HUMAN-MACHINE COLLABORATION: FIGHT OR FLY?

The interface between humans and machines is critical in all aspects of work and life, and so it is in air traffic control and aviation. Rapid changes in technology require more of controllers than ever, in operation and in design. How should controllers approach this new age?
Giusy Sciacca discusses some of the issues.

KEY POINTS

1. **Technology is here to stay, and will become increasingly sophisticated.**
2. **There is a need to address controllers' and other users' concerns about technology.**
3. **Technology and people are interdependent and need to work in collaboration.**
4. **The involvement of users in design and development via system integration is needed to optimise human-machine cooperation.**

In the last few decades, aviation has undergone a process of automation, which has transformed human work irreversibly and improved system performance, including both efficiency and safety. As a result, the topic of automation is still widely debated at all levels during conferences and workshops, and in many publications.

As for air traffic safety – the focus of HindSight magazine – we must continue to discuss the future of automation, including the impacts on users: air traffic controllers, pilots and other personnel. What do users and other stakeholders need from automation tools? How is automation designed and introduced? What is the reaction in the ops room when new technologies are introduced?

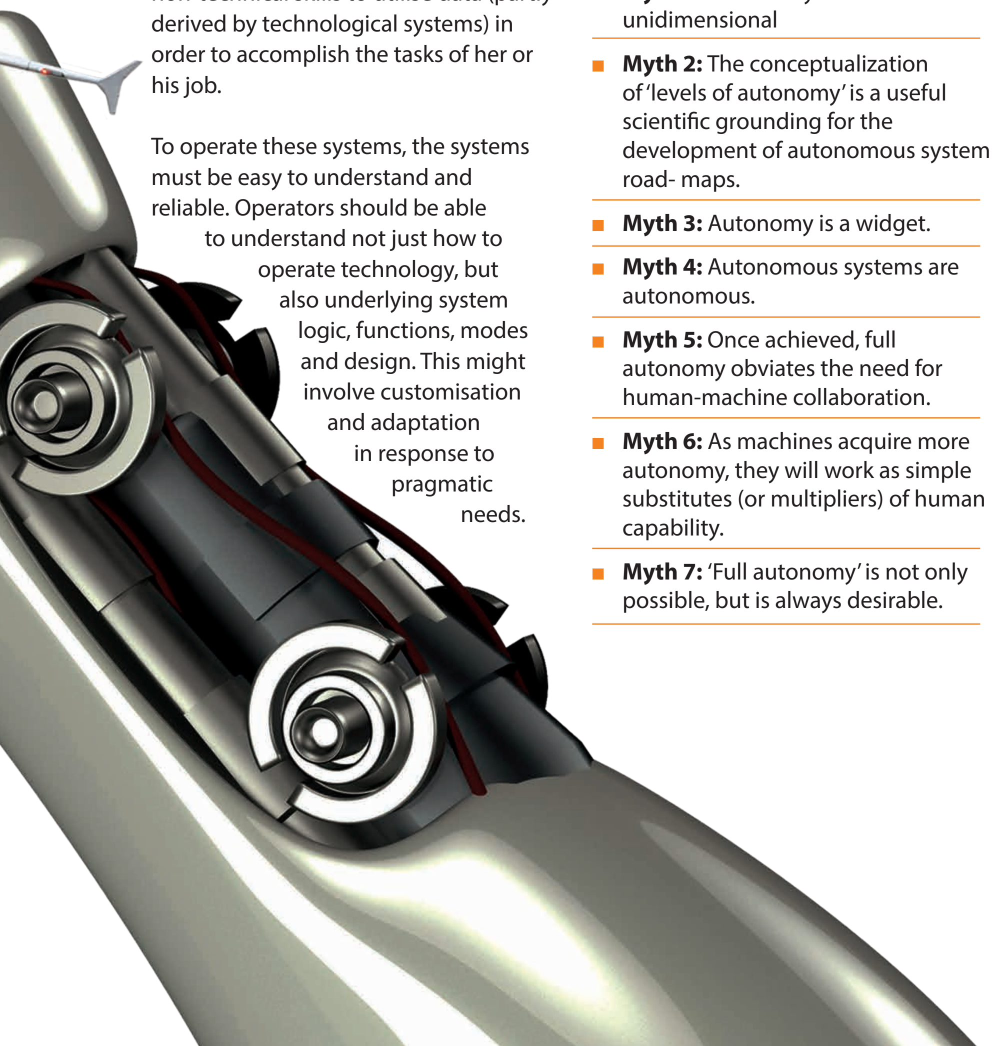
Often, in the process of introducing automation, reluctance and resistance emerge, along with general and specific concerns. In amongst these fears is the fear of unwanted changes to the job, and even fears of loss of the role of air traffic controller, at least in a form that we would recognise today. How can this be mitigated? The answer could be to help controllers overcome some of the myths related to automation, to dispel fears, and to underline the importance of the human role. This might help to move forward from polarised 'user-centred' vs 'technology-oriented' philosophies, toward a new paradigm.

