" (Endsley 2000 p. 4), situation(al) awareness is a core category in both civil and military pilot performance evaluation (Gilson et al. 1994), and in the contexts of health and safety in the workplace (HSE 2012). The notion has also been influential in CSCW literature, where staying aware of others and of changes in the working environment during cooperation is a central concern (Dourish and Bellotti 1992; Gutwin and Greenberg 2002; Kolfschoten et al. 2013; Ley et al. 2014). In CSCW, as in aviation, research has mostly focused on whether and how designed systems—e.g., by drawing on tools such as spreadsheets (Ginige et al. 2014), whiteboards (Heard et al. 2014), or smartphones (Strauss et al. 2010) for information sharing—facilitate SA, but not so much on how agents are instructed and prepared for SA in future performance. Yet, given that loss of situational awareness constitutes one of the main causes of aircraft accidents (Jones and Endsley 1996), understanding how training and assessment situations prepare operators for future performance in high-risk workplaces is important to further ensure safety.

In this study, we investigate the joint work that it takes to make situational awareness an *instructable* matter during multimedia-supported *debriefing* in aviation—where we take instructable to mean that situational awareness becomes something that participants in social interaction work out locally and with the resources at their hand (Koschmann and Derry in press; Zemel and Koschmann 2014). Situational awareness as an instructable and instructional matter is of particular salience in the light of contentions that the concept is part of a folk model, and in the light of an alternative focus on human performance (Dekker and Hollnagel 2004). The question then is not whether SA exists out there as a natural object but whether important aspects of job performance can be and are taught when SA is worked out locally and contingently as the topic of instructional situations such as debriefing.

Debriefing the performance of agents who have participated in complex and often dangerous or high-risk workplace environments is a common practice designed to lead to learning from experience for the purpose of improving future performances in high-risk circumstances. Although there is a long history of debriefing practice, the amount of peer-reviewed literature on how to debrief, how to learn/teach to debrief, and how effective debriefing practices look like actually is minimal (Fanning and Gaba 2007). Virtually unstudied is a phenomenon that we observe in aviation, where pilots undergo two 2-day examinations per year, with debriefing meetings at the end of each day. In these meetings, issues of awareness emerge in a retrospective manner: Pilots generally come out of the (simulator-based) examinations fatigued, often failing to remember what they have done during the preceding 4-hour examination session. As the introductory quotation shows, even the most experienced pilots may fail to notice the presence of only some (autofeather) but not other important malfunctions, such as the uptrim failure of the live engine (i.e., it had failed to increase thrust and supply the aircraft with maximum power). Thus, according to the assessment metric of the pilot's airline, they "missed some minor systems . . . factors [possibly] not critical to flight safety" or even "lacked awareness of clearly obvious systems . . . factors." Such failures to remember preceding experiences or aspects of the events that they had never been aware of are decisive to what and how agents (here pilots) can learn from their experiences. How is situational awareness during actual performance recovered during debriefing situations and becomes an instructional and indeed instructable matter?

This article is significant in the light of a 2013 accident involving Lao Airlines Flight QV 301 using the same aircraft type as our airline. The flight had crashed into the Mekong River killing all 49 people onboard after some erratic maneuvers of the aircraft. The crew was apparently unaware of the fact that the aircraft had descended to 60 feet altitude and then suddenly made the aircraft steeply rise to 1,750 feet only to descend again until it clipped trees and fell into the river. The Summary of Final Report states among probable causes the crew's failure to properly execute the landing procedure, including among the factors *the inadequate monitoring of primary flight parameters* during the approach, tunneling of attention, and limited coordination of action plans (AAIC, 2014). These all are indications that the crew had lost situational awareness. In another recent crash on the same aircraft type, the pilots of TransAsia Flight GE 235, after shutting down one engine following the same problem that is at the heart of the present study—engine flame out after takeoff—also turned off the second engine (ASC, 2015). Whereas the final accident report still has to be published, the pilots apparently were unaware of the present situation when deciding to shut of their live, operating engine. In this study, we show how *situational awareness*, though hotly debated in the academic literature as to its usefulness and precise definition, *practically already is an instructed and, therefore, an instructable matter*.

We begin the paper reviewing literature that distinguishes SA as product or state from the processes by means of which SA is achieved, and characterize SA as involving the social organization of relevance during cooperation. We then move from discussing SA as a situational achievement to discuss it as an instructional matter, reviewing literature on debriefing and the role of multimedia. Taking an ethnomethodological stance, we then provide a detailed analysis of one episode of debriefing where a loss of situational awareness during a previous simulated flight is recovered, assessed, and turned into an instructional matter with the help of a multimedia debriefing tool. Our analyses describe the transactional work performed to achieve the instructional character of the setting, which includes bringing particular relations between details so as to constitute contexts of relevance. We discuss the findings in terms of (a) the instructability of situational awareness and (b) affordances of multimedia displays for debriefing situational awareness. Suggestions for practical implications conclude the study.

## 2. Background

### 2.1. Situational awareness, formal descriptions, and the social organization of relevance

Situational awareness is a notion that has had an important presence in the human factors fields, and which has particular relevance to professional fields including, among others, aviation (piloting and air traffic control), weather services, aerospace operations, and emergency management systems (Gilson et al. 1994). In these settings, situational awareness is related to the competence of operating a complex system. Situational awareness has also been influential in the CSCW community, where the notion of *awareness* was defined as "an understanding of the activities of others, which provides a context for your own activity" (Dourish and Bellotti 1992 p. 107) and has become a major field of research. The situational awareness in an aircraft includes awareness of the operational parameters (Endsley 1994). Consistent with the author's characterization of the role of SA in pilot decision-making, the evaluation category *situational awareness* in our cooperating airline consists of the three subcategories perception, comprehension, and projection. That is, situational awareness implies that the pilots not only gaze at and perceive readily available flight-relevant system factors but also comprehend what is perceived and project into the future (Endsley 1994).

An important distinction is made between situational awareness as a product as opposed to as being a process. As a product, situational awareness is seen as an achievement that involves other processes, which, because they are of a different logical type, are not themselves termed or part of situation awareness (Endsley 1995). As a state, there is agreement regarding what situational awareness means in any given context. Thus, although complex and depending on a myriad of interdependent variables in its actual accomplishment, the task of safely piloting an aircraft is very well defined in its formal articulation. Years of experience have served to develop normal operating procedures and flight crew training manuals that specify system states that need to be monitored and understood by the human operators. In our study, for example, what the pilot monitoring has to do following the recognition of an "Engine flameout" and the canceling of the master warning is described in Section 6 of our participant airline's emergency procedures.

> Check live engine **UP TRIM**
> Announce "**ENG [x] uptrim".**
> Check failed engine **AUTO FTR**
> Announce **"ENG [x] auto feather".**
> Check ENG 1 BLEED and ENG 2 BLEED fault lights illuminated
> Check PACK VALVE 1 + 2 fault lights illuminated
> Announce **"Bleed and pack fault lights".**

Fig. 1. The flow pattern (kinetic melody) of attention required for the cockpit to maintain situational awareness. (Photograph courtesy Wolff-Michael Roth)

In the aircraft manufacturer's flight crew training manual, procedures are often accompanied by flow patterns—also kinetic melodies (Roth et al. 2015)—depicted in diagrammatic form over representations of the cockpit display as in Fig. 1. Thus, the engine flameout emergency procedure would involve a flow of operations to achieve attentional awareness, beginning with the torque gauges (Fig. 1, 1) to Np gauges (Fig. 1, 2) and then up to the overhead panel where the bleed (Fig. 1, 3) and pack fault lights (Fig. 1, 4) are found. Situational awareness is also a formal category in the airline's assessment form that rates the degrees to which a pilot *perceives* and *comprehends* systems factors. Importantly, these procedures and manuals do not accomplish an organizing function by sitting on some bookshelf, but become functional as part of large and complex infrastructures of standardized practices that involve different actors and organizations. Moreover, although in the example provided it might appear as if relevance was spatially organized for the pilot monitoring (PM) alone, maintaining the cockpit kinetic melody (flow) means that the announcement also needs to be heard by the pilot flying (PF). Rather than concerning individuals, SA in the cockpit most often is a cooperative achievement, and is always locally accomplished. In fact, the debriefing sessions that we examine in this study are but part of the way human cooperation is organized in *high reliability organizations* (Wilson et al. 2005) to ensure that these formal and detailed descriptions of how to safely operate an aircraft become instantiated in actual performance during future situations.

There is an ongoing debate about the concept of SA, as shown in a recent special issue of *Cognition, Technology and Work* (Carsten and Vanderhaegen 2015). Some scholars argue that the concept inappropriately turns the focus on the individual blamed in the case of accidents (e.g. Dekker 2015). Others argue that its current imperfections can be improved and that it is useful to understand collective situation awareness (e.g. Millot 2015). Others again, while agreeing with Dekker, suggest that of real theoretical and empirical interest is the SA of the system as a whole, which, in our situation, consists of pilots and the cockpit (Salmon et al. 2015).

In this study, however, we are concerned with the *social* processes that lead to the achievement of situational awareness of the cockpit as a joint cognitive system (Henriqsen et al. 2010; Roth et al. 2015). Such an endeavor has its rationale in the cognitive systems engineering literature, which led to a shift from attention on psychological factors in human computer interaction to a systemic perspective on cognitive processes, which are distributed throughout the system and irreducible to human factors (Hollnagel and Woods 2005). With respect to flying an aircraft, the cockpit is such a joint cognitive system (Henriqsen et al. 2011; Hutchins 1995). In the cockpit, the coordination of flow patterns is associated with the social specification of relevance: the cockpit as a whole has to achieve and exhibit situational awareness. Discoordination arises within the cockpit when system parameters are made salient that are not relevant to the overall flow pattern or when required system parameters are missing (Roth et al. 2015). Thus, in this study, we take situational awareness to be the state of being aware of flight-relevant phenomena; the maintenance of this state requires the joint work of the cockpit as a whole. On the part of the pilots, this includes the communicative aspects of work. We analyze below a debriefing meeting in which SA is taken not in the academic sense—where the concept and its substance continue to be debated—but in its mundane sense: as joint awareness of flight-relevant parameters, which can be achieved through bodily (e.g., deliberate pointing gestures as resources for self and other) and communicative work. The central point of this study and its contribution to the existing literature is that the performances associated with the maintenance of joint situational awareness not only are instructable but also are observed, here, in actual debriefing meetings.

## 2.2. Debriefing as an instructional site

In this study, we examine how SA becomes the subject matter of assessment and instruction during multi-media supported debriefing situations in the field of aviation. Debriefing has increasingly been adopted in training and work environments as a means of learning from experience. Although there is a long history of debriefing practice, the amount of peer-reviewed literature on how to debrief, how to learn/teach to debrief, and how effective debriefing practices look like actually is minimal (Fanning and Gaba 2007). Meta-studies investigating the efficacy of debriefs have found a positive effect on individual and team performance (Tannenbaum and Cerasoli 2013). However, these same studies point out that there is a need to "further refine our understanding of why [debriefs] work and how best to deploy them" (p. 242). Even those studies that had been investigating the interactions, coding such dimensions as the nature of issues (e.g., technical versus non-technical [CRM] human factors) end up suggesting the need for understanding debriefing practices in detail, a lack of knowledge about debriefing processes, and how the division of labor mediates processes and outcomes of debriefing meetings (e.g. Dieckmann et al. 2009).

A lack of attention to the details of how the local organization of debriefing unfolds is also a limitation in studies looking at the role of multimedia tools. Although there are studies and meta-analyses on the role of video recordings and multimedia aids during debriefing for technology-enhanced simulation (Cheng et al. 2014; Tannenbaum and Cerasoli 2013), these tend to focus on measurable effects—which have been negligible—without investigating the changes that arise from the inclusion of multimedia within the human-human-technology transactions to make sense of collaborative work situations. In particular, these studies encourage research investigating "when video should be used" and "how discussion should be structured around video" (Cheng et al. 2014 p. 662) for the purpose of identifying the debriefing processes that bring about, versus those that do not, the enhancement of learning.

