HUMAN FACTOR IN AIR TRAFFIC CONTROL (ATC)

AIR SAFETY CIRCULAR

VERSION	**:**	**1.0**
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OFFICE OF PRIME INTEREST	**:**	**Airspace &Air Navigation Standards (ANS) - DAAR**

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A. PURPOSE:

A1. The purpose of this Air Safety Circular is to provide guidance to Air Navigation Service Provider (ANSP) on the Human Factors issue which must be taken into consideration during establishment / implementation of Air Traffic Control System.

B. SCOPE:

B1. Human factor consideration helps in identifying safety hazards. This Air Safety Circular focuses on the issues which pertain to Human factors in Air Traffic Control system.

C. CORE RESPONSIBILITY:

C1. The Air Navigation Service Providers responsible to manage & control Air Traffic Services are responsible to look after Human Factors in ATC:

Ref: ICAO Doc-9758 Human Factors for ATM System and Circular -241 Human Factors in ATC.

D. DESCRIPTION:

D1. BACKGROUND:

D1.1. Studies of human factors in aviation have progressed significantly since the Second World war-II. However, the majority of correspondence has been focused primarily on Pilots, and the perspective from the flight deck. The development of human factors within Air Traffic Control (ATC) has progressed more slowly. As the number of aircraft and the demand for ATC services increases, so does the workload of the controller. It is observed that “human factors in air traffic control is evolving slowly from a mechanistic to a more socio-technical approach”, focussing more on the dynamics between controller and technology.

D1.2. Fundamental ergonomic issues regarding equipment and workplace design remain important, increasing focus is now being given to the role of human performance (including decision making and problem solving functions), communication, and teamwork. The impact of automation on ATC is also becoming more relevant, as a variety of new technologies are being introduced to cope with the long term growth of air traffic, with the goal of alleviating stress within already congested airspace.

D1.3. Air Traffic Control (ATC) is a complex profession that requires a highly skilled and motivated workforce

D1.4. The range of human attributes desirable for the selection of ATCO is large which includes the following:

D1.4.1. Above-average intelligence

D1.4.2. Basic medical fitness e.g. eyesight, hearing, cardiovascular health, mental health related to psychology etc.

D1.4.3. High motivation

D1.4.4. Spatial ability

D1.4.5. Tolerance of stress

D1.4.6. Tolerance of workload extremes (gross overloading or under loading)

D1.4.7. Emotional stability

D1.4.8. Clear articulation / linguistic ability

D1.4.9. Attention to detail

D1.4.10. Teamwork – the ability to identify with a group and be loyal to it

D1.5. Practical training often involves the use of real-time simulator (either aerodrome or radar) with a series of exercises. The obvious benefits of simulation are that mistakes do not result in real disaster and that the exercise can be paused and analysed when needed. Another advantage of real-time simulation is that the

same traffic scenario can be presented (with fairness) to different trainees. Simulation provides a cost-effective and intrinsically safe method of training for complex and interactive ATC processes.

Note-. *Psychological / emotionally unstable person should be screened out. During training Micro screening switch should be KEPT ON to indentify right / eligible person.*

D1.6. On-the-job training (OJT) commences after the trainee has had a good foundation in basic skills and essential knowledge. Once exposed to the nuances of OJT, trainees will learn quickly the need to be flexible in their decision-making. They learn strategies/ ideas of experienced brain behind their shoulder i.e. On the job Training Instructor (OJTI).

D1.7. The relationship between Instructor and student will be of paramount importance during this time. Patience will be a prerequisite, and the Instructor will have the additional pressure of letting a situation develop for the benefit of learning, coupled with the responsibility of providing a safe and efficient service. The key for the smart Instructor is managing how long to “let it run” while instinctively knowing when to regain control of the situation.

D1.8. Furthermore, training in ATC does not cease with the issue of a licence. Air Traffic Controllers are continually learning about new procedures, learning new roles and learning to use new equipment. The act of learning has in fact become integral to the work itself.

