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HUMAN PERFORMANCE, SITUATION AWARENESS AND AUTOMATION

Current Research and Trends

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THE DAY "GOD" FAILED OR OVERTRUST IN AUTOMATION.
A PORTUGUESE CASE STUDY

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ABSTRACT

The increasing development of computer based technologies open new horizons in task automation, helping pilots and air traffic controllers to carry out the analysis and resolution of an increasing number of cognitive tasks, in complex working environments. However, there is a general agreement that cognitive automation may lead to overtrust, complacency and loss of the necessary operational situation feed back, as the basis of the mental model refreshment which, in turn, allows for the maintenance of coherent situation awareness of all the operational processes.

The case study reported suggests there is a dimension to be followed in human machine integration, which is beyond the technological deterministic approach of human machine interface design, and calls for a better human comprehension of system nature. The human comprehension of this dimension, which we introduce as *the technological factor*, represents the basis of systemic self-constructed situation awareness, in a real human centered development.

Keywords: automation; situation awareness; mental model; overtrust in automation

INTRODUCTION

Situation Awareness is one of the most referred concepts, ever since the study of Operational Decision Making Processes, in complex working environments, comes to discussion.

From the individual perspective to the team dimension, Situation Awareness evolved throughout many definitions and theories (Dominguez et al., 1994) either supporting the development of sophisticated measurement methods - Query Techniques, Rating Techniques, Performance Based Techniques - or showing the most effective design techniques and rules to integrate Human Factors in System Development.

But, being a complex cognitive process, situation awareness can hardly be disaggregated in a set of simple definitions, as those required to support automation algorithms. On the other hand, there is general agreement that cognitive automation may lead to overtrust, complacency and loss of the necessary operational situation feed back, as the basis of the mental model refreshment which, in turn, allows for the maintenance of a coherent situation awareness of all the operational processes.

Based on a reported incident at Lisbon ACC, this paper intends to discuss the limits of situation awareness in the context of human centred operational decision. Considering the hypothesis that cognitive automation, as an extension of human cognitive capabilities, will lead to the construction of *virtual extensions* (replacing comprehension by information) of human mental models, we introduce the concept of *technological factor* to be balanced against human nature development, as well as human factors are against technological development.

Situation Awareness and trust in Automation

Late 80's and 90's witnessed an enormous development of information technologies, which have been, in the aviation field, the basis for the implementation of new ground and airborne facilities and techniques towards an always greater rational use of the airspace, in response to a continued growing airline industry demand for more processing capacity.

This situation is the basis of a growing development of machine-automated tasks and information processing that has been under air traffic controller's responsibility.

But, automation may lead to data overload (Endsley & Esin, 1995; Grau, Menu & Amalberti, 1995; Woods, Patterson & Roth, 1995), stressing the air traffic controllers to rely on the automated system, as a virtual extension of their own mental models. ATC operators may find themselves in an automation overtrust situation, replacing comprehension by information and loosing control of one of the most important phases of human cognition process: the construction of self mental model on the operational environment (Wickens, 2002; Bonini, Jackson & McDonald, 2001; Dzindolet et al., 2000; Hollnagel, Cacciabue & Bagnara, 2000; Parasuraman 1997; Muir, 1994; Bainbridge, 1982; Hopkin, 1975).

Situation awareness will then tend to be system obtained – figure 1, and not operationally self-constructed. The Human operator may tend to follow and trust unreliable automation, even when there is an evident discrepancy conflict between automation and operational reported or visible evidence (Wickens, 1998).