Existing studies of interaction tend to investigate debriefing in formal educational settings where learners, participating directly or vicariously in (medical, dental) operations, come to perceive relevant objects in the manner experienced practitioners already do (e.g., Koschmann et al. 2011; Lindwall and Lymer 2014; Sanchez et al. 2009). In one study, additional visualization was made possible when researchers attached a camera to a surgical microscope during a dental procedure (Rystedt et al. 2013). The camera offered a close-up into the procedures that the dentist carried out within the mouth. Because the learners were provided with a view through the eyes of the dentist, they could make sense of the instructors' clinical reasoning in situ. This provided them with the context required for understanding dental procedures. That is, formal aspects of professional practice were made visible and, thereby, could be made relevant in and through the practical performances that take place in the multimedia-supported instructional setting.

Studies that are taking a closer look at what happens in the debriefing, using methods such as conversation analysis, highlight that there are different foci that may arise in such meetings, including those related to the practices themselves (technical issues of the field and non-technical issues pertaining to interactions) and those related to the interface (Rystedt and Lindwall 2004). Our ongoing research of debriefing shows that interface issues never crop up and that the meetings are entirely focused on both technical and non-technical performance aspects. This is so because recent models of performance in aviation theorize technical and non-technical skills required to competently operate an aircraft separately (Flin et al. 2003) or as interacting in holistic models (Mavin and Roth 2014). Where appropriate, flight examiners introduce relevant performance dimensions as topic of discussion during debriefing. The dimension falls into the technical realm (i.e., *aircraft knowledge*) when a pilot, for example, does not know what an engine instrument should read when the propellers of a failed engine do not align with the flight path; the dimension falls into the non-technical dimension of situational awareness when a pilot failed to be aware of the instrument reading. Flight examiners point out that one of the purposes of the debriefing meeting is to find out the root cause for a performance problem, because their advice for professional development or recommendations for training will differ accordingly. This research and evidence thus further suggest that formal prescriptions of professional performance, such as those described in manuals, and actual forms of perceptually and conceptually structuring professional settings, are in reflexive relation to each other where assessment and instruction are concerned.

Given the centrality of the locally contingent bodily and discursive work that goes on during debriefing to achieve professional ways of organizing actual operation (Roth 2015), multimedia tools might be important resources for approaching SA as an instructable matter during debriefing. Our own work shows that after a 4-hour session in the simulator, the examined pilots often remember very little, especially very few of the details of the preceding scenarios and events. As the introductory quotation shows, even the most experienced pilots, themselves flight examiners for many years, may be unaware of what has happened or what the instrument readings had been. In such instances, and despite research finding no "effects" from using multi-media tools (e.g., Tannenbaum and Cerasoli 2013), debriefing without tools that afford the making present of past experience might be inefficient precisely because the pilots are unable to recall those aspects that need to be debriefed so that learning can occur. Without such supporting devices, as our ethnographic data from airlines without a debriefing tool show, pilots may remain unconvinced that the flight examiners' accounts do indeed describe what had happened in the simulator.

## 3. Research design

The aim of this study is to investigate the joint work that it takes to make situational awareness an *instructable* matter during multimedia-supported *debriefing* in aviation. As discussed above, we approach SA as a social achievement in which relations of relevance between different aspects in a given operational setting are established according to given operating standards. From this view, understanding how SA becomes an instructable matter in debriefing involves examining how relations of relevance emerge *in* the debriefing setting for preparing operators, here pilots, to achieve SA in future performance *in* the real settings, and how multimedia tools become an organizing resource for such achievements. This study is part of a research program designed to investigate the practices of debriefing and the role a variety of tools in mediating the exchanges between pilots and flight examiner. In this ongoing program, the debriefing meetings from five airlines from two countries of the southern hemisphere are recorded. At the time of this writing, our database contains the videotapes of 37 meetings, 25 of which employed the *debriefing tool* of interest in the present study.

## 3.1. Participants

The participants are practicing pilots with considerable aviation experience, including those who currently undergo type-rating training, that is, who are trained to fly the aircraft that their employer uses. A total of 46 pilots (43 male, 3 female) in training or under evaluation participated so far in the research program (7 pilots in training, 17 first officers, 16 captains, and 6 captains with flight examiner status). There were 16 flight examiner/trainers, 5 of whom also had been examined as part of the pilot group. The participants, aged 27–62 years, had commercial flight experience ranging from 1,200 to 24,000 flight hours, having been employed as commercial pilots from 4 to 45 years. For the purpose of this study, we selected an episode from the debriefing meeting involving very experienced pilots. This selection makes apparent that phenomena that might be attributed to exchanges with inexperienced pilots are in fact in play with very senior pilots as well. The flight examiner involved (47 years) has had 15 years of experience as commercial pilot, a total of 10,000 hours of flight, and 7 years of experience as flight examiner. The captain (43 years), who is flying in the role of *pilot monitoring*, has 15 years of experience as commercial pilot with a total of 7,000 flight hours, and has been in this rank for 5 years. The second pilot in the cockpit (48 years), who is flying in the first officer's seat, actually is a flight examiner and training manager with 28 years of experience (9 as flight examiner), and a total of 8,500 flight hours.

Ethics approval was obtained from the companies, labor unions, and standard institutional review boards. This was necessary because of the confidential nature of the simulator sessions and debriefing meetings, and the normally enacted destruction of all recordings. The invitation letter to potential participants included a guarantee that their non/participation would not affect employment; participation could be terminated at any time with removal of all data pertaining to the person. Separate consent was obtained for the use of images featuring the participants.

## 3.2. The episode and the scenario

Debriefing occurs in the context of the two annual examinations that pilots have to undergo for recertification. Each examination session tends to take place over a two-day period, including a 1-hour brief, 4 hours of flying in a simulator, and 1 hour of debriefing. During the examination, the pilots are confronted with "non-normals," that is, flight situations that they would not normally encounter as part of their everyday routine, and, in some cases, never actually do encounter. Nevertheless, the pilots must pass the examinations to be able to continue flying. Not passing leads to retraining, and repeated failure will lead to dismissal. That is, the examinations involve high stakes, and pilots tend to be quite apprehensive.

During the debriefing meetings, flight examiners tend to invite pilots to talk about what is standing out for them from the preceding 4-hour simulator session, where they had performed well, and where they felt their performance could be improved. However, very little and especially very little detail tends to come forth, because (a) so much had happened in a packed sequence of exercises and (b) the pilots tend to be exhausted. Flight examiners then tend to go through the entire session, talking about specific events, highlighting both positive aspects and problematic issues. When the airlines do not have a debriefing tool available, talk is the principal means to make the events present again, though the participants tend to rely on the flight examiners' accounts. When the debriefing tool is available, then flight examiners tend to select 3–5 events for replay on a large monitor at one end of the table that separates them from the pilots (Fig. 2), whereas other events are only talked about. Pilots often do not remember, or, in fact, cannot remember what happened because many aspects never had been in their conscious awareness while flying. This also is the case in the selected episode. Both pilots walked away from the debriefing meeting with the sense that they had learned. Thus, the pilot in the monitoring role noted, "That was really good, to actually see it." The significance of the event from the perspective of the pilot who was flying is apparent in the introductory quotation.

Fig. 2. The arrangement of pilots (left) generally taking the same relative seating that they had in the aircraft, flight examiner (right), and debriefing tool.

The flight examiner introduced a new topic by naming the event, an engine flame out right after takeoff. Both pilots had suggested during the interview following the simulator session and preceding the debriefing that this event might become a topic. Following the debriefing meeting, they asserted having become aware of aspects that they had not been aware of preceding the meeting. Prior to the debriefing session, the flight examiner had suggested to the researchers that he would discuss the event because two of three required items to be checked had not been so by the pilots. Neither pilot was aware that these items had not been addressed during the examination. The pilot flying at the time suggested that they had forgotten something from the after takeoff procedure. That is, when the issue comes to be raised in the debriefing meeting, the flight examiner had some plan about what is to be shown and addressed that the pilots had been and were unaware of.

During the simulator session that preceded the debriefing sequence analyzed below, the two pilots are confronted with an engine flame out immediately after their aircraft has taken off from an airport runway (familiar to the pilots). The flight examiner introduced two additional failures that require pilots to attend to the torque and Np gauges. The engine instruments are situated in the center of the cockpit front panel so that these are accessible to both pilots (Fig. 1). The torque gauges for the left and right engine are in the top row; the Np gauges, which give the propeller rotation in percent, lie below the torque gauges (Fig. 3). Above the row of torque gauges also are two lights (Fig. 3), which make the inscription "uptrim" light up in green color when an engine uptrims but stay unlit otherwise.

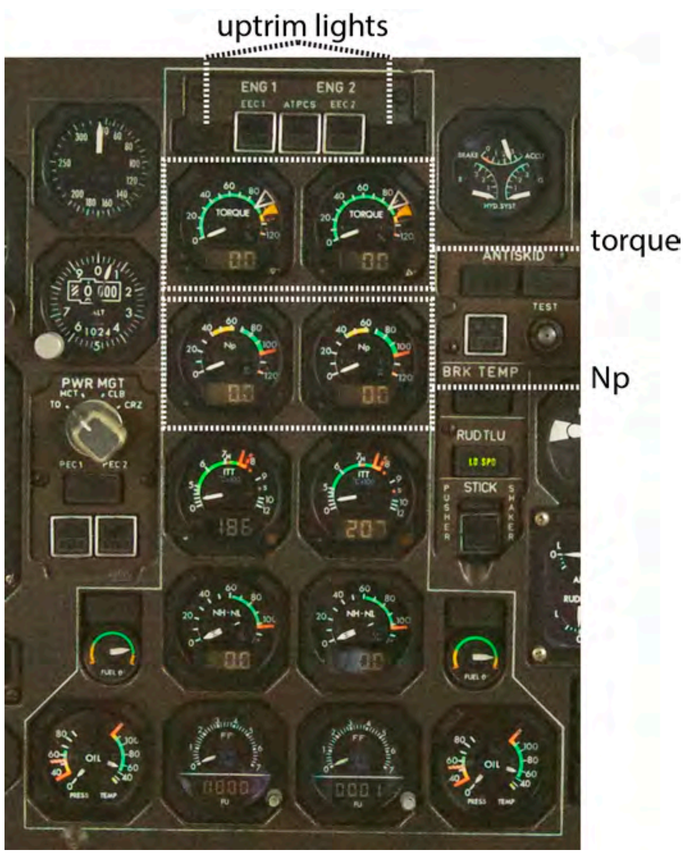


Fig. 3. The torque (first row) and Np (rpm in %) gauges (second row) lie in the top two rows of the four-row engine instruments; the uptrim lights are directly above the torque gauges. (Photograph courtesy Wolff-Michael Roth)

The first of the two failures introduced is an uptrim failure, which refers to the fact that the system has failed to move the live engine from the 90% torque at which it was operating to the 100% required in case of a failure of the other engine. The second problem is an autofeather failure, that is, a failure of the system to move the propeller blades of the failing engine parallel to the direction of flight, which reduces air friction, prevents further engine damage, and increases the stability of the flight. To detect an autofeather problem, pilots have to look at the torque and Np gauges. If the first is at 0%

while the other shows a value unequal to 0%, there is an autofeather problem (i.e. the propeller continues to spin). In the interview preceding the debriefing meeting, the flight examiner said that he would discuss this event because the pilots had been unaware that the uptrim had failed, and they had missed to follow the associated procedures, which required the pilot monitoring to advance both power levers and to check that the live engine indeed was operating at the higher torque level.