D1.9. Strict process and mechanism needs be followed to ensure Quality of OJT.

D2. HUMAN PERFORMANCE:

D2.1. An ATC environment consists of a vast array of information presented in visual, physical and auditory form. The mental processing capabilities of air traffic controllers are stated as the primary determinant of their ability to deal effectively with the task demands of the ATC environment. However, it is an oversimplification to refer to ATC as some “uniform global activity” as the cognitive task demands will vary greatly with controller position.

D3. HUMAN FACTORS WITHIN SYSTEM:

D3.1. Automation in ATC; Human Factors within Systems are introduced, whilst demonstrating how ATC performance and safety could be compromised due to inherent limitations in humans

D3.2. Type (s) of Air Traffic Service (ATS) to be provided

D3.3. Establishment of ATS unit(s) / Ergonomics factors

D3.4. Types / Surveillance facilities available,

D3.5. Capacity Assessment for the determination adequate traffic density that can be handled safely and accordingly Manpower requirements can be identified

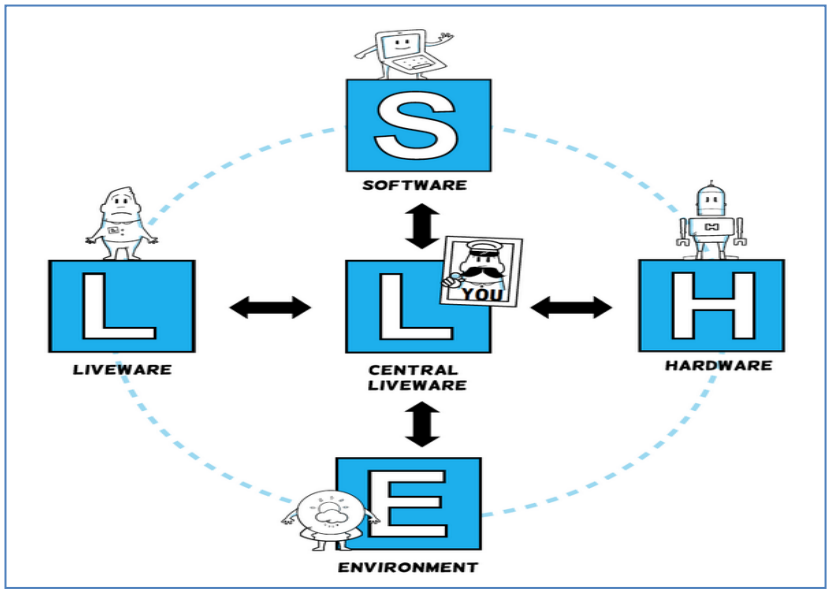
D3.6. Safety assessment for hazard Identification & its mitigation measure

D3.7. Training of Air Traffic Controllers

D3.8. Human interactions with Software, hardware, Live ware and Environment.

D4. ATC SYSTEM AND SHELL MODEL:

D4.1. The SHELL model extensively applied in ATC system and whole story of Human factor in ATC revolve as illustrated below:.



D5. **AIR TRAFFIC CONTROLLER & MACHINE INTERFACE:**

D5.1. An ATC system is a model of a human-machine system with the aim of achieving a safe and efficient flow of air traffic;

D5.2. Necessary pre-requisite for this is the continued supply of professional human resources well versed in the interaction and usage of technology (machines) available.

D5.3. This interaction/matching of the human-machine system is an ongoing and changing process, hence it is imperative that humans are successfully matched with systems by applying correct application of data available so that the full benefits of the ATC system can be connected.

D5.4. These Human Factors knowledge must thus be applied both to the effects of the human on the system and to effects of the system on the human with the aim of improving safety and prevention of accidents.

D5.5. Controllers also must have a firm grasp on how the system operates whilst utilising his own professional attributes for the above to be achieved.

D5.6. Adequate Simulator training should be conducted so that trainee become fluent to use all software& Hardware functional keys & best mouse control.