The first question is, what is technology and why do we need it? "The word 'automation' as a noun captures a complex blend of technology interacting with human operators, each carrying out a wide range of tasks, in support of human goals". This is how automation is defined in the UK CAA guidance document *ATM Automation: Guidance on human-technology integration* (2016). Complex technology is not just a machine. It is more like a living organism, which adapts to the context. It should not be seen as a tool to remove humans from the system, but instead to empower them, ensuring that controllers are always in the loop.

The digital revolution has changed our lives and the impact of technology has been disruptive. Just as Facebook and Amazon are changing the old business model, we could look at ATM in the same light. In the old days, air traffic controllers used to carry out their jobs using a clock, a pen and a piece of paper. Now, we are moving towards remote towers implementation, virtualisation, immersive technology and augmented reality, and intelligent approach.

The second question is, what is an operator and why do we need operators? The operator can be defined as a human being with technical and non-technical skills to utilise data (partly derived by technological systems) in order to accomplish the tasks of her or his job.

To operate these systems, the systems must be easy to understand and reliable. Operators should be able to understand not just how to operate technology, but also underlying system logic, functions, modes and design. This might involve customisation and adaptation in response to pragmatic needs.



In many cases it is not possible to think that one solution fits all. One suitable example could be radar surveillance interfaces or remote towers. When a radar interface is introduced, colours and labels play a significant role. During the remote towers live trials all over Europe, controllers reacted, conveying those adjustments and features they considered useful to work in accordance with their 'conventional' experience. Sometimes, for instance, the use of speakers to provide the sound of aeroplanes was considered helpful to enhance their virtual presence in an airport remotely located.

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Understanding the mutual adaptation and interdependence between technology and controllers would help to overcome some of the myths about automation. Bradshaw, et al (2013) elucidate 'The seven deadly myths of autonomous systems':

- **Myth 1:** 'Autonomy' is unidimensional
- **Myth 2:** The conceptualization of 'levels of autonomy' is a useful scientific grounding for the development of autonomous system road- maps.
- **Myth 3:** Autonomy is a widget.
- **Myth 4:** Autonomous systems are autonomous.
- **Myth 5:** Once achieved, full autonomy obviates the need for human-machine collaboration.
- **Myth 6:** As machines acquire more autonomy, they will work as simple substitutes (or multipliers) of human capability.
- **Myth 7:** 'Full autonomy' is not only possible, but is always desirable.

Several of these are of particular relevance to collaboration. Technology and humans do not work alone and neither can work independently. They both perform collaboratively to the same purpose. No agent, whether machine or human, can perform all functions all of the time without implying some interdependencies with another agent. Automation changes the nature of work.