### 3.3. The debriefing tool

The term *debriefing tool* refers to a technology that integrates a variety of multi-media means that allow replaying any part of a simulator session during the debriefing meeting that follows. The particular debriefing tool in this study was available to two of the airlines flying the same aircraft type (ATR 72-500) and using the same simulator facility. The debriefing tool includes a video of the cockpit as seen from behind and approximately the position of the flight examiner, visualization of various instruments and action levers as these were available to the pilots during the simulation, the aircrafts track, a panel displaying flight data such as altitude, air speed, and vertical speed, the pilots' view or the aircraft seen from behind, and a panel for selecting specific episodes (Fig. 4). Although it is possible to display any one or any set of panels, most flight examiners in our dataset organize the display in the manner featured here, with the pilots' view outside the window selected.

### 3.4. Data analyses

The data analyses provided arose in *data sessions* (Heath et al. 2010) organized according to the principles of *interaction analysis* (Jordan and Henderson 1995). In this form of analysis, groups of researchers analyze human and human-machine interactions for the purpose of generating hypotheses concerning the order in and of observed events. The purpose of these analyses is to develop *ethnographically adequate accounts* (McDermott et al. 1978). To produce such accounts, researchers "*use the ways members have of making clear to each other and to themselves what is going on to locate to [their] own satisfaction an account of what it is that they are doing with each other*" (p. 247, original emphasis). The results are accounts that provide how the participants themselves produce the ordered and orderly features of the event. Although researchers might have additional information available, these do not explain the unfolding of the event, which is produced in this specific way in which it unfolds in the give-and-take between the participants, who act upon, and therefore influence, what currently is happening. Any participant in a data session may ask for replay to be stopped to initiate a discussion about whatever has been observed. In this discussion, the participants hold each other accountable to what can actually be observed. Thus, in the way enacted in this research, it is not permissible to make claims about what a speaker in the video has in mind, unless these contents are available to the recipients, who take up what is available in their own actions.

Competent analysis of practical action and how it both produces and makes visible the structures of a field presupposes the practical competencies analyzed, as exemplified, for example, in the study of airline cockpits (Hutchins 1995) or mathematical proofs

(Livingston 1986). In the present study, the second author is a learning scientist with a specific focus on the role of media in interaction and learning. The first author is an applied cognitive scientist with extensive record of studying learning in workplace settings including in aviation. As part of this study, he (a) took training sessions flying small aircraft and (b) flew some of the same scenarios on the same simulator that the examined pilots flew during our study. In addition, over the 3-year period of the study, he accompanied crews on regular line flights taking the examiner's seat ("jump seat") just behind the two pilots. Where doubts arose over technical or procedural matters, we drew on the assistance of two senior flight examiners from the participating airline.

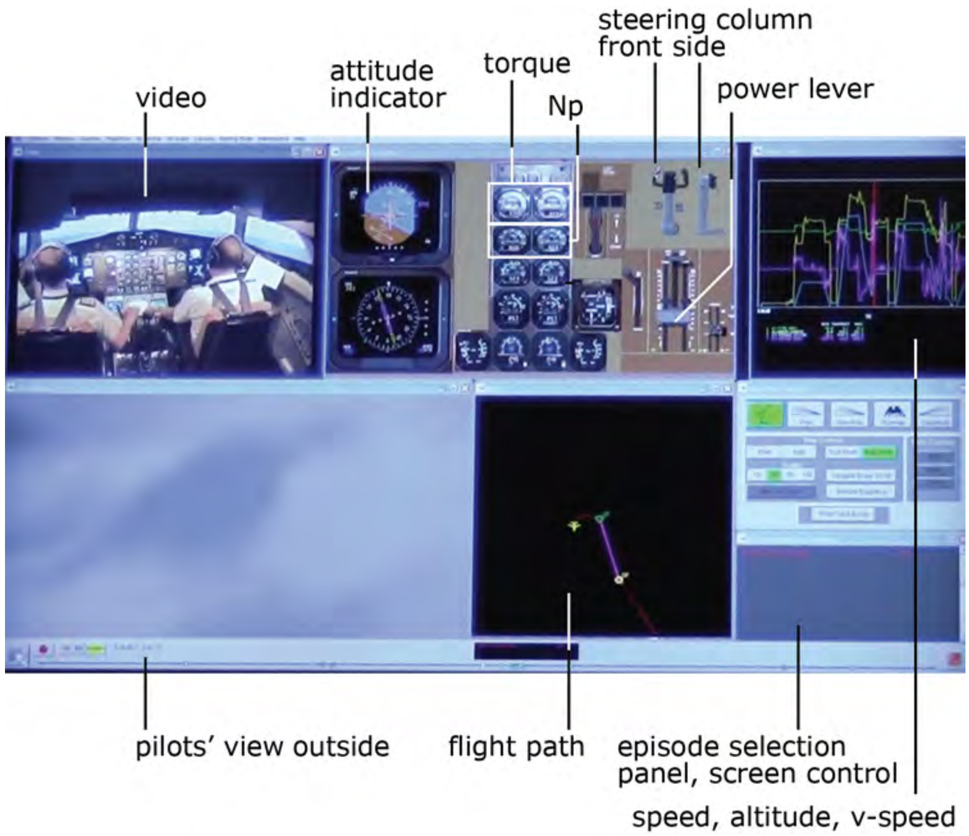


Fig. 4. The debriefing tool allows making present again a simulator exercise by means of different types of representations.

**4. The joint organization of situational awareness as an instructed and instructional matter: analysis of a debriefing sequence in aviation**

The participant identified episode—clearly marked by an announcement of the engine failure as the issue to be talked about, and ended with a continuation and playing of another segment—can be roughly divided into three parts: talk preceding, during, and following the replay of the episode. This event is significant because the pilot monitoring is an experienced captain, who seemingly had not been aware of two of three items to be checked following an engine flameout and who had not appropriately checked the gauge—as per the emergency procedures stated above—and therefore announced its state incorrectly. But, because of the affordances of the debriefing tool—the making present again of a past event in sufficient detail—the assessment is eventually revised.

To assist reading our account and analysis, we provide the flight examiner's characterization prior to entering the debriefing meeting:

> We had a flameout, and I failed the uptrim. When you get airborne and you have a flameout, there are three things to check: you check the uptrim, you check your autofeather, and you check the bleed faults. The uptrim didn't uptrim, and the trouble with that not up trimming is the other thing it doesn't do: it doesn't send a signal to turn off the bleed. And [the pilots] identified that it hadn't auto-feathered . . . but the other two had been missed out. So I thought that's just a matter of slowing that whole procedure down . . . I'm going to tell [the pilot monitoring] to actually put the finger on the dial, which will help and then [the pilot flying] would . . . have seen that [the torque of the live engine] wasn't at a hundred percent.

In this gloss, the flight examiner describes the issue and what his instructional plan was. We then provide an in-depth analysis of the actual work required to achieve what the flight examiner stated as a mundane issue of his practice. We thereby follow the advice that "if a characteristic isn't fully embedded in the ordinariness of practitioners' work, it isn't what we're looking for" (Livingston 2008 p. 217).

In the following five subsections, we provide empirical evidence for empirical assertions. The assertions are presented in the introduction of each subsection (italicized); we then provide the empirical evidence in the form of meeting fragments and in the form of an extended gloss thereof; we conclude each subsection with an analysis.

4.1. Introducing the event to be debriefed as an instruct-able one

4.1.1. *Introduction*

In this section, we describe the work that the participants perform to establish the "flameout" event that took place during the simulator session as the subject matter of debriefing. We describe how this is not a straightforward task but becomes a joint achievement that is accomplished in and through the local organization of talk and of specific attentional dis-positions over and about the debriefing tool. In the following, we show that rather than any occasion to recall the flameout event, *the setting becomes one in which the assessment of and differential access to knowledge about how to safely pilot the aircraft in a flameout situation is at stake*. (Transcription conventions are found in the appendix.)