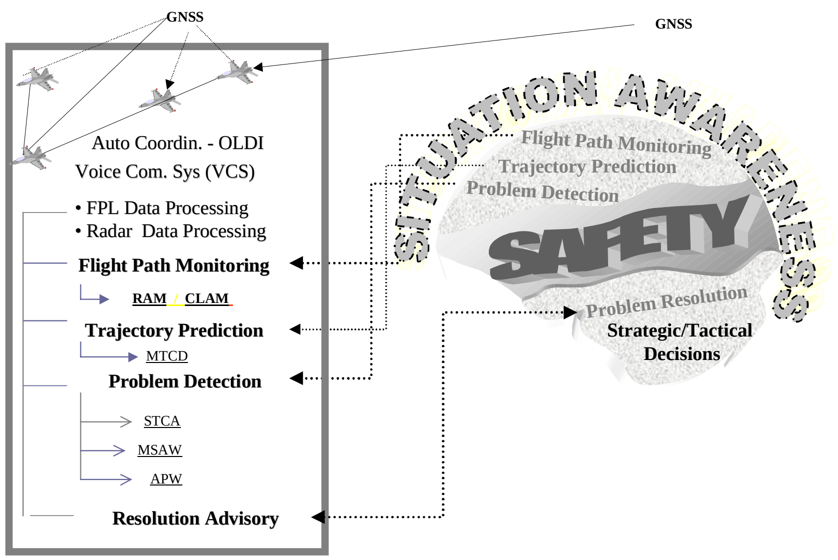

Figure 1– System based decision-making process

This tendency to (over)trust in automation as been well reported by a number of automation research studies (Rahman & Hailes,1995; Bisantz et al., 2000; Dzindolet et al..,2000; Muir, 1987) and it was also the main concern of the US National Research Council Committee on Human Factors study on human factors issues of ATC systems and technology: *efforts to modernize and further automate the air traffic control system should not compromise safety by marginalizing the human controller's ability to effectively monitor the process, intervene as spot failures in the software or environmental disturbances require, or assume manual control if the automation becomes untrustworthy*. (Wickens, Mavor & McGee, 1997, p. ix).

But what if there is no evidence of a system malfunction, while it really exists? What if the system information is so clear and normal, that there is no reason to assume that something is going wrong? How can the air traffic controller spot such an inconsistency of the information presented to him?

The answered is found in the concept of self-constructed situation awareness, as a dynamic/cybernetic cognitive process of checking and validating all the perceived information (mental picture) against cognitive mental model, allowing a coherent planning according to the foreseen future state of the operational environment. Only then, we can say that the air traffic controller may eventually, spot any "invisible" system inconsistencies, although this is virtually impossible in recent air traffic control automated systems, where, as we already said, comprehension is being replaced by more and more information, which has to be processed in real time and in a few seconds. For the air traffic controller, trustful information is fundamental for his job and that is the reason why it is out of the question to even presume that a normal shaped and well-presented automated information should be questioned.

Controllers are system believers. They just need to believe it exists and it's trustful. Like God.

The Day God Failed

Lisbon ATC centre sector was very busy. For that reason, phone coordination between control sectors had been replaced by the "automatic" procedure of assuming the traffic, at the moment it was spotted, on radar display by the next air traffic controller, some five minutes before entering the respective jurisdiction area. While being normal at rush hours, this procedure (resulting from the great knowledge and trust of all air traffic controllers in each other's work) implies that control is essentially radar supported, as no flight progress strips are manually pre-activated at the subsequent control sector.

The facts

At 1640 LMU134 calls for the first time Lisbon control (north sector) and, after squawking 3247, is radar identified.

At 1650, the pilot is told to contact Lisbon centre sector, and the controller of the centre sector asks the pilot to confirm the flight level 370.

At 1657 the air traffic controller had some doubts on the profile and correct position of LMU134, so he asked the pilot to squawk ident. After this new identification, and confirmation of the aircraft's position, the pilot was instructed to turn left, direct to VFA.

Still, three minutes later, the aircraft was showing a different heading that the one it should be flying, if routing direct to Faro. For that reason, the centre sector air traffic controller asked once more the pilot for confirmation, this time on the flying heading. The answered was that LMU134 was flying heading 203. But the radar was showing LMU134, on heading 226… At this time, the controller realised that something was wrong with the radar representation of LMU134.

Searching a reason for the discrepancy between the reported heading, and the one he was spotting in the radar display, the controller assumed the possibility of a mistake of his north sector collage, when assigning the SSR code to the aircraft, i.e., may be the track showing heading 226 would not be the one of LMU134. To verify this possibility, he searched for the LMU134 flight progress strips (remember they were not pre-activated, due to the *automatic* procedure, already mentioned) to confirm the SSR code mentioned there.

Once more, the SSR code allocated to the flight was correct: the flight progress strips showed code 3247, the same code north sector controller gave to the pilot and was displayed in the track's radar label.

After this, the controller thought there was still the possibility of an operator mistake at the flight data section, during the SSR code allocation procedure. So, he called the flight data section for confirmation of the correct SSR code of LMU134. And the answered was 3247…

From this moment on, the air traffic controller lost situation awareness towards LMU134, based on his own comprehension of the operational situation, and decided to adjust his mental picture to a refreshed mental model (after all the radar image was quite clear and trustful, and he had already checked every possible human error - pilot, flight data section and himself) based now on a situation awareness built exclusively on radar processed information.

At this time, DAL693 was also flying FL 370 and, according to the radar information on a parallel track to the LMU134, while XLB566 was flying north at FL 350.