For instance, inevitably, automation fails at same point. In such 'extraordinary' situations, which tend to be unpredictable by nature, human reasoning and problem solving is irreplaceable. Through both technical and non-technical skills, the operator plays the role of a creative strategist who – within the regulatory framework – is able to provide the flexibility needed to keep the system going. During radar failures, which have occurred in Europe in recent years, controllers faced challenging moments with a remarkable effort and competence using all the means at their disposal to preserve safety.

Referring to Rasmussen's (1983) S-R-K theory of performance, human activity is based on skills, rules and knowledge. Our conceptual and physical performance at work is then based on professional education, continuous training, knowledge of codified procedures plus additional experience, deriving from our cultural and personal background, judgement and our non-technical skills (NTS). The human component of the system makes the system resilient. Via continuous interaction with the automated systems, operators employ both standard rules to achieve a level of standardisation in certain defined situations, and reasoning and cognitive strategies to manage variability through flexibility.

This is what we do every day in our operational rooms, where we operators face minor or major unpredictable events. Inaccurately, we tend to think about major failures only, disregarding the everyday adjustments and actions that we take. For example, if as a controller you work in a paper strips environment and your strip printer or the Flight Data Processor (FDP) breaks down during the peak of traffic, you have to copy the flight data manually. Or in the case of bad weather conditions, predictive tools, such as mid-term conflict detection (MTCD) and tactical controller tools (TCT) may not be sufficient to solve potential conflicts.

Consider also the extended arrival management (E-AMAN) concept, developed as an automated sequencing tool, especially for busy terminal movement areas (TMA), relying on target times. Again, in bad weather conditions, such planned operations would be inapplicable in the operational reality. Likewise, operational opinion must be taken into account by the industry about the future optimisation of controller-pilot data link communication (CPDLC) in the effort to find a long-term solution to the issues of the current system based on Link2000+.

So, to reduce the distance between advanced automated systems and human operators, especially during out-of-the-ordinary situations, automated systems and interfaces must be understandable and accessible. An interactive and iterative cycle for software engineering and interface design is needed, involving manufacturers, engineers, users and also legal experts, with reference to legal liability. This must ensure that tools meet user needs. Only via cooperation between these worlds can the air traffic control system achieve optimum performance.

Interdependence is therefore needed, to encourage a cohesive approach where humans and automation are conceived holistically, as an integrated system engaged in joint activity. Our professional life is not immune to change, and indeed we need to adapt to the technological evolution in order to survive as controllers.

How can we face this disruptive change? The conventional approach might lead us to the perception of change as loss, and to resistance or passive acceptance. The alternative option is to see change as a continuous evolution of already acquired skills and the development of new ones. Such an approach is crucial in the process of technological implementation in ATM, because the active participation of operators enables innovation from regulatory, procedural and design (including human factors and ergonomics) points of view.

If we controllers are to survive as a species, we must help to co-design the human-technology collaboration through the design and development process, and play an active part in system integration. As Charles Darwin reminded us, survival depends on being responsive to change.

"Another technician?! Put him into the hold!"

References

Bradshaw, J.M., Hoffman, R.R., Johnson, M., & Woods, D.D. (2013). The seven deadly myths of "autonomous systems". *IEEE Intelligent Systems*. May-June 2013, 54-61.

CAA (2016, February). *ATM automation: Guidance on human-technology integration*. CAP 1377. Gatwick, UK: Civil Aviation Authority. Available at: http://bit.ly/CAAHCA.

Catino, M., Coletto, D., Bianco Dolino, A., & Locatelli, C. (2015). *La professione dell'Air Traffic Controller: Operare in contesti ad alta affidabilità tra efficienza e sicurezza* [Working paper].

HALA! SESAR Research Network (2016). *HALA! Position Paper: State of the art and research agenda*, 25. Available at: http://bit.ly/HALASESAR

Rasmussen J. (1983a). Skills, rules, and knowledge-signals, signs, and symbols, and other distinctions in human performance models. *IEEE Transactions on Systems, Man, and Cybernetics*, 13(3), 257–266.

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