4.1.2. *Empirical evidence*

4.1.2.1. Fragment 1

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01   FE:   we had a lOOK at the flAMeOUt (0.20) for «PF».
02          (2.24)
03         u:::[m::  ]
04   PM:       [uhhh] thats thats rEALly not that cLEAr. (0.66) is it? (0.50) i thought
           good to do
05         (0.61)
```

06 PF: um [mm ]
07 FE: [well ] thats good.
08 (0.39)
09 PM: that cause I:: j [ust ]
10 PF: [no ] autofeather.
11 (0.20)
12 PM: <<pp>that> (0.20) k> (0.23) wa:s:: (0.39) i=had to REA::lly think aboud (0.23) whAT engine had failed.
13 (0.18)
14 PF: y[eap ]
15 PM: [cause] its prop was still about eighty (0.76) <<p>percent>
16 (1.79)
17 FE: ((*looks towards the debriefing tool*)) awright so: heres (0.14) theres the flameout. (0.20) <<p>okay> and the flameout (0.34) <<dim>was given to you with;> (0.83) an uptrim that had failed (0.20) and an autofeather system <<p>fail.>
18 (1.57)

4.1.2.2. Extended gloss of fragment 1

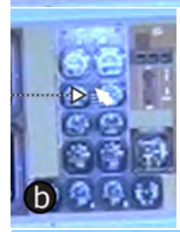
The sequence begins as the flight examiner announces to be looking at a particular event that had occurred for the pilot flying the aircraft at the time (PF), a flame out just after takeoff. The captain, who is the pilot monitoring (PM) at the time, objects stating that “that’s really not that clear” and asks “is it?” but then signals that it is “good” to look at it. The examiner consents, still gazing towards the debriefing tool (turns 04–07). The PM, however, further expands the objection by providing an account of the event, that he “really had to think about what engine had failed,” which is followed up with agreement by the PF. In doing so, the pilots also mention other features of the episode, such as “no autofeather” (turns 08–16). The examiner (FE), who visibly monitors the debriefing tool to find the sequence where the event is registered, re-orients then the group’s attention to the tool announcing the presence of the identified flameout event (“there’s the flameout”), and providing the information that the flameout was given to the pilots “with an uptrim that had failed and an autofeather fail” (turn 17). That is, as a way to address the objections and observations of the pilots, the examiner invites them to orient towards the debriefing tool where he announces the event itself to be present, and, in addition, informs them *that* the event was presented as an uptrim and an autofeather fail. At this point, while the participants attend to the debriefing tool, there are no objections or extensions to the announcement/acceptance sequence. And the examiner proceeds offering a series of questions.

4.1.2.3. Fragment 2

19 FE: so (0.70) wHAT are the thrEE things you were looking for [PM] when you have the; (0.25) a flameout; when you=re calling a flameout as a monitoring pilot.
20 (0.28)
21 PM: yea, so you check (0.32) the uptrim.
22 (0.28)

23 FE: uh hm (0.14) so wHAT are you looking for with uptrim.
24 PM: a hundred percent.
25 (0.35)
26 FE: whereabouts?
27 PM: <<dim>on the torque>=
=<<f>couldnt w[e change one]thing>
28 FE: [so top one? ]((*points to the top pair of instruments, moving 2 times back and forth across them [a]*))


29 (0.13)
30 PM: yea.
31 (0.48)
32 FE: alright. [so not this one here.
((*moves cursor 3 times back and forth across Np gauges [b]*))]




33 PM: No.
34 FE: [not the np then
((*moves cursor back and forth across Np gauges*))]
[but the torque
((*cursor at torque gauge, where it rests*)).]


35 PM: yea
36 PF: should have the uptrim lights as well.
37 (0.51)
38 FE: yap.
39 (2.45)

4.1.2.4. Extended gloss of fragment 2

As the participants silently gaze towards the debriefing tool, the flight examiner asks what the three things are that the PM was to look for. The PM says uptrim, which is taken up in the examiner's query about what the PM was to look for (turn 23). The next query | reply pair establishes that uptrim has to be checked on the torque gauge, which is followed by an offer to attend to something else, but the flight examiner already initiates another query | reply turn concerning the affirmation of the location of the instrument ("top one") to be read *as* the torque. That is, the simple statement to read the torque gauge is treated as insufficient in the query that seeks to affirm the upper gauge as being the torque gauge. Although there is an affirmation completing the turn pair, the flight examiner initiates another affirmation seeking pair to ascertain that the information concerning the uptrim is not to be sought in the Np gauges; and this affirmation is provided. There is a repetition of the affirmation that the top gauges are in fact the torque gauges. With each querying part of the turn pairs, there are movements of the cursors across the associated instruments shown in the debriefing tool (turns 28, 32,34, and 34 again).

4.1.3. *Analysis*

In the fragments described, joint work can be observed that introduces the event as the subject matter of debriefing, that is, as a definite and univocal referent that is to provide for debriefing what there is to be debriefed and learned from. As the analyses show, this work does not simply happen as the announcement of the flameout event, but becomes a joint task where particular alignments are sought and achieved. First, the flameout event is not treated as a settled matter; instead, its recognizability as something that the participants can orient and refer to becomes problematic. What the participants take interest in is *how* the work taken to make the event the topic of debriefing is not achieved in just any manner, but in a way that involves revising the participants' knowledgeability about how to perform in a flameout situation. In this way, the sequence begins not as the recalling of any past event, but turns the topic of discussion into an instructional matter where knowledge and competence are assessed and displayed.

In most settings, instruction involves an "asymmetric distribution of specialized competence" (Lindwall and Lymer 2014 p. 272), where more competent ones make professional objects and doings instructably observable and reproducible for novices. In the current setting, the participants are all experienced pilots, with one of the examined pilots being an examiner himself. Despite this, the sequence unfolds through a series of query | reply pairs in which the competence of correctly monitoring a flameout situation during takeoff is both assessed and displayed. These pairs take the form of what research in education knows as *questions with known answers* (Mehan 1979; Macbeth 2011), that is, sequences of talk in which the participants know that the inquirer knows the answers to the questions s/he poses. Here, the question of "what are the three things" that are to be looked for in a flameout situation and the following affirmation-seeking turns are typical instances of the an epistemic asymmetry that characterizes instructional settings. Thus, although the pilot monitoring is an experienced pilot who has already been flying this aircraft in the captain's role for 6 years, his simple statement that the information concerning uptrim is to be sought and found on the torque gauge is treated as insufficient. There are repeated query | reply pairs confirming the first row of instruments to be the torque gauges rather than the second row, confirmed not to be the (torque) instrument where one can see whether uptrim has occurred or not.

There is actually another piece of information available whether uptrim has occurred: a green light just above the torque panel, which, in the scenario flown here, would have been on the side of the pilot flying seated on the right in the cockpit. Here this information is offered on the part of the flying pilot and briefly acknowledged by the flight examiner. That is, the flight examiner does not ask for this information but it is provided. Moreover, in contrast to the repeated offering of an affirmation seeking | affirmation giving pairs, no such repetitions occur in regards to this piece of information that the pilot monitoring apparently has not considered. In this, the flight examiner exhibits interest solely in the pilot's reading of the torque gauge. As the remainder of the episode shows, the torque gauges, as well as the Np gauges, will be the focus of subsequent talk without any mention of the green light that would have shown that uptrim had occurred. In addition, there are two more lights that would not have shown the correct information if the uptrim has failed: those for the bleed and pack (fault) lights. Again, the flight examiner elicits the information but did not pursue it subsequently.

Through its instructional and instructive character, the sequence brings about awareness that there might have been a loss of situational awareness during the simulator session. It does so by virtue of bringing about particular forms of awareness with regard to the immediate material (debriefing) setting. Hence, through the sequence, the event to be debriefed is established as an unsettled matter, and as something that the debriefing is to bring certainty about. This becomes clear also in subsequent turns, when the PM offers up a query concerning whether the pilot had “both fail” (Fragment 3).

Fragment 3
54 (1.88) ((*video starts*)) (0.91)
55 PM: did=he=have (0.31) bOTH fail.
56 (1.92)
57 FE: well lets just see what (0.45) <<all>so=y[ou=talk=me=through=it]>

Here “both” can be heard as doing reference to the two failures that the examiner has previously announced (uptrim and autofeather). The flight examiner differs a reply until later and invites the pilots to talk him “through it,” where the “it” refers to what is to be shown but already known to the pilots as the part of their experience where they had taken off and had an engine flameout. Precisely because he asks, the pilot monitoring can be heard as not having been aware that there was an uptrim failure; the question can therefore be heard as indicating a failure to be aware of the situation as a whole.

Important to how the sequence provides for its instructional character is the way it establishes a referent concerning where to look for and what to see. In this, it orients the pilots of what and where to look out for in the episode that apparently is to come, as the flight examiner already is oriented towards the debriefing tool in what can be seen as a readiness to play the event. The entire exchange up to this point was an *advance organize*r (Ausubel 1968) for doing what the flight examiner has announced: having a look at the actual event. Advance organizers present, in textual or graphical form, the essence of what is to come and from which the learner is to learn. Before the flameout, the flight examiner has already introduced five other flight events, for which he replayed some part that was discussed both before and after. Thus, this exchange so far sets the participants up for watching the event with a particular orientation to those aspects that have just been talked about. Precisely because the instruments have been the topic of the talk, their states rather than other aspects available on the debriefing tool display are to stand out over and against the actual video footage, which makes available what had happened in the same temporal unfolding. In this episode, therefore, the query | reply pairs establish the presence of knowledge of where to look for to ascertain the first piece of information required after an engine flameout has occurred. Situational awareness is thereby treated as a complex involving knowledge and process (e.g. Smith and Hancock 1994), and this part of the debriefing meeting establishes that it was not the knowledge-related part but indeed the process aspect where the pertinent issue arose. The pilot comes to name the instrument, which is then identified as being found in the top row rather than in the second row (Fig. 3), which is named to be “the Np” (turn 34). The information that the uptrim actually has to occur is identified to be 100%, as indicated by the pointer sitting at this mark on the dial.

### 4.2. Achieving awareness of what has happened

#### 4.2.1. *Introduction*

A cockpit is a complex setting with a large array of instrument panels and actuators in front of the pilots, on the ceiling, to the side, and between the two pilots (Fig. 1). Any videotape of the performance of the cockpit system is limited unless the debriefing could be conducted in an environment where the entire situation is replayed to the pilots as if they were actually sitting in the aircraft. The debriefing tool provides at least some of this information in photo-realistic detail, including the engine instruments. These then can be used to establish the precise course of events as it had unfolded, including exactly those instrument readings that the pilots had at the time. In debriefing an event where a loss of situational awareness might have been at stake, such accurate re-presentation is important to make it possible for the participants to achieve a univocal account of what actually had happened and what the instruments had displayed. Just as is the case during actual performance, the re-presented event may be structured in a variety of ways depending on how features of the environment are perceived to be forming part of a larger pattern of order or context that gives sense to the situation as a whole. In the following analyses, we describe how two different accounts of the same situation become articulated in and as particular perceptual dispositions and orientations. In this subsection, we describe *how, to achieve alignment, the participants turn to the recorded event made present by means of the debriefing tool, and treat it as an objective ground for establishing a univocal account of what happened, a work that itself involves particular forms of group awareness in the debriefing setting.* In this instance, we focus on an aspect of situational awareness that flight examiners relate to events *inside the cockpit*, which they distinguish from situational awareness relating to events *outside*, such as weather, current path of the aircraft, or current position (e.g., Roth and Mavin 2015).

4.2.2. *Empirical evidence*

4.2.2.1. Fragment 4[1]

| | | |
|---|---|---|
| a | PM: | [vee=one rota= ]ate. |
| b | | (4.50) |
| c | PM: | <<all>positive [rate>] |
| d | | [hou]: hou:: ((*pitch trim indicator, stops when pitch trim de-energized*)) |
| e | PF: | [gear up] |
| 58 | FE: | [here is the] engine failure [((* *points to Engine 1 torque*)) |
| f | | (1.80) |
| g | | bin ((*chime, together with light on CCAS, signaling problem*)) |
| h | PM: | i have impaired [and engine (0.41) uh::::: (0.17) flame=o [ut] |
| 59 | FE: | [((* *points to Engine 2 torque*)) |
| i | | [bin] |
| j | | [bin bin ] bin bin bin bin bin bin bin ((*continuous chime, 0.22 seconds per cycle, alerting pilots of a problem, stops when activated*)) |
| k | PF: | [confirmed] |

[1] In the transcript, the turns corresponding to the actual simulator event replayed in the debriefing tool are marked with letters, whereas turns corresponding to the debriefing setting are numbered.

l (0.11)
m PM: and uptrim
n (0.46)

4.2.2.2. Extended gloss of fragment 4

