

ATM Automation: Guidance on human- technology integration

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Contents

Foreword	5
Chapter 1	6
Introduction	6
Background	6
Terminology	7
What is Meant by Automation?	7
Levels of Automation	9
ATM Automation Benefits, Issues and Challenges	11
ATM Automation Needs.....	13
Industry	13
Regulatory.....	13
Workforce.....	14
Chapter 2	15
Overview of ATM automation themes and principles.....	15
When and how to use the guidance	15
Chapter 3	17
Theme 1 – Scope	17
Overview.....	17
Principles	17
Chapter 4	20
Theme 2 - Human.....	20
Overview.....	20
Principles	20
Chapter 5	23
Theme 3 – Obligations.....	23
Overview.....	23
Principles	23

Chapter 6	25
Theme 4 – Integration.....	25
Overview.....	25
Principles	25
Chapter 7	28
Theme 5 – Resilience.....	28
Overview.....	28
Principles	28
Chapter 8	30
Theme 6 – Competency.....	30
Overview.....	30
Principles	30
Chapter 9	32
Theme 7 – Transition	32
Overview.....	32
Principles	32
Chapter 10	34
Theme 8 – Emergence	34
Overview.....	34
Principles	34
Appendix A	36
Abbreviations	36
Appendix B	37
Bibliography	37
Appendix C	41
ATM Automation Project Team Members	41

Foreword

For the foreseeable future, humans are expected to play a key role in the delivery of Air Traffic Management (ATM), and the maintenance support of the technical systems used. However, it is expected that the tasks, roles and means of the human delivering these services will evolve through the deployment of a broad range of complex automation.

The aim of this document is to provide guidance on how to address the relationship between humans and automation within the framework of a contemporary safety management system. The direct scope is ATM; therefore including the domains of: Air Traffic Services (ATS); Airspace Management (ASM); Communication/Navigation/Surveillance (CNS); Meteorology; and Air Traffic Flow Management (ATFM). Consequently, the publication is primarily intended for:

- Air Navigation Service Provider (ANSP) managers and safety practitioners, in meeting their legal requirement to manage the safety of their services.
- Competent Authorities in meeting their legal requirement to exercise safety oversight of air navigation services.

The publication also provides information for:

- Aerodrome operators, in considering infrastructure and technology procurement that has an impact on the provision of aerodrome ATS and CNS.
- Equipment manufacturers and design authorities, to ensure their awareness of the needs and expectations of the ANSP. This includes consideration by large-scale regional programmes such as Single European Sky ATM Research (SESAR).
- Any other users outside the scope of ATM who may wish to assess the utility of the guidance in their own operation.

The contents of this publication would not have been possible without the collaborative work of the collective project partners. We are also very grateful for the external review of this guidance material provided by:

- Professor Don Harris - Coventry University;
- Dr Kathy Abbott – FAA;
- Mr Richard Parker – Director RDFP Consulting Ltd.

C. M. Gill

CAA ATM Automation Project Lead

Chapter 1

Introduction

Background

Human interaction with technology and automation is a key area of interest to industry and safety regulators alike. In February 2014, a joint CAA/industry workshop considered perspectives on present and future implementation of advanced automated systems. The conclusion was that whilst no additional regulation was necessary, guidance material for industry and regulators was required.

Development of this guidance document was completed in 2015 by a working group consisting of CAA, UK industry, academia and industry associations (see Appendix B). This enabled a collaborative approach to be taken, and for regulatory, industry, and workforce perspectives to be collectively considered and addressed. The processes used in developing this guidance included:

- review of the themes identified from the February 2014 CAA/industry workshop¹;
- review of academic papers, textbooks on automation, incidents and accidents involving automation;
- identification of key safety issues associated with automated systems;
- analysis of current and emerging ATM regulatory requirements and guidance material;
- presentation of emerging findings for critical review at UK and European aviation safety conferences.

In December 2015, a workshop of senior management from project partner organisations reviewed the findings and proposals.

EASA were briefed on the project before its commencement, and Eurocontrol contributed through membership of the Working Group.

¹ S Quercioli-Torrens, Hertfordshire University, 2015

Terminology

Throughout this document, the following terms are used:

System	The complete socio-technical system
Technology	A piece of equipment
User	Those interaction with the ATM automation including Air Traffic Control Officers (ATCO), Air Traffic Safety Electronic Personnel (ATSEP), pilots, etc.

What is meant by Automation?

Automated systems come in many different forms with a broad scope of system characteristics and capabilities. Therefore 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. However, ‘automation’ can also be used as a verb describing the process of fully or partially delivering or augmenting a function or service previously carried out by the human.

The terms ‘automation’ and ‘autonomy’ are often misused and mixed up. ‘Autonomy’ relates specifically to self-determination and independence of decision-making; however, whilst forms of automation can include such independence, the scope of automation is broader than this and captures a wide spectrum of functions.