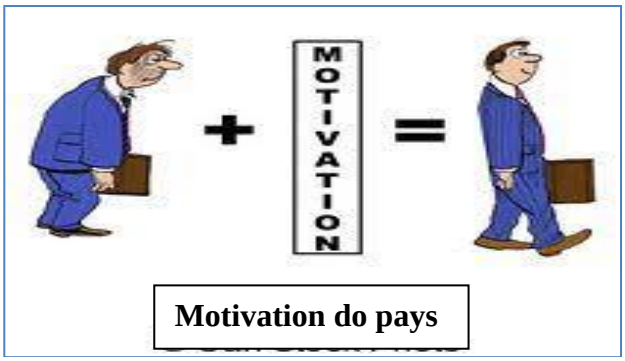
D6. **LIVEWARE (HUMAN) TO LIVEWARE (HUMAN) INTERFACE:**

D6.1. In the subcontinent Asia the least priority is given to Human interactions with each other whereas this is a vital issue and the best interaction results in the good team work which resulted in the achievement of optimum efficiency. This requires top level commitments to provide a continuous fuel of motivation.

D6.2. With continuous interaction with ATC officers / officials Manager can easily identify dedicated, discipline and smart / hard workers. Due weightage should be given to their requirements.

D6.3. Best Manager always plan ahead and at a same time contingency planning is always remain in his / her mind.

D6.4. Top Management may plan / arrange good work reward ceremony preferably yearly or on requirement basis.



D7. **SHELL MODEL APPLICATION:**

D7.1. As the above figure (a) shows, the cognitive work of a Tower controller is somewhat distinct from a (figure (b) Radar controller (Approach or En Route) due to the different memory demands and time constraints. For the sake of simplicity, whenever reference is made to "Controllers" in human factors studies, it usually refers to the Enroute radar environment as the best approximation, but can usually be applied across all positions. During performing ATC duty every controller has to cater following elements;

(a) Aerodrome Control Service

(b) Area/Approach Control (Radar) Service

D7.2. **SELECTIVE ATTENTION:**

D7.2.1. External events include the mix aircraft traffic, weather patterns, equipment serviceability and unexpected events such as emergencies requires selective attentions of a controller. The skilled controller must continually scan for new events and selectively attend to the most critical information in a timely manner.

Note: *For a perfect ATC System Distraction elements should be minimize. A small distraction can play a major disastrous role.*

D7.3. **PERCEPTION:**

D7.3.1. Perceptual processes are greatly influenced by long-term knowledge, and may be based on past experience or well-established procedures or protocol. The information presented may be either visual or auditory and a busy controller must use both continuously.

D7.4. **SITUATION AWARENESS:**

D7.4.1. Situation awareness has been defined as: "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future"

D7.4.2. Situation awareness in ATC relates to the controller's mental picture, often referred to simply as "the picture" or more colloquially as "the flick".

Situational awareness is a product of the controller's dominant mode of sensory imagery, of their training, and of professional knowledge of ATC procedures, rules and practices.

D7.4.3. Since the majority of information presented to the controller is visual, and because ATC takes place in three-dimensional space, a fair assumption would be that the Controller's picture would be primarily spatial. However, this is not always the case as experienced controllers may base their mental picture on the time criteria, because time (rather than space) may well be the better guide to the relative urgency of tasks.

D7.5. **PLANNING AND DECISION MAKING:**

D7.5.1. Decision making under pressure is an essential skill for an air traffic controller. Those working in environments with rigid and reducing time constraints such as ATC do not have the luxury of weighing up the options, reducing all alternatives to the very best option.

D7.5.2. "Although expert decision makers may make small errors, they generally avoid large mistakes. They seem to have discovered that for many decision, coming close is often good enough: the key is not to worry about being exactly right but to avoid making really bad decisions".

D7.5.3. The decision-making and planning processes draw heavily on knowledge retrieved from long-term memory. It would seem that experienced effective controllers may not differ greatly from novice personnel in terms of basic information processing. However the experienced controllers may be recognised as accessing a large repertoire of well organised situational information from long-term memory.