As the debriefing tool replays the scenario, allowing the two pilots to hear themselves as well as seeing themselves on the small video monitor segment of the debriefing tool, the flight examiner uses the cursor to direct the pilots to relevant instruments. Thus, precisely at the instant that the left torque needle moves downward from the 90% position, the flight examiner announces “here is the engine failure” and points to the left torque gauge (turn 58), which occurs while the pilot flying in the simulator had made the call “gear up” (turn e). He then moves the cursor to the torque gauge of Engine 2 (right), thereby orienting the pilots to its reading (turn 59). The needle apparently sits at 90%, which is to say that it does not sit at 100% where it should be if the engine had uptrimmed—as the participants have established prior to replaying the scene. Less than 2 seconds later, the pilot monitoring can be heard to make the call “and uptrim” (turn m), which, if it had been recognized to have failed, would have led the pilot monitoring to say “no uptrim,” which is followed by moving the power lever to the ramp and a check that the torque has moved to the reserve takeoff torque bug (orange), i.e., at 100%. (The shaded parts pertain to the video that participants watch.)

4.2.2.3. Fragment 5

60 PF: <<p>there is an uptrim> *((nods while gazing towards the debriefing tool))*
<<p>[the n=p is too high isnt it,
[((*FE turns towards PF*))
[(.) almost a ninety percent
[((*FE turns body and gaze towards monitor*))
z PM: power lever one forty=five degrEEs
61 PM: yea i [think it was (?)]
aa PF: [confirmed]
ab (0.22)
62 FE: the n=p is a hundred.
ac PF: confirmed
ad PM: engine number one
[condition lever autofeather fuel shutoff]
[((* *places cursor on right Np gauge*))
63 PM: [no=no [other side was] still eighty percent]
64 PF: [my other side]
ae PF: confirmed
af PM: [engine] one feathered
65 FE: [((* *places cursor in left Np gauge*))
[oh yes]
66 PM: ´is `it.
67 FE: i dont think thats right actually
68 PM: i was vE:ry confu:sed by it

69 FE: i think thats the sim i dont think you would see it at eighty percent on a failed [engine]

4.2.2.4. Extended gloss of fragment 5

The participants continue watching the videotape unfold, when the pilot flying nods as he is gazing towards the debriefing tool and states that "there is an uptrim" and talks about the Np, at which point the flight examiner turns his head towards him, and, while the former announces the value that the gauge reads, the latter turns his gaze in the direction of the monitor (turn 60). In response, the pilot monitoring affirms (turn 61); but the flight examiner states that it reads 100, and then places the cursor on the right hand Np gauge (turn 62). This is the gauge associated with the engine that should have uptrimmed but has not, the fact known by the flight examiner but that the pilots have not been aware of before. Both pilots use a negation before stating that the other side, the side other than that the flight examiner has been pointing out, was sitting at 80% (turns 63, 64). The flight examiner places the cursor on the left Np gauge and, simultaneously "oh yes," in apparent surprise (turn 65). He formulates thinking that this (reading) is not right (turn 67), to which the pilot monitoring responds having been very confused (turn 68), and the flight examiner makes a statement attributing the issue to the simulator, and, using the same formulation "I think" that modifies the statement, states that a failed engine would not exhibit an 80% reading (turn 69). (Later in the meeting he would acknowledge that from the examiner's seat he could not see everything on the panel.)

4.2.3. *Analysis*

In this fragment, we observe different orientations and accounts with regard to what has actually happened. The flight examiner, as the cursor shows, is oriented towards the Np gauge of the engine that has failed to uptrim, the issue that the flight examiner has earlier addressed as the problem. It is therefore possible to hear the examiner's observation as instructing about a particular way of structuring the situation: if there had been an uptrim, there *should* also be a 100 on the right hand Np gauge. The two pilots, however, are oriented towards the Np gauge of the failed engine. The statements they articulate are in fact instructions for the flight examiner to re-orientate, as seen in the fact that his cursor now moves to the left gauge. There is uncertainty about the left (Engine 1) gauge, which is reflected in the modifiers "I think" that are used to weaken the strength of a statement (Latour and Woolgar 1986). The flight examiner's statement employs this modifier three times, twice related to the value that the Np gauge should be reading and the third related to the attribution of the cause for the state observed.

We clearly observe here one of the important functions of the debriefing tool, which is to assist the participants in the meeting to identify the aspects each party is talking about. Most importantly, making such aspects identifiable in this sequence brings about not just awareness about single features, but a reorganization of the way in which the entire event to be debriefed is structured as a coherent whole. This is achieved in and through the joint work that brings awareness to objective features of the immediate environment. In the first instance, the flight examiner indexes the gauge he is focusing on, which is consistent with a given con-text for interpreting the event: there had been loss of awareness by the pilots that the right-hand gauge had not been at 100%, where it should have been if uptrim had been successful. But in the second, he moves the cursor to the corresponding "other side." In this movement, he also re-orients, and in so doing, becomes aware of a state that he apparently had not been aware of, and which changes the whole perception of just what the participants are debriefing and what there is to be learned from the session. Important in this regard is that the flight examiner does not dispute or otherwise pursue the description of the mental state that the pilot monitoring provides. In fact, the statement about being confused is consistent with instruments that appear to function incorrectly, as the statements provided by the flight examiner describe (turn 67, 69). The confusion, arising from an inappropriate instrument reading, becomes an intelligible and plausible cause for missing the uptrim failure, which provides the new con-text of what is there to be debriefed and learned from.

The joint work of bringing situational awareness of the debriefed event involves not just making certain objective features of the immediate environment salient, but also, and at the same time, performing heeding work (Schmidt 2011) to monitor each other's orientation in the setting. Here there is an orientation towards the monitor, but their seating configuration is in a direction orthogonal to the alignment of table and monitor (see Figure 1). The participants can be seen to do additional work that manages any required changes in their orientation to a recipient or to the monitor. Here, when the pilot flying begins to speak in turn 60, the flight examiner, up to this point with body and gaze orientation to the monitor, turns toward the speaker, who states "the Np is too high, isn't it" and then provides its reading, "eighty percent." After the first part of the statement, the flight examiner returns body and gaze orientations towards the monitor, thereby bringing the instruments back into his perceptual field. Placing the cursor on the Engine 2 Np gauge (right instrument), he states, reading of the instrument, "Np is a hundred." The PF's statement not only constituted a statement of affairs but also an instruction for the flight examiner where and what to look for.

## 4.3. Establishing (performing) the cause of loss of awareness

### 4.3.1. *Introduction*

For debriefing to become an occasion that prepares pilots for future performance, not just what actually happened, but also the cause of unsuccessful performance needs to be clarified. This is precisely the work that we observe in Fragment 6 after a new form of structuring the flameout event has been achieved. The opportunity for it arose only a few turns after Fragment 5, the examiner states that what actually happened was that the participants "weren't aware that we didn't have an uptrim." That is, despite there previously existing different orientations towards the specific instrument readings, what actually happened here is glossed as consisting of a loss of awareness of a critical feature for safely piloting an aircraft: the PM had called uptrim to have occurred but uptrim had indeed failed to happen. The examiner then offers a new question as he indexes the human factors model used in this company and available on the table both verbally and gesturally (Fig. 5): "so looking at this; why did it happen?" In this manner, he offers a horizon of possible answers that somehow will have to deal with the abstract categories that the model of assessment of pilot performance (MAPP) consists of. As the analyses below show, *establishing the cause of the problem is achieved by turning attention towards the debriefing tool again, where the latter is used not just to do referring—to use* *it as a means to refer to things or events—but also to actually* perform *not being aware of some aspects while being aware of others*.

4.3.2. *Empirical evidence*

4.3.2.1. Fragment 6

108 PM: probably this ((*points to* aviation knowledge *bubble in the MAPP human factors model*)) i=s=pose.
109 FE: <<all>[nO: because i=think]> [you knew;]
110 PM: [i kne:::w] [i know]
111 FE: you [knew] you know
112 PM [.Hkh] ((*laugh*))

113 PM: i just couldnt see [it.]
114 FE: [you] just told me
be[fore i pressed] play that you had to have
[((*lH gesture* *))]

a hundred percent up [here.
[((* *cursor to right engine torque gauge*))


115 PM: I: (1.23) just couldnt see it (0.40)
<<p>really>. [<u>(0.35) and i (1.47) had gone past the n=p and looked at that sitting on eighty (0.51) and i straight away couldnt really figure out initially what</u>]
[((*points towards engine instrument panel* *))]
(.) engine for a few minutes had failed.

116 FE: yea
117 PM: so i=ve more (0.60) (0.22) .hh (0.26) like
(0.95) mnea (0.25) so fixated; selective (0.32)
i dont know. (0.65) yea. (0.45) thats [linear]
118 FE: [well theres] a possibility <<all>and i=m not saying
[that it is> but theres a pos]sibility that you we::re (0.17) in a hurry.

4.3.2.2. Extended gloss of fragment 6

In response to the examiner's invitation to answer by "looking at" the MAPP model (Fig. 5), the PM responds that "probably this" and points to the "knowledge" category of the performance assessment model that the airline uses, and which at that instant lies between the two speakers (turn 108). But there is a hedge, a modifier of the kind that weakens the strength of a statement as undisputable fact (Latour and Woolgar 1986). This version, however, immediately comes to be rejected by means of a negation, followed by an adverb announcing a reason supporting the negation ("because"), which is articulated in the statement that the pilot actually knew (turn 109). Already while the flight examiner is speaking, the pilot monitoring confirms having known and knowing (turn 110). The flight examiner repeats the statement, but the pilot, who has already laughed, takes a turn stating not having been able to see it (turn 113) before the flight examiner says what can be heard as a continuation of the reason: the pilot monitoring had stated this knowledge before the flight examiner had pressed play. The flight examiner moves his left hand from his left and pointing towards the pilot to his right and towards the monitor. He then says that the pilot had to have 100%, and while using the indexical "here" moves the cursor onto the torque gauge for the right engine, that is, Engine 2 that had stayed live during the exercise. Here, the left-hand gesture invites the pilots to orient towards the monitor, which they do, and the flight examiner then unmistakably identifies that gauge where the 100% reading was to be found. But, as the two pilots can ascertain, the instrument does not show the required reading consistent with the call (turn m). Instead, as the replay has been halted, the torque gauge still shows the 90% consistent with an uptrim failure.

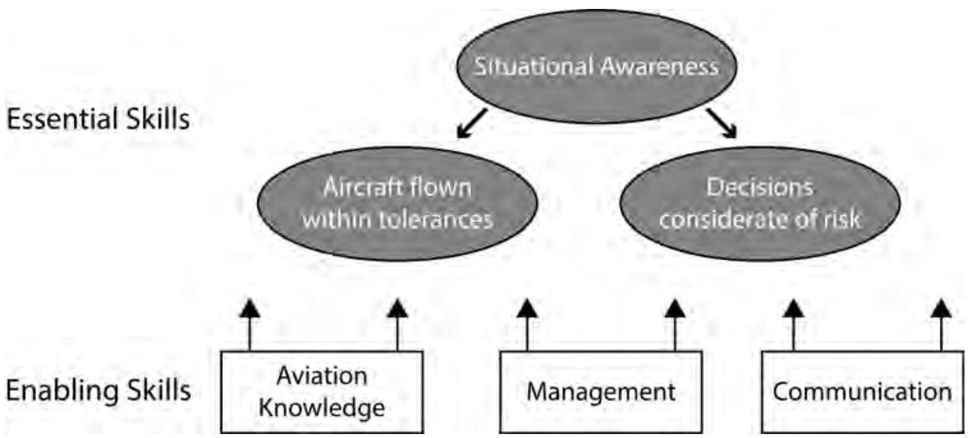



Fig. 5. The model of assessment of pilot performance (MAPP) is employed by a number of airlines in the southern hemisphere, also is used in the participant airline (cf. Mavin et al. 2013).

4.3.3. *Analysis*

In this fragment, the participants establish that the pilot monitoring *knew* what needed to be done and what the instrument should have read and provide alternative descriptions of what actually or possibly had happened. With respect to the assessment model (Fig. 5), it therefore was not lack of knowledge that had led to the problem. In the first few turns of Fragment 6, the flight examiner makes available to the pilot monitoring what he had found out earlier: that the pilot knew where to look and what the torque gauges should read, and he provides his evidence: The pilot has told it prior to the start of the replay of the event. The pilot monitoring has known that the instrument should have uptrimmed but had not actually looked at the torque gauge (or, for that matter, at the uptrim light). The pilot monitoring ascertains to know and to have known, and then provides an alternative version of why the required call had been missed. In this version, the fact that the Np gauge of the failed engine was sitting on 80% was the reason for the inability to identify the failed engine quickly, which led to a fixation and selective focus. While the pilot monitoring presents the first part of the version, the hand is pointing in the direction of the engine panels, moving up and down in the way that the required gaze would have to do to identify whether autofeathering had (torque $TO = 0\%$, $Np = 0\%$) or had not occurred (torque $TO = 0\%$, $Np > 0\%$). That is, the pilot monitoring again refers to the *Np* gauge sitting at 80%, which the three participants have highlighted before and described as being higher than it should have been.[2] The flight examiner offers an alternative version—as a possibility that his hedge allows perhaps not describing what actually had been the case: the pilot monitoring was in a hurry.

Importantly, the work of offering an explanation for why there had been a loss of situational awareness is not only articulated verbally; instead, it is *performed.* The hand movements in the direction of the engine instruments invite gaze and orientation to be directed towards the problematic issue, articulated verbally as an instrument sitting at 80%. It also is fixed in place, up and down where the eyes had come to be fixed during the flight and, therefore, been selective in what they were attending to. The hand does not move to the right, consistent with the verbal account where the gaze had "gone past the Np" but then could not figure out whether this engine had failed. In fact, there is a contradiction inherent in this description, for if the pilot monitoring had problems figuring out *which* engine had failed, this would have required also having looked at the torque and Np gauges of the engine on the right. But the pilot says having been fixated on the Np gauge that is closer to the captain (i.e., the failed Engine 1), and the up and down movement of the hand describes the gaze as being focused on the gauges of one rather than on both engines. If the sequence has begun with an invitation to account for the actual loss of situational awareness by looking at a formal description of safely piloting an aircraft, the actual account given by the person implicated takes recourse in the affordances of the tool to make the actual situation present again. The pilot then, rather than verbally articulating a cause, bodily performs it: his hands, gaze, and the material elements that they demonstrably orient towards are provided as both model and cause of what *actually happened to him.*