Socially what we consider to be categorised as automation changes over time. What is thought of as automation today may not be in future when it becomes accepted as routine. For example, home central heating thermostats and electric kettles are not today thought of as forms of automation. Other such examples are a car’s automatic choke control and electric windows. Yet all of these functions fit the definition and would have been socially considered as being examples of technology augmenting human functions when first introduced.

ATM already has a wide variety of technology and systems that provide automation support to humans, with some key examples as follows:

- Radar Data Processing,
- Electronic data displays,
- Electronic flight strips,
- Mode S down-linked airborne parameters,
- Safety nets such as Short Term Conflict Alert,
- Medium Term Conflict Detection,

- Arrival and Departure Manager,
- Time Based Separation support tools,
- Aeronautical Message Handling Systems,
- Aeronautical Information Management.



Figure 1: Automation in contemporary visual control room, including electronic flight strips. Picture courtesy of NATS.

There are also a number of new ATM automation technologies currently being deployed. Remote Tower systems include the ability to enhance the tracking of aircraft and provide 'heads up' information and warnings to the controller. Through the integration of Advanced Surface Movement Guidance Control Systems, airfield lighting systems, and controller workstations, there is now the capability to automate aerodrome ground control applying what is known as a 'follow the greens' concept. Whilst there has been very little automation of decision-making, when workload increases and users become more confident in the systems that provide possible solutions and advice, automation can and perhaps already has surreptitiously become a decision maker by proxy.

In the immediate future, SESAR functionality mandated by the Pilot Common Project relies on various types of automation as the core means of delivery. Examples include:

- Extended Arrival Manager,
- Departure management synchronised with pre-departure sequencing and integrating surface management constraints,
- Automated assistance to controllers for surface movement planning and routing,
- Airport safety nets,

- Flexible airspace management and free route airspace,
- Automated support for traffic complexity assessment,
- Initial System Wide Information Management (SWIM),
- Initial trajectory information sharing.

