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WORKING PAPER

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Agenda Item 4: **NACC/WG Work Programme Update to 2024**
4.3 Implementation of mechanisms for measuring the performance of air navigation services

HUMAN PERFORMANCE AND HUMAN FACTORS IN AIM

(Presented by the Secretariat)

EXECUTIVE SUMMARY

This Working Paper is based on the current Resolution A40-4 (Doc 10140), which requests States to ensure the integration of human performance considerations (Doc 10151) in the planning, design and implementation of new technologies, systems and processes as in the AIM Area is becoming more technical and shares a safety management approach, with the rest of the Air Navigation Services (ANS) Matters especially.

Action:	Suggested Actions in Section 3
Strategic Objectives:	• Safety • Air Navigation Capacity and Efficiency
References:	• Annex 15 - *Aeronautical Information Services* • Doc. 8126 - *Aeronautical Information Services Manual* • Doc 10066 - *Procedures for Air Navigation Services — Aeronautical Information Management (PANS-AIM)* • Doc. 10151 - *Manual on Human Performance (HP) for Regulators* • Doc. 10140 - *Assembly Resolutions in Force*

1. Introduction

1.1 It is evident that new technologies mean development in Air Navigation (AN), with an important transformation in the performance of global Air Traffic Management (ATM), so that, consequently, the way in which information is distributed and Aeronautical data is also changing, to the broad data-centric concept of Aeronautical Information Management (AIM). In other words, there is now a more sophisticated method of providing and managing quality data and information.

1.2 It is recognized that human performance is influenced by both cognitive and physiological capabilities and limitations, which contribute significantly to the global safety of the aviation system, since, even with the advantages of new technologies, systems and procedures, the safety and efficiency can only be achieved when they are designed considering the performance of the individuals who make use of them.

1.3 High-quality aeronautical data and information is a prerequisite for new technologies and tools that will be used by aircraft and ATM systems to provide more services to more aircraft in the same airspace at the same time.

1.4 This implies the development of the first stages of a new mode of operation with current performance-based navigation (PBN) and area navigation (RNAV) systems, which depend on the immediate availability of data of guaranteed quality, and which recognizes, that the implementation of future aviation systems will generate changes in the functions of aviation professionals such as ATM, AIM, MET, among others, which requires working in multidisciplinary teams to support collaborative decision-making. Therefore, Member States should promote and facilitate the integration of human performance elements in competency-based training programmes throughout the professional career of a professional staff.

1.5 The way Human Performance (HP) is supported is based on Human Factors (HF). The topic of HF is concerned with the application of what is known about human beings, that is, their abilities, characteristics, and otherwise their limitations, by considering the design of the equipment they use, the environments in which they function, and the work they perform, in addition to other aspects related.

Human factors (HF) *encompasses knowledge from a range of scientific disciplines that support* ***human performance (HP)*** *through the design and evaluation of equipment, environments and work, in order to improve* ***system performance.***

2. Discussion

2.1 Human Performance considerations are a key element in enabling safe operations, whether they focus on Flight Operations, Air Traffic Control (ATC), Aeronautical Data and Information Management, Databases, Maintenance or Remote Operations, including aircraft systems remotely piloted and remote towers and others. The areas of work related to Human Performance are dispersed in a wide variety of ANS topics that mainly include and by way of example:

- Collection and analysis of safety data
- Management and Analysis of terrain and obstacle data
- Change management and introduction of new Control and Flight systems

- Fatigue management throughout the aviation system
- Human Performance Considerations in automated systems such as Human Factor (1)
- Safety risk management
- Staff training and licensing

(1) *"Human factors must be taken into account during the implementation of automated procedures, as they can influence the operation of technological systems. Incorporating human factors into systems engineering enables users to become an integral part of an automated system and considers their human needs and requirements at all levels for the system to function effectively."*

2.2 Is quoted in Annex 15, paragraph "3.7.1 The organization of an AIS, as well as the design, content, processing and distribution of aeronautical data and aeronautical information, must take into account the human factor principles, which facilitate its optimal utilization"

2.3 Recalling Recommendations: 1.2/1, 3.3/2 and 4.1/2 of the Aeronautical Information Services/Aeronautical Charts (AIS/MAP) Divisional Meeting (Montreal Canada, 1998); that, since that time, the principles and considerations related to human factors were also included in amendment 30 to Annex 15 in July 2000. Now it is time to consider the elements and the five Principles of Human Performance which are included in detail in the Appendix to this Paper.

2.4 In the new 7th. Edition of Doc. 8126, in Part II, Chap. 7 Automation, Paragraphs:

"7.2.5 Human factors must be considered during the implementation of automated procedures, since they can influence the operation of technological systems. Incorporating human factors into system engineering allows users to become an integral part of an automated system and considers their needs and requirements at all levels so that the system can function effectively.

7.2.6 Take advantage of new communication technologies for the retrieval, exchange and distribution of aeronautical information for the transition towards automated systems. Information exchange models, such as AIXM, FIXM and IWXXM facilitate the smooth distribution and exchange of aeronautical information."