D7.5.4. Most ATC decisions are at the skill or rule-based levels in which decisions are made automatically or instinctively. As a method of reducing cognitive effort, controllers may also employ *Thumb Rules* that have worked with reasonable success in the past.

D7.6. **ACTION EXECUTION:**

D7.6.1. Typical actions include maintaining separation by providing clearances to aircraft relating to their heading/track, altitude and speed. The action may be an immediate action, or consist of a strategic plan or series of actions to be employed at a later time.

D7.7. **COMMUNICATION:**

D7.7.1. Communication is the most prevalent of controller duties, and the vast majority of ATC communication is via radio transmissions utilising standardised English phraseology.

D7.8. **MODEL OF COMMUNICATION:**

D7.8.1. Radio transmissions do have some limitations or weaknesses including being vulnerable to error, often ambiguous and subject to congestion and blocked transmissions. Controller-Pilot Data Link Communications (CPDLC or Data link) is an advancing technology which essentially uses text messages between controller and pilot, instead of spoken word, to improve the accuracy and consistency of routine clearances. To date, the widespread uptake of Data link communications has been mostly limited to Oceanic control where it is seen as a superior alternative to unreliable HF radio. As a direct replacement to VHF communications it's future seems doubtful, as many in the industry view the technology as a backward-step, abandoning the nuances and subtleties of voice communication.

D7.8.2. The qualitative information (as distinct from quantitative information) contained in voice communications is often overlooked when discussing the relative merits of ATC clearance automation.

D7.8.3. "The judgements and assessments that pilots and controllers make about each other, concerning their professionalism, ability, confidence and apparent familiarity with tasks and messages, are based largely on the content, pace, phraseology, consistency, standardization, courtesy, and felicity of expression of the spoken messages between them".

D7.8.4. These qualitative judgements will form the basis of action for an experienced controller. For example, whether to speak more slowly and clearly, to seek confirmation that a message has been fully understood, to utilise the more obscure but expeditious reporting points to a pilot conversant with the local area, or to give extra attention to a pilot that seems uncertain. ATC system is of paramount importance to aviation safety, and likely to remain so despite a proposed increase in levels of ATC automation.

D8. CONTRIBUTING FACTORS OF INCIDENTS /OCCURRENCES /ACCIDENTS:

D8.1. The depth analysis / safety investigation reveals that Human error is listed as a contributing factor 70% - 80% of the time. In the opinion of some aviation experts the Human error should be listed as a contributing factor 100% of the time as whether it's maintenance, inspection, procedure, automation, programming, or something else, somewhere along the line, a human is involved. Most of the time, accidents are the result of multiple events

D8.2. Contributing factors could be; personal, environmental, mechanical, organizational, or any combination of these identified preconditions for unsafe acts

D8.2.1. Fatigue
D8.2.2. Stress
D8.2.3. Complacency
D8.2.4. Communication
D8.2.5. Awareness
D8.2.6. Distraction
D8.2.7. Lack of knowledge
D8.2.8. Teamwork
D8.2.9. Lack of resources
D8.2.10. Pressure
D8.2.11. Lack of assertiveness
D8.2.12. Norms

D9. FUTURE OF ATC:

D9.1. There is now an exponential increase in air traffic round the world with ATC systems operating at close to near capacity for longer periods of time.

D9.2. With the distinct possibility of these capacities being exceeded, new avenues must be explored to deal with these increased demands; this include increased automation, availability of better up to date information to the controller and changing existing mental models of reacting to new traffic scenarios to better advanced forward planning of efficient traffic flows.

D9.3. The lack of an increase of controllers could also exacerbate the increasing demand to the limited airspace and restrictions present which might require more controllers to intervene should a potential confliction emerge.

D9.4. In spite of all these possible changes and developments through the improvements in radar, collision avoidance and navigation systems, these must be balanced with the capabilities of humans with safety in ATC never compromised.