### 4.4. Instruction—a case of modeling successful situational awareness

#### 4.4.1. *Introduction*

In this section, we examine the instructional work involved in articulating what the pilot monitoring should do following the failed engine call (pilot monitoring), its acknowledgement (pilot flying), and the cancelling of the master warning. The verbal description comes together with hand/arm movements in reference to the instrument represented on the debriefing tool that provide a model for action in this case and, because this also is instruction, in all such and similar cases. There are studies suggesting positive effects when experts model relevant practices (e.g., LeFlore and Anderson 2009). *In the following, we show that and how the debriefing tool affords such expert modeling as a means of making successful situational awareness an instructable matter.*

#### 4.4.2. *Empirical evidence*

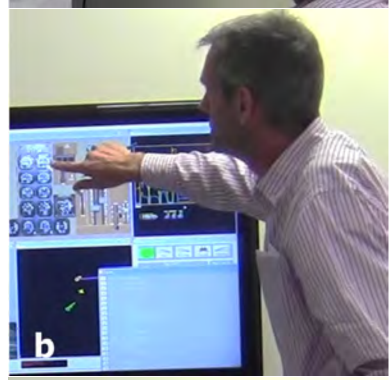
4.4.2.1. Fragment 7

120 FE: (1.59) and what (.) and what i (0.41) [think [you should do is]
121 PM: [u:::m]

[2] In our investigations, other flight examiners do in fact point out that during an autofeather failure the gauge sits around 83%, but this is irrelevant to the unfolding meeting here, where the three participants appear to be in agreement—there is no contest—that the instrument reading was due to the simulator and should not have occurred.

122 FE: ac[tually slow ] down [ ]
123 PM: <<all>[o:h (just couldn't see that:] [u::mm ]
124 FE: and actually put your finger (0.15) on
[what you=re calling.
[((* *points towards monitor generically, a*))
so (0.66) if you=re going okay (0.20)


125 [UPtrim
[((* *finger on Engine 2 torque gauge, b*));
<<all,p>well you=re on the other side>
((*Removes right hand, moves left hand forward*))




126 [UPtrIM here (1.02)
[((* *lH finger on Engine 2 torque, c*)) «PF»
would=ave=been perhaps looking saying well uh no it isnt. (1.06) and and it makes you ((*removes finger from torque* gauge)) if you put your finger on it jUSt makes you identify it. ((*sits down*))


4.4.2.2. Extended gloss of fragment 7

Fragment 7, which immediately follows from Fragment 6, begins with a statement that announces an instruction to come, "what . . . you should do" (turn 120), here modified by the formulation "I think." He then states what the pilot should do, which is to "actually slow down" (turn 122) and elaborates by stating to put the finger on what (the instrument) is being called (turn 124). Simultaneously, the flight examiner uses a deictic gesture to obliquely point to the monitor and in the direction of the engine panel that can be found there. Using the connective "so," he introduces a description of the first step in the standard operating procedure after an engine flameout, which begins with a statement about uptrim (turn 125). In so doing, he gets up from his chair and, using the index finger of his right hand to point to the torque gauge of Engine 2 that had stayed live during the simulator exercise and that should have uptrimmed (turn 125). He states that the pilot monitoring is on the other side. He changes hands and, placing the index finger of his left hand on the same gauge, he states "uptrim here" and then leaves a pause (turn 126). The flight examiner says that this would have given the pilot flying the opportunity to verify the call, finding out that it had been inappropriate. Moreover, putting the finger on the instrument actually affords the pilot to gaze and identify the instrument the state of which is being called rather than merely calling a state without actually verifying it, in the way this was hypothesized to have occurred here.

4.4.3. *Analysis*

In the fragment, the examiner instructs achieving situational awareness by suggesting a way of performing what otherwise is a formal description of safe aircraft operation: monitoring the instruments to check that the automatic takeoff power control system (ATPCS, of which uptrim and autofeather are part). First, the suggestion is given verbally. But there is also instruction of how and where to place the finger, where the examiner moves from performing an orienting gesture, to placing a finger on the instrument featured by the debriefing tool, and to gesturing the placement of the index finger from the position of the left, captain's seat that the pilot monitoring held during the exercise. The instructive demonstration can indeed be seen as a performative modeling of core competences that are otherwise spelled out formally in manuals and descriptions. There are two pauses, one following the identification of the instrument by means of pointing and naming the feature sought (uptrim), the other following that the preceding action would have come with an affordance for the other pilot. The pauses therefore are iconic with respect to the deliberate slowing down action that the flight examiner previously glossed.

The examiner's performance, however, does not just have an iconic function; it does not instruct the correct operation through *representing* what is being modeled—i.e., as something that, in other modality, stands for what it presents, such as, for example, a graph that stands for a mathematical equation. Rather, the examiner's performance, which draws on the complete re-presentation that the debriefing tool offers, provides a *presentation* of the correct monitoring operation. Thus, for example, there is actually a conflict in that flight examiners tend to produce exactly the movements of the pilot concerned (Roth and Mavin 2015), which here would have been the index finger of the right hand because the pilot monitoring is a captain and the engine panel is situated between the two pilots. This is the first hand/arm movement observed. At the same time, the captain has to look to the right and the hand movement comes from the right towards the engine gauges, which is the second movement that can be seen here. In this fragment, the flight examiner exhorts the pilot monitoring to place a finger on the instrument currently read, and then, with a temporal delay models in his performance, the reading aloud. Here, he instructs the pilot monitoring, and in this, both pilots, to point to the instrument, which identifies it as the instrument being checked, before making the associated call (i.e., "Engine 2 uptrim" or "Engine 2 uptrim failed"). In pausing following the "uptrim here," the flight examiner's performance features what he is looking for in the pilot's performance: a pause that would allow the other pilot to take a look, disconfirm, before continuing with the routine. But that same pause allows the pilots in the meeting to orient to the instrument: they do actually perform what they should have performed and how they should perform in the future.

4.5. Summing up debriefing: reiterating what has been taught and learned

4.5.1. *Introduction*

Summing up to reflect what has been learning during a learning situation is a critical in instructional practice in general. It is also the core aim of debriefing prior performance for the purpose of learning from it. Here, we examine the work by means of which the purposes of this episode learned come to be articulated: what has been achieved and what is there to be learned. But the same sequentially ordered turn sequence does more work: it also brings the episode to a close. *We see in this part of the meeting how the instruction provided elaborates and, more accurately than the preceding fragment, models what slowing down and being deliberate is to imply*.

4.5.2. *Empirical evidence*

4.5.2.1. Fragment 8

132 FE: as opposed to just saying uptrim [we tend]
133 PM: [ye::a::]
134 FE: to just (0.46) u:h vERbalise stuff (0.78) and possibly (0.73) you had verbalised it (0.72) having already noticed * that you didnt (0.53) have an autofeather.


135 PM: yea.
136 FE: so i think this (.) just slow down and be (.) deliberate about each thing; okay [uptrim (1.09) [yes. (0.61)
[((*gesture a*)) [((*gesture b*))
[autofeather. (1.66) [yes.=
[((*gesture c*)) [((*gesture d*))
137 PM: =uh hm
138 (0.77)
139 FE: um (2.61) <<all>does that fit?>
140 (0.16)
141 PM: yea. (0.21) yea, (1.71) <<dim>yea i didnt i dont think i did really look at it just staring at the n=p.
142 (0.89)
143 FE: right.
144 PM: ye:a:.
145 FE: i=i i think thats [whats hap]pened but [its=hard] [to tell] from back [here.]
146 PM: [hh .hh] [.hh] [hh] [yea.]

4.5.2.2. Extended gloss of fragment 8

The meeting fragment begins with a statement about "just verbalizing stuff" after something else has been noticed (turn 134). In the operating procedures for a flameout, the pilot monitoring first is to check the uptrim of the live engine, then announce the results of the check, before checking whether the affected engine had autofeathered. The flight examiner states the hypothesis that the pilot monitoring had announced uptrim having *already* noticed that the autofeather had failed (turn 134). There is a hand gesture right after the verb "to notice," where both hands are crossed, each index finger pointing away from the examiner. This can be seen and heard as having the order crossed, for the uptrim in the exercise had an uptrim failure on Engine 2, to the right, and an autofeather failure on Engine 1, to the left. The statement intimates that the pilot monitoring was "just verbalized the uptrim call rather than actually checking, which is followed by an affirmative (turn 135). This is not just a perfunctory "yea," as the pilot subsequently states explicitly not having really looked at the gauge (turn 141). However, before that the flight examiner instructs the pilot to slow down and being deliberate about "each thing." What each thing is becomes apparent in the instructional statement that follows.

The examiner moves his index finger to the top right (turn 136, Fig. a) and in the direction of the engine panel (where gaze is directed), stating "uptrim," pausing, and then while saying "yes" moves the index finger as if pushing or deliberately touching the instrument pointed to (turn 136, Fig. b). The hand then clearly moves to the left with respect to the flight examiner to produce the identical sequence for the second check: the finger pointing towards the instrument identifying the failed Engine 1 (turn 136, Fig. c), followed by a considerable pause, in turn followed by a hand/arm movement as if touching the thing pointed to while affirming, "yes" (turn 136, Fig. d). The pilot monitoring affirms attention by means of an interjection used in such situations (turn 137).

The pilot monitoring affirms that s/he probably had not looked at the live engine torque gauge (turn 141), having stared instead at the Np gauge. The flight examiner accepts this version as a plausible one ("I think that's what happened") and then adds that this is hard to tell from the back of the aircraft (turn 145). After turn 146, there are a few more turns in which the flight examiner reasserts the need to slow down and the pilot monitoring formulates that it was "really good to see it." The end of the episode is accomplished with the (flight examiner's) offer | (pilots') acceptance to look at another issue. Towards the end of the debriefing meeting, the flight examiner announces having had to change one of the grades he earlier gave; and the pilot monitoring suggests during the interview following the meeting that the flight examiner's version had been successfully contested leading to a changed grade.

#### 4.5.3. *Analysis*

In this situation, as was the case few turns before, an instruction occurs in the form of modeling the desired deliberate practice. Deliberation occurs in the form of conversationally long pauses between the naming of the feature attended to and the affirmation of its current status. Deliberation also is articulated in the form of the associated pointing gesture followed by the tapping motion coinciding with the status-affirming call. Earlier, the flight examiner has stated slowing down as the possible course of action that would avoid the problematic course of action: failing to notice the uptrim failure. In this fragment, he models slowing down and being deliberate about that part of the flight, thereby recognizably practicing what he described the required practice to look like: "being deliberate about each thing" (turn 134).

The instruction in turn 136 concerning the check whether the live engine had uptrimmed is both different and repeats the preceding instruction where the flight examiner actually touches the gauges on the monitor. A first difference exists in the fact that when he touches the monitor, the flight examiner moves into what has been called a *virtual space* created by a speaker who talks and acts with respect to an inscription (Roth and Lawless 2002). Because the inscription here depicts a part of the cockpit, the hand/arm movement placing the index finger on the torque gauge of Engine 2 creates a virtual space that recreates (simulates) the locale of the cockpit and its directionality in the space between the flight examiner and the represented engine instruments.

When the instruction is repeated, the flight examiner is actually turning away from the inscription entering what has been called a *narrative space* (Roth and Lawless 2002). In this space, hand/arm and body movements reproduce those movements that would be found in the situation talked about. In flight examiner talk, these would be identical to and with high spatial accuracy of what would be found in the cockpit (Roth and Mavin 2015). However, in the present instance, we observe one of the very rare instances in our database where the flight examiner does not use the hand/arm movements of the pilot whose performance is the topic of the talk. If the flight examiner had moved in the way the captain moves in the role of pilot monitoring, then the right hand/arm should have been used but with the same locations of the indexing gesture and tapping movement. However, the repeat performance mirrors precisely the earlier instruction and, in so doing, does not introduce additional complexity and potential for confusion.

If the flight examiner had merely described in words what the pilot monitor should have done, the instruction would have resembled any other instruction that one might read in a book or hear in a lecture. Here, the verbal description comes together with an acting-out of what the words describe. The flight examiner also provides a perceptual model of what the words describe. In the first part of the instruction, the instrument is located on the represented engine panel; and in the second part, the sequence is played out in the corresponding temporal and spatial order but without a representation of the cockpit. This might occur either on the monitor or as provided in the cockpit poster also available in the room behind the two pilots, and as done in other debriefing meetings, where pilots and flight examiners actually get up and act out a sequence. Here, because the physical location has already been identified, the debriefing meeting unfolds as if another reference to a representation of the cockpit were unnecessary.

## 5. Discussion

This study was designed to investigate the joint work that it takes, during aviation debriefing sessions, to make situational awareness an instructional and instructable matter. We begin discussing how, rather than as a natural and unmediated cognitive process, situational awareness can be thought of as a normative achievement that, as such, involves social sanctions and transactions. Whereas there are many ways in which a given situation may be structured perceptually and conceptually, there are but few ways of operating that actually qualify as successful, reliable, and safe professional performance. How are those ideal ways, which often are formally and abstractly described in manuals, become the object of instruction during debriefing of actual performance situations?