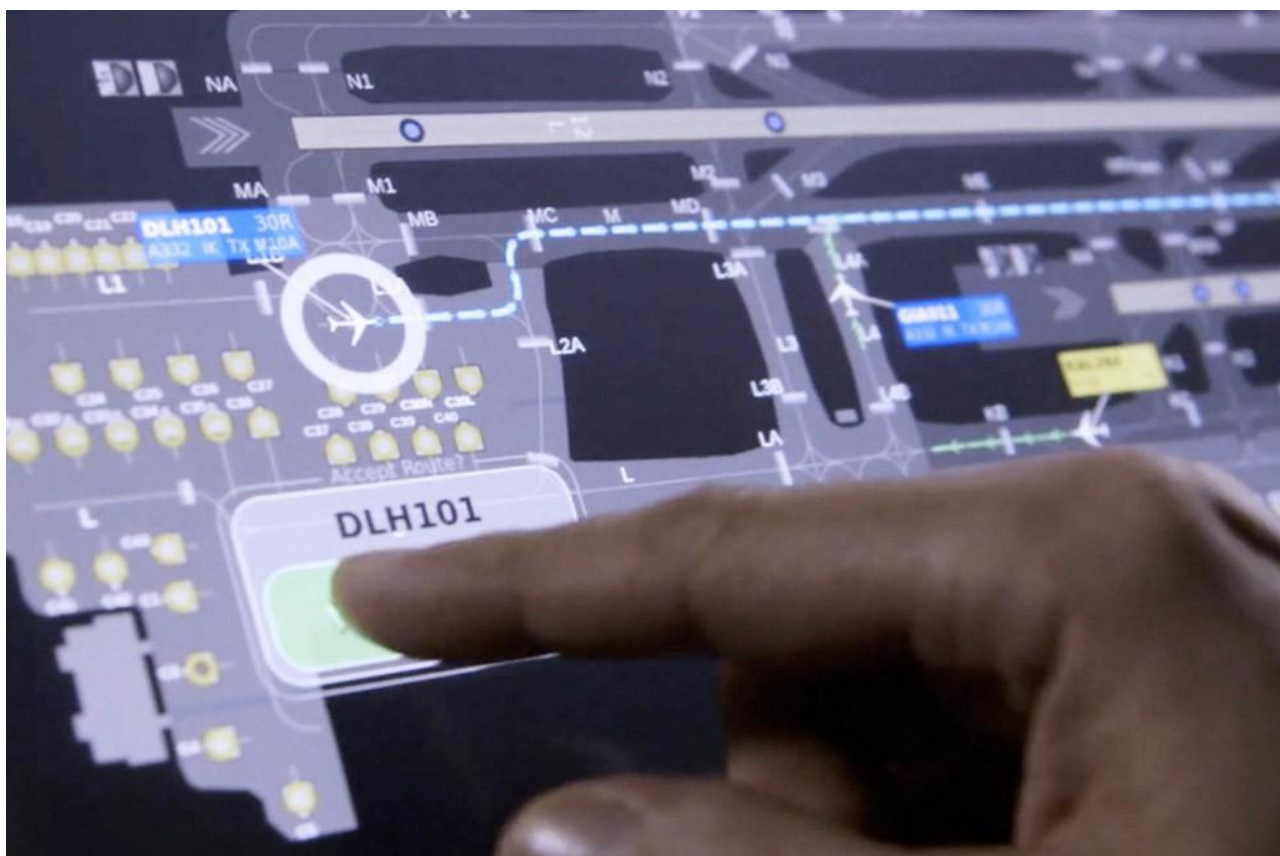


Figure 2: Integrated aerodrome control user interface. Picture courtesy of ATRiCS.

Levels of Automation

At the present stage of ATM technological development, a taxonomy that supports the understanding of the spectrum of automation can be a helpful tool, and can be a useful concept for communicating ideas about automated systems. The taxonomy can help identify the degree to which a function is delivered by technology, on a continuum from a low level (no assistance from technology) to a high level (completely automated system). However, it should be remembered that even a very high level of automation involves some human interaction, for example maintenance where the operational engineers are the 'users'.

Research by SESAR identified that previously developed taxonomies could not fully meet the demands of classifying ATM technology examples, mainly due to the lack of inclusion of the full scope of cognitive functions. Consequently, SESAR developed a new Levels of Automation Taxonomy (LOAT), inspired by previous work, which:

- addresses specific functions rather than the complete system;
- recognises that a technical system can support multiple cognitive functions.

The SESAR LOAT is grouped by the four cognitive functions:

- Information Acquisition,
- Information Analysis,
- Decision and Action Selection,
- Action Implementation.

For each cognitive function there are a number of levels from Level '0' (manual task accomplishment) through to Level 8 (full automation). The condensed SESAR LOAT is as shown in Figure 3.

As future ATM systems increasingly interact, share data, and operate across interconnected and closely coupled 'systems of systems' this will lead to the concept of 'levels of automation' becoming blurred as it becomes less realistic to assess specific functions for their particular 'level'. Furthermore, the notion of levels of automation does not address the requirements for human–technology integration; recent developments in this area have pointed out that a lack of effective activity to address this aspect might not only challenge effectiveness but also the safety of operation.