Note-1: *Human resource, Airspace and Air Traffic Management should be given priority, the top management should focus on development of expertise in this regard the Air Traffic Controllers with live ATC service of more than 25 years service or age 50 years or more has shown potential to become effective Air Traffic Manager should be deployed for administrative job.*

Note-2: *Airspace management Team should be established which must includes Chief Operation officer (COO), Radar Facility Chief (RFC) or Facility Training Officer (FTO), Instrument Flight Procedure Designer (IFPD) (Air Navigation Service Provider (ANSP) & Regulator), Additional Director-ATS and major stakeholders & Airline operator(s). The frequency of airspace management review should be determined.*

Note-3: *For effective Air Traffic Management Performance Based Navigation (PBN) Concept for enroute / approach / Departure should be utilized, and especially unidirectional parallel PBN routes should be developed which will help to reduce Air traffic Conflicts.*

D10. **TRANSFER OF INFORMATION:**

D10.1. Efficiency of flight in ATC is dependent on several factors such as characteristics of aircraft, equipment, how the aircraft is controlled, professionalism of ATC / pilot, information and number of aircraft and environmental factors.

D10.2. With experience, controllers are able to identify and react to poor quantitative (performance based) and qualitative (accuracy of data) information about aircraft.

D10.3. In most instances, it is the qualitative automation that determines how close aircraft can be from one another, hence increasing efficiency in the ATC system.

D11. **CLASSES OF INFORMATION:**

D11.1. Controllers must have a thorough understanding of all the forms of information available to them through the myriad of sources; these include those from speech transmissions and displayed information on the radar screen. Future ATC systems will attempt to help controllers through more concise and processed information, alerting controllers to anomalies and conflictions and help in predicated future problems by offering solutions of projected confliction in flight paths. Notwithstanding the development of these sophisticated systems, controllers still must be conversant of all available information in the event of system contingencies, hence all information needed by the controller must be reliable and up to date.

Note: *With the advancement of Surveillance technology the training to ATC should be given top priority, and in this regard familiarization tour for Air Traffic Controllers should be arranged to visit other ATS units which will certainly enhance vision and best results can be achieved.*

D12. **THE CONTROLLER'S WORKPLACE:**

D12.1. Workplace conditions directly influence the efficiency of controllers. Workplace conditions are such in that personnel with operational skills must experienced them to varying degrees, these include:

D12.1.1. workforce infrastructure and stability,
D12.1.2. qualifications and experience,
D12.1.3. morale,
D12.1.4. management credibility, and
D12.1.5. traditional ergonomics factors.

D12.2. Quality management system (ISO 9001-2015) requires that the organization shall determine, provide and maintain the infrastructure needed to achieve conformity to product / services requirements.

D12.3. Environmental Management System (ISO 14001:2004) focuses on organization's role in minimizing the harmful effects on the environment caused by its activities

and to achieve continual improvement of its environmental performance. EMS provides a framework for managing environmental responsibilities efficiently in a way that is integrated in the overall operations of an organization.

D12.4. Occupational Health & Safety Management System (OHSAS 18001:2007) promotes a safe and healthy working environment by providing a framework that allows an organization to consistently identify and control its health and safety risks, reduce the potential for accidents, aid legislative compliance and improve overall performance.

D12.5. Less-than-optimum workplace conditions supports active failures by operational personnel.

D13. **APPLICATION OF ERGONOMIC DATA:**

D13.1. Controlling in ATC is dependent on the interaction of the human-machine interface and it is paramount that the workspace be set up with all of constraints resolved to facilitate maximum task performance through the application of ergonomics.

D13.2. The broadest application of ergonomics to ATC workspaces is environmental and examples include:

D13.2.1. Buildings must be designed with basic amenities close by.

D13.2.2. Rooms must be spacious enough to accommodate all staff members comfortably.

D13.2.3. Controller's workstations must be equipped with all the necessary tools for controlling and if there is a need for sharing, information must be displayed clearly and within reach for both controllers. If various control positions collapse due to lull traffic, supervisors at their workstation must still be in the position to monitor all the controllers.