For the purpose of exemplifying how situational awareness can be an instructable and instructed matter, we chose an episode in which the pilots were confronted with an engine flameout after takeoff, the same issue that had led to the spectacular, by a dashcam recorded crash of TransAsia Flight GE 235 killing 48.[3] As the preliminary report shows, the flying pilot ordered the power of the live Engine 1 to be retarded even

[3] Versions are available on YouTube (e.g., https://www.youtube.com/watch?v=-lhQn-fAR6U).

though the instruments showed that Engine 2 was shut off (torque $TQ2 = 0\%$) and feathered ($Np2 = 0\%$). Seconds before crashing, the flying pilot states: "*wow pulled back the wrong side throttle*" (ASC, 2015, p. 13, original emphasis). Although the final report specifying the causes of the accident for the record still is to be delivered, a lack of situational awareness in regards to engine instruments may be part of the accident narrative. The relevance of our study lies in the fact that it shows how situational awareness, rather than being an innate skill that pilots have or do not have, can be made an instructable and instructed matter in the course of debriefing meetings.

Through our empirical analyses, we exemplify how an important aspect of concern to the participants was to achieve a univocal account of what happened during actual performance, so that the debriefing thereof could be performed. In reviewing, describing, and analyzing the preceding simulator events, the participants in our study established a record of what had happened that served them as the objective (shared) facts that were to be debriefed and learned from. In most cases, it provided the pilots with a version of the events that they often had forgotten entirely or what the states of the affairs had been, bringing awareness about specific features of the debriefed event that had slipped away or which had been taken to mark contexts that were not the same for all participants. In some debriefing tool facilitated sessions observed (but never when the tool was not available), it also became a way of supporting the pilots' as opposed to the flight examiner's version of the events.[4] This tended to entail the revision of assessments and assessment rationales. To make these rationales apparent and accountable for all, the participants performed work to monitor and orient each other's awareness of the immediate environment. Thus, topicalizing situational awareness during performance also involved managing awareness in the debriefing situation. As part of this work, specific features of the re-presented event became relevant with regard to particular rationalities and premises by means of *performative* acts, that is, by means of acts that did not do referring but which were aimed at *presenting* specific actions and situations as they actually are performed during real operation. In this section, we discuss how these observations add to our understanding of situational awareness as an instructional matter, and the role that multimedia tools play in debriefing situations.

### 5.1. Situational awareness as an instructable and instructional matter: ethno-methods and the embodiment of professional relevance

The analyses presented in this study have closely followed the locally contingent methods by means of which members of professional aviation organized debriefing as a setting for assessing and instructing situational awareness. In this regard, our analysis of one episode from an airline debriefing session exhibits situational awareness not only as an instructable but also as an instructional matter, where formal descriptions of professional practice are achieved in and through *ad hoc practices* (Garfinkel 1967). These ad hoc practices are the inevitable, contingent means by which the relevance of

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[4] Our ethnographic observations show that even when a pilot examined had flight examiner status, he never contested the observations of his examiner. Instead, they submitted to the examiner–examinee division of labor and thereby avoided the possibility of conflict ("I snuff it up").

professional ways of sanctioning and prescribing performance achieve factual status (instruction).

Consistent with some conceptions of situational awareness (Smith and Hancock 1994) the debriefing meeting established that the pilot monitoring (captain) *knew* where to look (procedural knowledge) and what instrument reading should be made (declarative knowledge) in the case of the live engine when the other had a flame out. In the middle part of the flame out related debriefing session, it was unambiguously established that the torque did not show the 100% reading established but that the captain had indeed confirmed the occurrence of the associated uptrim. The flight examiner took this as evidence that there had been a problem with the performance rather than in the factual knowledge associated with this flight situation. Establishing this distinction was important, as the flight examiner eventually would have to make a judgment as to the knowledge of a pilot, which is also used in designing the program in the case when a pilot has exhibited sufficient deficiencies that require retraining. All three participants know and have been trained to evaluate pilot performance using a specific assessment model (MAPP) with six main performance categories (Fig. 5) and 20 subcategories and the associated assessment metric. Here, the exchange (Fragment 1) established the existence of the knowledge but a problem with the actual performance—thereby achieving the distinction between the knowledge and process aspect of situational awareness (Smith and Hancock 1994). This issue is directly addressed by providing the pilot with instruction then and there in the debriefing meeting.

In the first part of the meeting that concerned the Engine 1 flame out, the lack of knowledge is established concerning what to look for when there is an engine flame out. The only item that the pilot monitoring (captain) identified also was the one that was read incorrectly, which first was established while viewing the video of the event and associated instrument positions. The flight examiner then taught what is to be done to avoid the incorrect step by enacting a particular way that would actually slow down events and increase the pilot's focus on the actual reading.

In the opening part of the episode, participants establish a reason why the appropriate call was not made. When the flight examiner asked why the pilot monitoring identified to have had uptrim, the reply pointed to a lack of knowledge, though with a hedge ("I suppose"). However, this reply is not accepted ("No"), and a reason for the rejection is provided: the pilot actually knows that aspect of the procedure. The flight examiner continued stating that the pilot monitoring had stated this fact during the earlier examination, where s/he had stated that the torque gauge needed to read 100%. Thus, it was not the case that the pilot had lacked relevant knowledge. Even before the flight examiner had completed, the pilot monitoring already suggested that he had not seen what the instrument read (turn 06). Although the flight examiner just suggested that he had stated having had uptrim, the pilot monitoring restated definitely not having seen "it," having gone past the Np gauge, and not having been able to identify which engine had failed.

The flight examiner then suggests a possible chain of events: that the pilot monitoring, being in a hurry, had not actually read the instrument—a form of inattentional or perceptual blindness that has the effect of decreasing situational awareness (e.g. Gosbee 2010). He then proposes a course of actions that would slow down the perceptual processes and, simultaneously, provide the pilot flying with the opportunity to see the instrument that s/he is reading and calling and notice that the call is wrong. While doing so, the flight examiner first points to the instrument from afar, but then goes up and places the index finger of the right hand on the right (Engine 2) torque gauge of the engine that was still running. He then stops, comments that the pilot monitoring was in the captain (left) seat, changes his hand/arm so that the pointing now comes from his left side (iconically representing the two sides of the cockpit), and places the finger on the ways his words described. In this situation, the flight examiner engages in a performance that when accomplished in the aircraft deals with the problem of inattentional blindness and contribute to the communicative endeavor required for maintaining the situational awareness of the joint cognitive system (Gosbee 2010).

There was a second important issue at work. The captain (PM) describes it as staring at the engine instruments not being able to identify the failed engine, because the Np gauge was still sitting at 80%. While watching the event, the pilot flying points out that the Np gauge was showing 80%, which it should not have. At that point, the flight examiner suggests that it was an issue with the simulator. That is, this is an acknowledgment of the fact that it was indeed difficult if not impossible to identify which engine had the flameout. Here, after having seen it, the flight examiner now acknowledges that this had been the situation and that it was hard from his position behind her in the simulator to assess what the pilot monitoring actually had done, looked at, and perceived. But, as he pointed out, what the pilot monitoring *should have done* was verbalizing whatever was seen or done, slowing the action sequence down, and to actually touch and point (while announcing the perceived state of the instruments). In and through the exchange with the pilots, the flight examiner becomes aware of the Np gauge reading. Existing research has shown that there are often considerable variations in the flight examiner assessments of the same events (Holt et al. 2002), which tend to be the result of different aspects of the flight being the observed facts (Roth et al. 2014). The exchange with the pilots and the access to the debriefing tool allows the flight examiner to become aware of something he had been unaware off. As a result, he revises his position on what the pilot has done. The pilot monitoring had not looked at and misread the torque gauge but had been fixated selectively to the Np gauges. It is after reviewing the events that the flight examiner accepts this version. He does so in two places. First, he acknowledges his own version as being but a possibility; and subsequently explicitly formulates this version to correspond to his thinking.

### 5.2. Multimedia affordances for debriefing situational awareness

Currently available meta-analyses of the role of video and other multi-media tools suggest that these do not have an effect on the (learning) outcomes of debriefing (e.g. Tannenbaum and Cerasoli 2013). The present study suggests, however, that the debriefing tool does come with affordances that may play a significant role in facilitating the meeting by allowing participants to establish factual matters that affect the assessment; the debriefing tool also enables forms of indexical grounding of the verbal narratives that allow pilots to remember or reconstruct events that may be impossible in the meetings without the tool.

#### 5.2.1. *Facts and fictions*

Adequate assessment requires knowing what has actually happened. This is difficult for a number of reasons. As all flight examiners indicated during interviews, there are many aspects of the situation that they are not and cannot be aware. In fact, the flight examiner expresses this to the two pilots in the course of the episode featured here, and as a result modifies the way in which he had assessed one of them. Pilots either forget or are not aware of certain aspects of the flight, making it difficult to impossible to establish what has occurred other than what is possible for pragmatic purposes (e.g., there is only a limited time available for debriefing). Flight examiners, too, often perceive very different facts, which affects how they assess the pilots and explains the substantial variations within and across assessment categories (Mavin et al. 2013). Establishing what the facts were on which the assessment is based nevertheless is an important aspect of debriefing meetings in which the debriefing tool is available. In Fragments 1 and 2, the participants oriented each other to the current instrument readings and, in so doing established the events as these have really occurred—the facts for the purposes of this meeting, the evaluation of the pilots, and the instruction that ensued from it.

Whereas the participants do engage in establishing what actually has happened, their inquiries tend to stop whenever they have achieved what can reasonably be achieved in the context of a debriefing meeting held in a 1-hour slot, which differs from the kinds of result that can be achieved when researchers (we) spend two orders of magnitude more time with the same fragment. Thus, for example, when the video displayed in the debriefing tool is magnified several times, we can see that the pilot monitoring moves forward to reach out with the hand until it is near or actually touching the instrument panel at the torque and Np gauges (Fig. 6). That is, the pilot had actually been doing what the flight examiner said needed to be done. But, as the analysis shows, the pilot never contested the version implicit in the instruction, which implied that the pilot monitoring had not acted accordingly. At the same time, other aspects of the performance were not pursued, though one might have considered them relevant. Thus, for example, the uptrim failure also entailed a failure for the uptrim signal to light up (green), and the bleed and pack lights would not come, because they would have been triggered only if the uptrim had worked. Yet the pilot monitoring did read the bleeds and pack lights as if uptrim had occurred. That is, what might have been of interest to an investigator with ample time available did not become an issue for the practical purposes of this meeting.

Fig. 6. Screen print of a small section of the debriefing tool, overlaid with pencil lines, showing how the captain leans and reaches forward while announcing "uptrim."

The tentative nature of the facts is apparent in the frequent uses of “I think” and “I suppose,” modifiers that weaken the degree to which a statement can be heard as articulating a fact (Latour and Woolgar 1986). These modifiers allow the statement to be shown incorrect without a loss of face. In our case study, not only the pilot examined but also the flight examiner uses these modifiers. In debriefing sessions without the debriefing tool, pilots tend to accept the flight examiners’ versions of events, especially because the latter also take notes, whereas the pilots themselves generally admit to have forgotten much about what actually has happened and what the instruments have read at the time. When a debriefing tool is available, the different versions may be tested. During the recorded interview that followed the debriefing meeting, asked what was standing out, the captain actually noted that her version of events had stood up testing whereas the flight examiner had to accede that his version did not correspond to what could be observed with the tool.

5.2.2. *Indexically grounding the narratives*