2.5 Doc 10066 defines the Human Factors Principles as:

"Principles that apply to aeronautical design, certification, training, operations and maintenance and whose purpose is to establish a safe interface between the human component and the other components of the system through due consideration of human performance."

2.6 Below are the five principles of human action that summarize the way in which people's actions are influenced by different factors. These principles are:

- Principle 1: People's performance is shaped by their capabilities and limitations;
- Principle 2: People interpret situations differently and perform in ways that make sense to them;

- Principle 3: People adapt to meet the demands of a complex and dynamic work environment;
- Principle 4: People assess risks and make trade-offs; and
- Principle 5: People's performance is influenced by working with other people, technology and the environment.

3. Suggested actions

3.1 The Meeting is invited to:

a) discuss the content of this Working Paper;

b) review and analyze the Appendix to this Note: and

c) discuss any other matter deemed appropriate.

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APPENDIX
THE FIVE PRINCIPLES OF HUMAN PERFORMANCE (HP)

Reference -- ICAO Doc 10151 - *Manual on Human Performance (HP) for Regulators*

Principle 1: People's performance is shaped by their capabilities and limitations

People have various physical and mental capabilities, such as strength, flexibility, memory, attention, resourcefulness and creativity. They apply these capabilities in their daily work to keep the system functioning safely, effectively and efficiently. However, the same abilities that make people so critical to safety, system resilience and operational success may also make them susceptible to errors and to unwanted Behavior.

People have limitations too. Some are based on physiology. For example, people cannot function well without adequate sleep and nutrition. They cannot lift very heavy weights, cannot see in the dark and are subject to involuntary responses under stress. Some of these physiological limitations can be aggravated in aviation when flying at high altitude (e.g. decreased oxygen delivery to organs, including sensory organs, can result in problems with night vision or impaired decision-making).

People also have cognitive constraints. For example, they cannot always remember what they were told. Nor can they always immediately solve complex calculations in their heads, or maintain attentiveness when they are bored, tired or cognitively overloaded.

To free up cognitive resources for other tasks, people can make quick, automatic responses when performing frequent activities and well-practiced routines. Although this ability is mostly effective, this "automatic mode" can also lead to unintended actions. For example, a well-learned response to one situation might be executed in response to a related situation that needs a different response. People naturally use reasoning strategies or mental shortcuts that allow them to "speed up" their decision making. These shortcuts, also called heuristics, are often very effective. However, they don't always work, and can result in a variety of decision biases that may lead to poor decisions.

Sensory limitations and information processing limitations can lead to perceptual illusions and to failure to notice subtle changes in the environment, especially when attention is focused elsewhere or when experiencing spatial disorientation during flight.

Furthermore, people's performance is variable. No one can perform at the same level all the time, and the level at which people can perform certain types of tasks changes throughout the day. For example, people's performance may deteriorate when they are ill, bored, stressed or fatigued. However, for all their limitations, when well supported, people are able to manage novel situations, adapting their skills to safely manage the operation. It is this human trait of adaptability that enables the global aviation system to function.

Principle 2: People interpret situations differently and perform in ways that make sense to them

People are always trying to make sense of the world around them. They look for patterns and predictability. Using the information available to them, they make conscious decisions and take actions based on explicit knowledge of facts and procedures as well as on implicit knowledge informed through experience, insights and intuition. People rely on such implicit knowledge to interpret facts, to judge their credibility, to fit them together and to determine what is relevant. This implicit knowledge plays a particularly important role in the way people make sense of an operational environment where not everything can be predicted or controlled, including the actions of other people. This implicit knowledge is especially powerful when there is little time in which to make a decision.

People do not go to work with the intention of making an error or of contributing to a safety event. Although people can sometimes make reflexive responses that they cannot explain, generally people behave intentionally. They behave and make conscious decisions in ways that make sense to them, and that they think will achieve a good outcome. They analyze and interpret information presented to them, and act according to their understanding of the situation. In hindsight, it is often easy to see how decisions and actions led to an undesired outcome and how it might have been avoided – but at the time the decision was made or the action taken, it seemed appropriate. It made sense. The unintended consequences were unknown and may not have been predictable. People's actions therefore need to be considered in context and understood from the individual's perspective at the time of the action.

Principle 3: People adapt to meet the demands of a complex and dynamic work environment

People are key to the aviation system, creating resilience by constantly adjusting and adapting to overcome delays, adverse weather and other unexpected situations. Further, within the aviation system, multiple organizations are often working towards the same outcome, although each has different goals, pressures and cultures. Individuals from one organization may be heavily dependent on, and influenced by, the actions of another organization. An example might be a safe and speedy aircraft turnaround between flights, which involves flight crew, cabin crew, dispatchers, maintenance personnel and ground handlers.

As a result of this continuous adaptation, the work actually performed by people is often different from how the work was originally expected to be performed. Rules, procedures, tasks and equipment are often designed and planned in an environment where a limited set of variables is considered. In the operational environment, work is performed under conditions in which not everything can be predicted or controlled.