Based on the refreshed mental model, after the checking procedures already mentioned, the position of the three aircraft left no doubt about the good separation between them. That is why, the air traffic controller found no reason for the TCAS advisory reported by the pilot of the LMU134, who requested descent, to avoid a traffic conflict. Anyway, and for the pilot’s comfort, the controller decided to clear the descent of LMU134 to FL 350- fig.2 a).

This decision, while absolutely correct in relation to the information showed by the radar, and coherent with the refreshed mental model of the air traffic controller, created an additional air miss conflict between LMU134 (descending to FL 350) and XLB566 (maintaining FL 350) – fig.2 b).

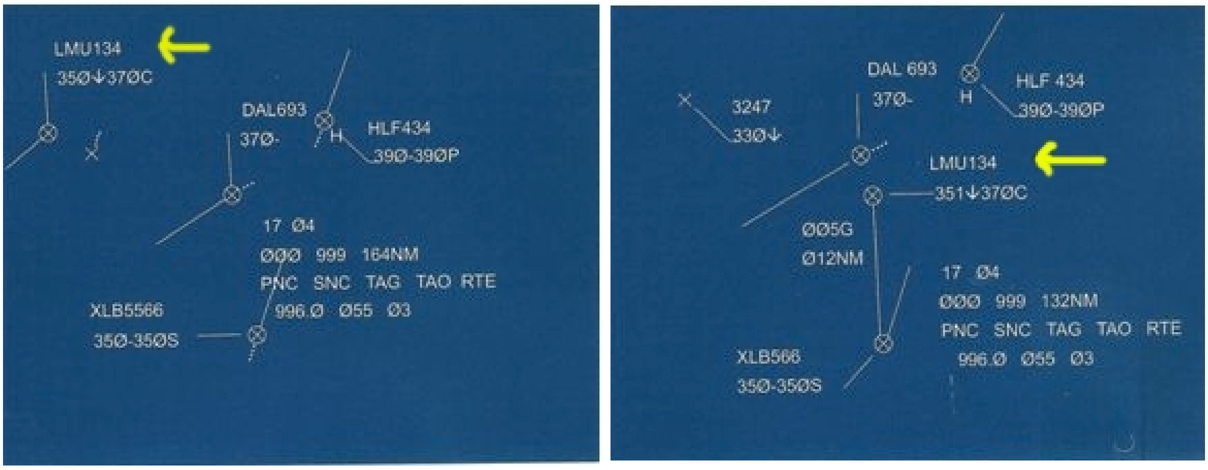

Figure 2. a) – The Radar Image b) – The Real Operational Situation

The Investigation

The investigation, which followed this events, showed that LMU134 has been in conflict with two other aircrafts, while the radar image shown no conflict at all.

The investigation also concluded there has been a real, *trustful*, and almost impossible to detect discrepancy, between the real position of LMU134 and the position processed and displayed by the radar data processing system. This situation lasted for 21 minutes and the real (correct) position of the aircraft could only be spotted in the radar display, for as much as 2 (two) seconds.

The main reason for this abnormal behaviour of the radar processing system, has been found in the incompatibility of the software developed for the recently installed monopulse radar antennas, and the software of the main system, installed in the mid eighties. Yet, there is still a question for which this explanation does not suit:

Why did it **only** happen with LMU134?

Discussion

When analysing this incident, there is a question everybody asks: “How could such a situation last for 21 minutes, without the air traffic controller realise it and find a correct solution?”

In fact, although being aware of the all situation, it took an 18-minute discussion to a group of three incident experts, to find out which kind of action should have been taken by the executive controller, instead of replacing his own constructed and comprehensive situation awareness, by a system processed one. Realising that information is the base of the decision-making process, the group concluded that, for the necessary psychological balance needed for his job, an air traffic controller has to trust the automated system, for the day he doesn’t, safe and coherent decision will be replaced by uncertainty and ambiguity.

This incident was only possible because the air traffic controller trusted unconditionally the radar automated processed information. In fact, should he have used a procedural method of identification, for example, VOR/DME readings, he could have realized the correct geographical position of the aircraft.

But procedural control qualification doesn’t exist anymore…

Another lesson learned is that in a situational awareness lost situation help is always needed, but no more than one person, preferably the operational supervisor, shall be involved. Otherwise, decisions become incoherent, as the air traffic controller will assume all kind of suggestions he will possible hear from the colleagues, trying to help. To avoid this situation, all air traffic controllers should be acquainted with TRM – Team Resource Management techniques.

NAV has already implemented this training as a routine in normal radar courses, where specific exercises are executed, along with different routine training, according to the specificities of each control unit.