An important aspect of information technologies is their affordance with respect to grounding participant exchanges (Conole and Dyke 20104). Most importantly, technologies such as the debriefing tool have important functions in establishing the indexical ground of pointing references (Zemel et al. 2008). This indexical ground—providing opportunities for pointing, actors’ relations to the referenced phenomena, and actors’ relations—constitutes and is constituted by participants as a coherent field of action. An important part of the debriefing meetings with the debriefing tool available are the repeated indexical references to the aspects of the cockpit. Relevant to the simulator event the participants discussed were two pairs of engine indicators (torque, Np). The precise location of the instrument that has to be read and should indicate 100% is at issue, as the three times repeated turn pair establishing the nature and location of the instrument suggests. There is no reason to repeat and thereby assert the precise instrument if it were not important and at issue. The flight examiner’s query seeks to identify the identity of the torque and the instrument pair on the top, while pointing to and moving the cursor back and forth the top pair of instruments. A negative statement is produced together with an indexical placement and back-and-forth movement of the cursor on the second pair of instruments, the Np gauge. This negative statement is repeated, followed by a positive identification of the torque together with the placement of the cursor on the torque gauge. At this point, the cursor comes to rest; following a brief period, a fat white bar beginning at the tail of the cursor further highlights its position.

An analysis of lecturing with inscriptions showed that there are different spaces, those where the talk is mediated by an orientation to the inherently 2-dimensional inscriptions and a 3-dimensional narrative space (Roth and Lawless 2002). Each space comes with its own affordances to the deployment of gestures. In the episode, we see that the participants orient each other to the relevant space. Thus, for example, in turn 114, the flight examiner moves the hand/arm from pointing towards the pilots until it pointed towards the monitor where the fact indexed previously has been seen. In turns 124–126, the flight examiner gets up so that he could reach the monitor at the place where the engine instruments could be seen, enabling him to touch these in the way his instructions suggest that the pilot should touch them.

In the case of the debriefing meetings without a debriefing tool, the orientation of flight examiner and pilots is towards each other. This is also the case when the debriefing tool is present but unused. However, there is a dual orientation to the other participants and to the debriefing tool in those instances where aspects of the preceding simulator sessions are replayed or when the display becomes the topic or referent of the talk. There is a participation framework that now includes, and is changed by, something else (Goodwin 2003): the debriefing tool. The analysis shows that the debriefing tool is used to anchor the talk indexically: participants orient to or touch a particular pair of instruments in contrast to another pair of instruments. In that sequence, the exact location is worked out where the pilot monitoring should have oriented. In this, the extended sequence establishes a perceptual field of relevance to the exclusion of other parts not relevant to flying the particular type of event. This situation needs to be considered against the background of other debriefing meetings where this kind of interaction is not possible or cannot be taken advantage of.

### 5.3. From here to hence: indexical reference and instructions (plans) for action

The episode presented has an important instructional dimension besides its evident assessment-related purpose. The instructed object here is the preparation for the future performance of the pilots. Sharing features with the instruction in the operating room (Zemel et al. 2008), the flight examiner instructs the pilots with respect to a performance that does not yet exist, its future instantiation, and its appropriate deployment in the future. Thus, the actual sequence to be enacted by the pilot monitoring is fully enacted and, thereby, modeled for the purpose of its visibility. The iconic representations of the instruments, together with the hand/arm gestures, fully play out the process following the engine flame out call that should have been enacted in the original situation and, in respect to future instances, is the scenario (plan) to be followed.

In the episode, we see the work involved in establishing a double orientation inherent in the debriefing practice: past events are analyzed and assessed for the purpose of improving future performances. This double orientation is apparent in that the flight examiner addresses not only the captain specifically but also the two pilots generally. Moreover, while pointing to and talking about *this* flameout, the sequence constitutes instruction how to fly this type of event from now on in the future (i.e., it constitutes a plan for flying *such* events). That is, although the talk is (initially) about what this captain has done in this examination event, the debriefing meeting establishes what either pilot should do if s/he were confronted with some such a failure in future simulator exercises or on the job.

On a first level, pointing and other locative gestures here occur within the activity of debriefing, where these are employed in the context of identifying the nature (torque) and location (top row) of an instrument and its reading in the case of the remaining live engine after the other has had a flame out. In this respect, pointing is for the purpose of this particular aspect of the debriefing meeting. The flight examiner has already initiated playing the event on the debriefing tool. There is therefore also a forward, future orientation. The instruments, locations, and readings identified here are to be oriented to once the video is being played. The present part of the activity constitutes an instruction of where and how to orient in the immediate future once the past event comes to be replayed. The repeated identification of which instrument to look for and which to regard diminishes the possibility that there is any remaining ambiguity as to where the pilots are to orient.

There is an additional dimension to this instruction: pilots not only are to orient in the manner established but also during any future instance should such an event occur. This is precisely part of the purpose of the biannual retraining / examination sessions, which not only assess the pilots but also prepare them for non-normal events that they might not ever actually experience during their career. The two spatial frameworks are different (Goodwin 2003), because one is to occur with respect to the instrument displays on the debriefing tool as part of the debriefing meeting, whereas the other is in the context of actual flying (in future simulator sessions or on the line). In the debriefing meeting, there is also a retrospective dimension, for when the event is replayed, it provides an opportunity for assessing what the pilots have or have not attended to during the preceding simulator session. That exchange therefore establishes a normative framework against which past actions are to be assessed and as instruction for future actions. The pointing therefore is not a simple but a triple action, pointing here, to where the gaze should have been oriented but had not been, and as instruction toward where the gaze should be in the future. These kinds of pointing, therefore, are not *simple* ways of indicating something in the surrounding environment but complex semiotic acts in which multiple fields come to be juxtaposed simultaneously.

We also observe a third important function, which is related to the effort of making present a presence that has slipped away. The pilots are assessed on their performance. But the process is made difficult because the flight examiner cannot observe everything that is happening or is salient to the pilots. Although the videotape replays what pilots have been saying and shows in a rather coarse way what can be seen in the dark cockpit from behind, many aspects of the flight, such as the state of the instruments, are not easily obtained, if they can be obtained at all. In making available the engine instruments *in the same way that these were present to the pilots*, the debriefing tool provides opportunities to literally make those aspects of the flight present again that either pilots or the flight examiner cannot recall or that were never present to them so that they could be represented subsequently.

In this situation, what the instruments had shown is indisputable. It is available to and inspectable by all participants. In their presence, the states of the instruments at the instant talked about are available to inspection. The pilots can actively acknowledge the instrument readings, whereas without the debriefing tool, they tend to remain quiet rather than voicing any disagreement that they might have with the flight examiner's rendering of the events.

## 6. Implications

Replaying aspects of the preceding 4-hr simulator-based examination session takes time, especially given the affordances of the tool to investigate performance in greater detail and in establishing matters of fact. In those airlines that have access to a debriefing tool, the debriefing sessions already push the 1-hr time limits available for debriefing. One consideration for airlines and regulator agencies may be to shorten the simulator session and increase the debriefing to provide more time for learning to occur through more detailed viewing, analysis, and instruction that the debriefing tool affords. The potential benefits of such an arrangement are currently investigated by means of an experimental study in the field. The above-cited meta-analytic studies did not attempt to ascertain the role of video and other multi-media tools in situations where, as in aviation, there are long examination sessions with many different tasks to be solved, circumstances that lead to a great deal of forgetting and the difficulty make the event present again. If the purpose of debriefing continues to be learning from experience to improve future performance, then the means (debriefing tool) and time need to be made available that is required for establishing precisely what has happened, why it has happened, and what can be learned from it.

Theorists and practitioners alike frequently take situational awareness to be an essential skill, perhaps the most important essential skill required for safely operating an aircraft (Mavin and Roth 2014)—though questions have been raised about the usefulness of the concept (Dekker and Hollnagel 2004). The present study shows that situational awareness has practical relevance and is an instructable matter. Airlines and the flight examiners that represent them will be interested in the fact that awareness of important systems factors can be taught. The debriefing tool in the form available to the participants in this study constitutes an important mediational means for the teaching | learning of situational awareness.

In the introduction, we refer to the 2013 accident of Lao Airlines Flight QV 301 involving an ATR-72-600 that crashed into the Mekong River. The preliminary report includes as cause "the inadequate monitoring of primary flight parameters" and the associated recommendation that the airline provide pilots with a course that "allows them to re-work their visual scan and the callouts linked to *awareness* of automated modes" (AAIC 2014 p. 5). It also includes limited coordination through communication—which has been linked to the lowering of situational awareness (Gosbee 2010)—as a contributing source. Given the erratic flight path prior to the crash, our informants tend to invoke "loss of situational awareness" as a likely cause of the accident. Similar failures to monitor the primary instruments may have been involved in the crash of TransAsia GE 235. The present study has some clear instructional recommendations applicable to the re/training environments—the preliminary accident report of the TransAsia flight does indeed cites the Flight Operations Manual of the airline, where "maintaining situational awareness" is listed as one of the actions that addresses "error avoidance" (ASC 2015 p. 38). Thus, it is not merely sufficient to scan all the instruments—as in Fig. 1—but to become aware of what instruments currently read. The flight examiner in our study exemplified how pilots can be taught to "slow" their visual scan by explicitly placing a finger on the current instrument and to read it. Simultaneously it would allow the pilot flying to become aware of and monitor the appropriateness of the call. This would lead to an increase in the situational awareness of the cockpit as a whole. The instructors of both airlines can learn from our flight examiner how to make situational awareness an instructional and instructed matter.

There is a second dimension related to the instructional and instructable nature of situational awareness that would be of interest to the instructors of the two airlines and to the regulatory authorities. Thus, the purpose of ethnomethodologically informed studies is to provide reports that can be used as instructions to others to find the phenomenon in the field (Garfinkel 2002). Our study therefore may be taken not only as an instruction to locate the instructable nature of situational awareness in the field but also as a way for flight examiners and airlines to develop instructional strategies that make situational awareness an instructional matter. Moreover, the summary report of the Lao Airlines QV 301 crash recommends that the aviation regulatory authority "ensure that the operator implement flight data monitoring system" (AAIC 2014 p. 5). Our study provides a set of instructions in the sense of Garfinkel for the agents of the regulatory authority to find whether the operator (airline) does indeed implement (teach) pilots on how to maintain situation awareness by monitoring instruments and comprehending the information available.

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## Appendix

The following conventions are used in the transcription. The transcription conventions are those of standard conversation analysis enhanced for the transcription of prosodic features (Selting et al. 1998). Unless modified, all words are written with small letters.

| Notation | Description |
|---|---|
| (0.14) | Time without talk, in seconds |
| * | Asterisks marks the instant where the image to the right was seen |
| ((*turns*)) | Verbs and descriptions in double parentheses are transcriber's comments |
| «PF» | Guillemets (angle quotes) are placed where the name of a person has been used—the first name of the pilot flying (PF) in the example |
| (.) | Period in parentheses marks a hearable pause less than 0.1 seconds long. |
| : | Colons indicate lengthening of phoneme, about 1/10 of a second per colon |
| [ ] | Square brackets in consecutive lines indicate overlap |
| <p> > | Piano, lower than normal speech volume |
| <<pp> > | Pianissimo, a lot lower than normal speech volume, almost inaudible |
| <<f> > | Forte, louder than normal speech |
| <<dim> > | Diminuendo, decreasing speech intensity |
| <<all> > | Allegro, faster than normal |
| (?) | Missing words, one word per question mark |
| jUST | Capital letters indicate emphasized sounds. |
| .hh | Noticeable in-breath |

| | |
|---|---|
| hh | Noticeable out-breadth |
| –,?;. | Punctuation is used to mark movement of pitch (intonation) toward end of utterance, flat, slightly and strongly upward, and slightly and strongly downward, respectively |
| = | Equal sign indicates that the phonemes of different words are not clearly separated |
| ˇ´` | Diacritic indicates movement of pitch within the word that follows – down-up, up, down |