To be effective under these dynamic conditions, people need to be able to do more than simply complete a series of pre-identified procedural steps. Whilst standard procedures support safe and efficient operations, people may need to adjust their work in a way that takes into account potential risks and manages unanticipated events. Additionally, people must have and be able to integrate the right knowledge and skill with an accurate understanding of the operational environment and how their actions may affect others.

To address emerging and changing demands, rules and procedures should be reviewed, validated and updated to meet the demands of a complex and dynamic work environment.

Principle 4: People assess risks and make trade-offs

The aviation work environment presents people with conflicting goals. Any activity in aviation must balance safety objectives and other organizational objectives, such as on-time performance, cost savings and environmental protection. For individuals, these conflicting goals can sometimes translate into difficult operational trade-offs: efficiency vs. thoroughness, speed vs. accuracy, cost vs. benefit, short term vs. longer term benefits, and personal vs. organizational goals. Consciously or not, people evaluate the risks posed by these trade-offs, e.g., when assessing the risk of a delayed departure against the risk of not performing a procedure thoroughly. People perceive risks based on their individual characteristics, their own experience, and their ability to anticipate and manage possible outcomes.

These trade-off choices are influenced by personal beliefs, interests and motivations, as well as social, organizational, and cultural factors. These choices are also influenced by the perceived incentives and disincentives in the system. People are acutely sensitive to the perceived incentives and disincentives present in their work environment, even though these may not always be consistent with stated organizational priorities and goals. For example, if a manager continuously claims that safety is the highest organizational priority, but at the same time rewards speedy performance and discourages or even punishes thoroughness when it causes delays, employees learn to value speed over safety.

Trade-offs can sometimes result in errors or in deviations from published rules or procedures. This flexibility might be perceived as a safety deficiency. However, procedures and rules are often prescribed in a limited context or for specific purposes, and it is the responsibility of the people in the system to balance the risks and find the right trade-offs. In making choices, people attempt to make what they think is an acceptable compromise to resolve the goal conflict, while keeping risk within subjectively acceptable limits. The risks perceived by the individual may not align with management's or the regulator's view of risk. Individuals may consider risks to include being embarrassed, being ridiculed, threatening a relationship or being punished. Also, risks are likely to be perceived differently by different people at different times, especially after an unintended outcome.

It is worth noting that leaders and managers are also human, and so they too make such trade-offs and compromises. Although every person is different and can be unpredictable in some sense, each has an inherent ability to understand goals, and to assess risks and make trade-offs in order to provide an overall acceptable solution in a complex aviation work environment.

Principle 5: People's performance is **influenced** by working with other people, technology, and the environment

Human performance can be positively or negatively affected by interacting with other people and with all elements of the socio-technical system. We learn and behave within the constructs of the culture we are brought up in and in which we live. Group and organizational cultures provide the context in which people work together. Such cultures reflect assumptions, often unstated, about the nature of the world. These assumptions, in turn, determine how people perceive the world around them and how they respond to it. The group and the organization establish expectations for "the way things are done around here". The individual and the group can be influenced by the environment in which they work, such as by physical location, weather conditions or national culture. They are then influenced by the equipment and technology they are provided with. Even when provided with the proper equipment, procedures, guidance and training, people's performance is influenced by interactions with others, and everything around them, in ways that can vary from the expected result.

When people work together as a group, they can do more collectively than any individual can do alone. In the same way that some physical capabilities of the group are greater than the individual capabilities of any group member (e.g., the group can lift a heavier weight than a single person can), the group's limitations may also be greater than the limitations of any individual group member. For example, the cognitive bias of "group think" occurs when people's desire for group consensus, harmony or conformity results in a dysfunctional decision. Individuals in the group may make incorrect assumptions about others' thoughts, values, needs and desires, as well as about those of the group as a whole. At the same time, groups can also help individuals make better decisions, and improve performance by compensating for individuals' limitations, and encouraging and supporting appropriate Behavior and optimal performance.

In the aviation system, there are multiple different groups within which people operate. These groups can be within an individual organization, across multiple organizations that work closely together, or based on job type. Individuals may be heavily dependent on the actions and behaviors of other people from another group who may be working under different constraints and goals.

Similar to the way their performance is influenced by working with other people, people's performance is also influenced by the technology used and by the environment in which they perform. Well-designed tools allow people to improve their performance, whereas poorly designed or missing tools force people to improvise and might lead to reduced performance. And new or modified tools, even when well-designed, will result in changes to how people perform their tasks and may even change their role and their responsibilities. For example, the introduction of automation can change the role of the human operator from that of an initiator and direct manipulator to that of a reacting supervisor.

Environmental conditions such as lighting, temperature and space also influence people's performance. People work best with adequate lighting, comfortable temperature and sufficient space to perform their tasks. When such optimal conditions do not exist, people again have to improvise, and their performance might not be as intended.

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