D13.2.4. In the aerodrome environment, there must be unimpeded visual access of ground vehicles and aircraft at critical phases of flight. There must also be a simple and seamless flow of information so that aircraft details are always up to date and available for handover to the next control agency.

D13.2.5. The controller's console must meet the ergonomic requirements for all body types of controllers with easy access to critical and frequently used controls placed within eye distance.

D13.2.6. Anthropometry in the environment whereby the controller is working at his most comfortable position with ample space through the adjusting of his workspace must also be catered.

D13.2.7. The layout of equipment must fulfil its roles and responsibilities and not placed for the sake of being there and should be configured to minimize and prevent distractions.

D13.2.8. Lighting in the form of ambient light and glare must be taken into account be it in a radar or aerodrome environment so that all the displays and controls remain visible for controlling without any distraction.

D13.2.9. The thermal environment must be maintained at a comfortable level through sound management of temperature and air flow rate for controlling.

D13.2.10. Noise levels within workstations should be kept at a minimum less it becomes a distraction, causing important information and messages to be missed out by controllers.

D13.2.11. Visual displays containing information for controllers must factor in human capabilities in how they see and process the information for it to be of good use. Hence, visual displays must be clear and visible with information portrayed in the correct colour contrast, colour differentiated

to avoid ambiguity if need be, with symbols and alphanumeric having the appropriate spacing for easy deciphering.

D13.2.12. Input devices (keyboard, mouse) in which the controller executes all control actions must also be easy to use with the necessary response sensitivity and feedback.

D13.2.13. An essential ingredient of ATC is communications and controllers must be aware its uses and whether the system is functioning properly in his transmissions out to the pilot. Standard radio telephony should be articulated slowly and clearly at all times to prevent any ambiguity and controllers must always verify again if there is any doubt in the content of transmission.

D14. **RECOMMENDATIONS:**

D14.1. On the basis of airspace capacity & workload assessment the ANSP in coordination with concerned Directorate shall review / determine Human Resource requirement.

D14.2. For establishing the best ATC system the **SHELL** model must be taken into considerations.

D14.3. Airspace Management is a qualified post, well trained & competent personnel shall be deployed, and frequency for review of Airspace should be determined & documented.

D14.4. Human capability factors varies from person to person, therefore Airspace Design & ATS routes structure should be kept simple (as far as practicable), and frequent reciprocal climb & Descent, and blind crossings should be avoided.

D14.5. Best working environment with minimal distraction(s) to ATC should be provided.

D14.6. Training aspect should be given due priority, and OJT Instructor (OJTI) declaration mechanism shall be developed and strictly followed, so that Quality of OJT can be ensured.

E. EVIDENCES (ACRONYMS / RECORDS / REFERENCES)

E1. **ACRONYMS:**

ACC : Area Control Centre
ASC : Air Safety Circular
ATC : Air Traffic Control
ATS : AirTraffic Service
COO : Chief Operations Officer
CPDLC : Controllers Pilot Data Link communication
FTO : Facility Training Officer
OJT : On the Job Training
OJTI : On the Job Training Instructor
PBN : Performance Based Navigation
RFC : Radar Facility Chief
VHF : Very High Frequency

E2. **RECORDS:**

NIL

E3. **REFERENCES:**

E3.1.	ICAO Doc-9758	Human Factors for ATM System
E3.2.	ICAO Cir-241	Human Factors Digest- Human Factors in ATC
E3.3.	EASA	Human Factors by EASA
E3.4.	SkyBrary	Human Factors in ATC

IMPLEMENTATION:

This Air Safety Circular is implemented with effect from 30th June 2020.

--S/d--

(HASSAN NASIR JAMY)
Director General
Pakistan Civil Aviation Authority

Dated: - 4th July, 2020
File No. HQCAA/1111/112/ARAN/I

(ZUBAIR GHAZI)
Director Airspace & Aerodrome Regulations
Dated: - 1st June, 2020
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