Conclusion

This incident shows that automation needs to be balanced against human nature, but not exclusively in the field of human factors or cognitive ergonomics. Trust and overtrust in automation is an important dimension to be taken into consideration in future human centred technological development (Eurocontrol 2003). This means that, along with the development of error tolerant systems to cope with possible human errors, humans need to be trained in an automation error tolerant perspective, as well, i.e., operational training based on a system nature understanding in a comprehensive way, allowing humans to evolve from system operators to real in-loop system managers.

This approach, including **technological factors** in human training goes beyond user adaptation to automation. It has to be understood in a systemic interaction perspective, where the real interface between humans and machines is each own nature.

While this integrative dimension is not achieved, we will have human error tolerant systems development to be operated by unconditional system believers.

As we said before, that is the case of air traffic controllers. So, what else could have been done, that the controller didn’t? One must remember there was no evidence of a system malfunction, whatsoever. “Only” the processed information and the expected one, for that particular flight, didn’t match…

Everybody agreed it is not easy, when there is no evidence of a system error, to reject the system automated processed information and assume entire responsibility for that. In these circumstances it is more acceptable, for the air traffic controller, to doubt his own perception and comprehension of the operational situation, than to question the system. After all, “God” doesn’t fail!

But, this time “He” did.

REFERENCES

Abdul-Rahman, A. & Hailes, S. (1999). Relying on trust to find reliable information. 1999 International Symposium on Database, Web and Cooperative Systems (DWACOS'99), Baden-Baden, Germany.

Bainbridge, L. (1983). Ironies of automation. http://www.bainbrdg.demon.co.uk/Papers/Ironies.html [13-04-2003 3:10:30].

Bonini, D., Jackson, A. & McDonald, N. (2001). Do I trust thee? An approach to understanding trust in the domain of air traffic control. Proceedings of People in Control, 19-21 June, UMIST Manchester.

Bisantz, A.M., Llinas, J., Seong, Y., Finger, R. & Jian, J.Y. (2000). Empirical investigations of trust-related system vulnerabilities in aided, adversarial decision-making. Center for Multi-Source Information Fusion, Dept. of Industrial Engineering, State University of New York at Buffalo.

Cardosi, K. & Murphy, E. (1995). Human Factors in the Design and Evaluation of Air Traffic Control Systems. Federal Aviation Administration, Office of Aviation Research, DOT/FAA/RD-95/3.

Dominguez et al., 1994. Situation Awareness: Papers and Annotated bibliography. Armstrong Laboratory, Human System Centre, ref. AL/CF-TR-1994-0085.

Dzindolet et al. (2000). Buildings trust in automation. Paper presented at Human Performance, Situation Awareness and Automation: User-Centered Design for the New Millennium, The 4th Conference on Automation Technology and Human Performance and the 3rd Conference on Situation Awareness in Complex Systems, October15-19.

Endsley. Mica & Esin Kiris (1995). Situation Awareness, Global Assessment Technique (SAGAT) TRACON Air traffic Control Version User Guide, TTV-IE-95-02, Texas Tech University.

Eurocontrol (2003). Guidelines for Trust in Future ATM Systems: A Literature Review. EATMP Infocentre, Brussels.

Grau, J. Y., Menu, J. P., Amalbertyi, R. (1995). La Conscience de la Situation en aéronautique de combat. Proceedings of AGARD conference 575, Situation awareness: Limitations and Enhancements in the aviation environment.

Hollnagel, E., Cacciabue, P.C. & Bagnara, S. (1994). The limits of automation in air traffic control. Workshop report, Int. J. Human-Computer Studies, 40, 561-566.

Hopkin, V.D. (1975). The controller versus automation. AGARD AG-209.

Muir, B. (1994). Trust in automation: Part 1. Theoretical issues in the study and human intervention in automated systems. Ergonomics, **3**7, 1905-1923.

Muir, B. (1987). Trust between humans and machines, and the design of decision aids. Int. J. Man-Machine Studies, 27, 527-539.

Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. Human Factors, 39(2), 230-253.

Wickens, Christopher D. & Xu, Xidong (2002) .Automation Trust, Reliability and Attention. HMI 02-03 Technical Report, AHFD-02-14/MAAD-02-2, October.

Wickens , Christopher D. (1998). Automation in Air Traffic Control: The Human performance issues, in Automation technology and Human Performance: current research and trends, edited by Scerbo & Mouloua.

Wickens, C.D., Mavor, A.S. & McGee, P. (1997). Flight to the future. Human factors in air traffic control. Commission on Behavioral and Social Sciences and Education, National Research Council, National Academy Press.

Woos, David D., Patterson Emily S, & Roth Emilie M. (1998). Can we ever escape to data overload? A Cognitive Systems Diagnosis- Cognitive Systems Engineering Laboratory Institute for Ergonomics, the Ohio State University.