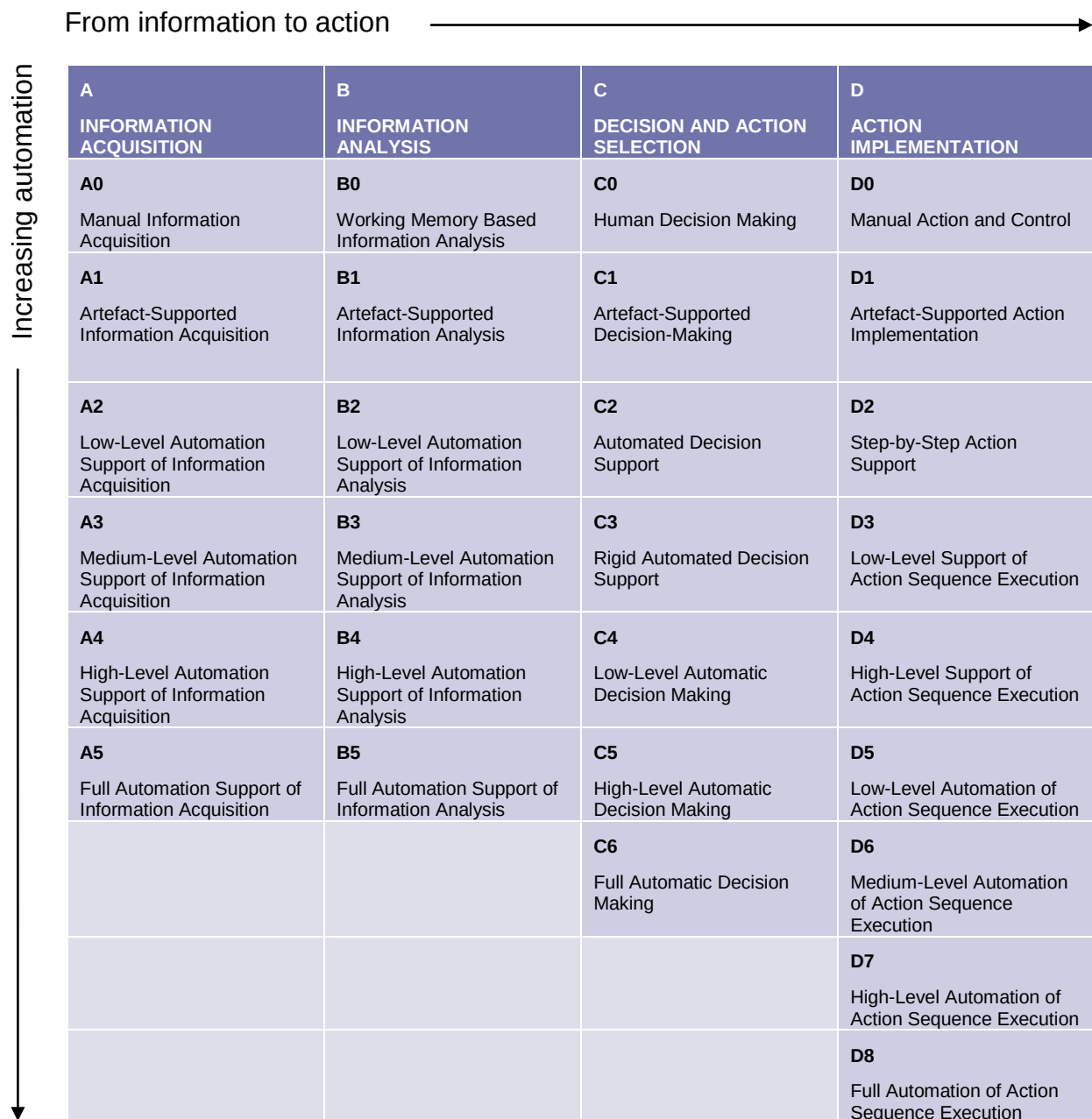


Figure 3: Condensed SESAR LOAT

ATM Automation Benefits, Issues and Challenges

The benefits of ATM automation can be categorised at a high level as providing potential improvements to:

- Safety,
- efficiency²,

² Through reduced cost, increased reliability and consistency.

- capacity,
- security,
- environment,
- passenger comfort.

However, automation can also create unintended consequences. Hence, it is vital to identify and understand the benefits and risks at a total system level.

Automation introduces a challenge for human–technology integration, as whilst the automation often has the ability to perform routine tasks, there is often an enduring need for a human to be in the loop to deal with the novel and unexpected. Human reliance on the automation to perform routine tasks means that if the automation fails, they may not be able to detect this, and even if they do so, they may not have the competence to resolve the situation manually.

Automation creates new human weaknesses and amplifies existing ones. Human error does not vanish; automation changes its nature. The key to success lies in automation supporting and co-operating with users, not only in normal operation but also during novel and unusual circumstances³.

The following captures the high level grouping of human-automation interaction issues and challenges:

- Inadequate understanding by those that procure and design such systems of the current operation and the real need for technology.
- Technology designed, developed and deployed without sufficient attention to human performance.
- Revised roles, responsibilities, and accountabilities resulting from the introduction of technology are not appropriately bounded or reasonable.
- Weak technology interfaces and dependences.
- Insufficient planning conducted for technical failures and fallbacks.
- Training focused on how to operate but not how to understand the technology.
- The adaptation and normalisation of new technology is not appropriately managed.
- The emergent properties and human behaviours are not identified and acted on in service.

³ On Your watch: Automation on the Bridge, M H Lutzhoft and S W A Dekker, Journal of Navigation (2002), 55, 83-96

ATM Automation Needs

Recognising and balancing the specific needs of industry, regulatory authorities, and the workforce has been a key aspect in developing this guidance material. These needs, whilst having variations in priority, were complementary and could be reconciled. The key needs of each community were identified as:

Industry

- Automation is necessary to help to ensure safe and resilient services, delivered more cost-effectively, and in a manner that delivers capacity to meet demand.
- Automation is a key enabler for the deployment of SESAR.
- Automation provides opportunity to bring together and share data with airports, airlines, and other ANSPs. This can enable delivery of services and solutions that were previously impossible, and by removing the silos, it will deliver benefits to the passenger.
- Automation must be delivered safely. There is a need to ensure that the system is designed for human interaction.
- Guidance material is required to provide a framework for automation, which ensures that the right balance is achieved between 'the manual and the 'automated' and to achieve appropriate human-technology integration.

Regulatory

- Automation needs to be introduced in a safe manner and one that delivers benefits for all users of the ATM system by ensuring that all aspects of the change are assessed primarily from a safety perspective using a standardised approach.
- Human performance aspects should be fully considered from initial concept design and continually through the operational life of the system, using processes defined as an integral part of the ANSP's safety management system.
- Recognition is needed of the need for increased emphasis required on in-service safety monitoring and identification and management of emergent human and system behaviours.
- Guidance material should support and be aligned with current and predicted regulatory requirements.
- Processes should be compatible with large-scale European programmes such as SESAR.