SIERRA LEONE CIVIL AVIATION AUTHORITY

ADVISORY CIRCULAR

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Human Factor Principles

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1 GENERAL

The Sierra Leone Civil Aviation Authority's Advisory Circulars contains information about standards, practices and procedures that the Authority has found to be an Acceptable Means of Compliance (AMC) with the associated Regulations.

An AMC is not intended to be the only means of compliance with a Regulation, and consideration will be given to other methods of compliance that may be presented to the Authority

Information considered directive in nature is described in this AC in terms such as "shall" and "must", indicating the actions are mandatory. Guidance information is described in terms such as "should" and "may" indicating the actions are desirable or permissive, but not mandatory

1.1 Purpose

This Advisory Circular provides guidelines, acceptable to the Authority, for the improvement of safety in aviation by ensuring Aerodrome Operators become more aware and responsive to the importance of human factors in civil aviation operations through the provision of practical human factor materials and other measures, with regards to the role of human factors in the present and future operational environments.

1.2 Description of Changes

This AC is the first to be issued on this subject

1.3 Reference

(a) SLCAR Part 14A - Aerodrome Design and Operations.

(b) ICAO Doc 9137 – Airport Services Manual, Part 1; and

(c) ICAO Doc 9683 – Human Factors Training Manual.

1.4 Cancelled Documents

Not Applicable

2 INTRODUCTION

2.1 General

(a) Human performance is cited as a causal factor in the majority of accidents and incidents. If the accident rate is to be decreased, Human Factor issues in aviation must be better understood and Human Factors knowledge more broadly and proactively applied. By pro-action it is meant that Human Factors knowledge should be applied and integrated during the systems design and certification stages, as well as during the operational personnel certification process, before the systems and the people become operational. The expansion of Human Factors awareness presents the single most significant opportunity to make aviation both safer and more efficient.

(b) The subject of human factors is about people in their working and living environments, their relationship with equipment, procedures and the environment. Just as importantly, it is about their relationships with other people. Human Factors involve the overall performance of human beings within the aviation system; it seeks to optimize people's performance through the systematic application of the human sciences, often integrated within the framework of system engineering. Its twin objectives can be seen as safety and efficiency.

(c) Human Factors is essentially a multidisciplinary field, including but not limited to: psychology; engineering; physiology; sociology; and anthropometry.

2.2 Meaning of Human Factor

(a) Human Factors is defined as a "multidisciplinary effort to generate and compile information about human capabilities and limitations and apply that information to equipment, systems, facilities, procedures, jobs, environments, training, staffing, and personnel management for the safe, comfortable, and effective human performance". The human element is the most flexible, adaptable and valuable part of the aviation system, but it is also the most vulnerable to influences which can adversely affect its performance. Throughout the years, most of the accidents and incidents have resulted from less than optimum human performance. This has commonly been classified as human error.

(b) The term "human error" is of no help in accident prevention because although it may indicate WHERE in the system a breakdown occurs, it provides no guidance as to WHY it occurs. An error attributed to humans in the system may have been design-induced or stimulated by inadequate training, badly designed procedures or the poor concept or layout of checklists or manuals. Further, the term "human error" allows concealment of the underlying factors which must be brought to the fore if accidents/incidents are to be prevented.

(c) An understanding of the predictable human capabilities and limitations and the application of this understanding are the primary concerns of Human Factors. Human Factors has been progressively developed, refined and institutionalized, and is now backed by a vast store of knowledge which can be used in enhancing the safety of the complex system which is today's civil aviation.

(d) It encompass a wide spectrum of activities, ranging from training and operations to station routine and audits. The study of human factors principles can be described as both an art and a science and must be associated with the entire range of RFF and Emergency Planning activities in order to achieve a higher level of professionalism,

operational effectiveness and standards for safety.

2.3 Regulatory Standards

(a) Paragraph 9.1.6, 9.2.43 and 10.1.2 of the Sierra Leone Civil Aviation (Aerodromes) Regulation - Part 14A, mandates an aerodrome operator to observe human factors principles in the development of the Aerodrome Emergency Plan, RFF Training Programme and the design & application of an aerodrome maintenance programme.

(b) This AC has been formulated to provide guidance to aerodrome operators, ensuring incorporation of human factor principles in the development of the above documents, and implementation thereto, in order to ensure that concerned personnel are conversant with the application of human factors.

2.4 The SHEL Model

(a) It is helpful to use a model to aid in the understanding of Human Factors, as this allows a gradual approach to comprehension. The **SHEL** concept/model (the name being derived from the initial letters of its components, **S**oftware, **H**ardware, **E**nvironment, **L**iveware) is a practical diagram that uses blocks to represent the different components of Human Factors. The model can then be built up one block at a time, with a pictorial impression being given of the need for matching the components.

The following interpretations are suggested: Liveware (human), Hardware (machine, equipment etc.), Software (plans, procedures, documentation etc.), and Environment (the situation in which the L-H-S system must function). This building block diagram does not cover the interfaces which are outside Human Factors (hardware-hardware; hardware-environment; software-hardware) and is only intended as a basic aid to understanding Human Factors.

(b) In the centre of the model is a person (Liveware), see figure 1 below, the most critical as well as the most flexible component in the system. People are subject to considerable variations in performance and suffer many limitations, most of which are now predictable in general terms. The edges of this block are not simple and straight, and so the other components of the system must be carefully matched to them if stress in the system and eventual breakdown are to be avoided.

The Liveware (Human) is the hub of the SHEL model of Human Factors. The remaining components must be adapted and matched to this central component.

(c) In order to achieve this matching, an understanding of the characteristics of this central component is essential. Some of the more important characteristics are the following:

(i) Physical size and shape.

(ii) Physical needs.

(iii) Input characteristics

(iv) Information processing.

(v) Output characteristics.

(vi) Environmental tolerances.

Note: further details of these characteristics are found in ICAO Doc 9683 Human

Factors.

2.4.1 SHEL Model Interfaces

(a) **Liveware-Hardware**. This interface is the one most commonly considered when speaking of human-machine systems: design of seats to fit the sitting characteristics of the human body, of displays to match the sensory and information processing characteristics of the user, of controls with proper movement, coding and location. The user may never be aware of an L-H deficiency, even where it finally leads to disaster, because the natural human characteristic of adapting to L-H mismatches will mask such a deficiency, but will not remove its existence. This constitutes a potential hazard to which designers should be alert. With the introduction of computers and advanced automated systems, this interface has repositioned itself at the forefront of Human Factors endeavours.

(b) **Liveware-Software**. This encompasses humans and the non-physical aspects of the system such as procedures, manual and checklist layout, symbols and computer programmes. Liveware-Software problems are conspicuous in accident reports, but they are often difficult to observe and are consequently more difficult to resolve (for example, misinterpretation of checklists or symbols, non-compliance with procedures, etc.).

(c) **Liveware-Environment**. The L-E section of the SHEL model involves the interaction that occurs between the human operator and the internal (Workplace) and external (Surrounding) environments. It involves adapting the environment to match human requirements.

(d) **Liveware-Liveware**. This is the interface between people. Training and proficiency testing have traditionally been done on an individual basis. If each individual team member is proficient, then it is assumed that the team consisting of these individuals would also be proficient and effective. However, this is not always the case and for many years attention has increasingly turned to the breakdown of teamwork. Maintenance technicians and other operational personnel function as groups and group influences play a role in determining behaviour and performance. In this interface, we are concerned with leadership, teamwork and personality interactions. Staff/management relationships are also within the scope of this interface, as corporate culture, corporate climate and company operating pressures can significantly affect human performance.

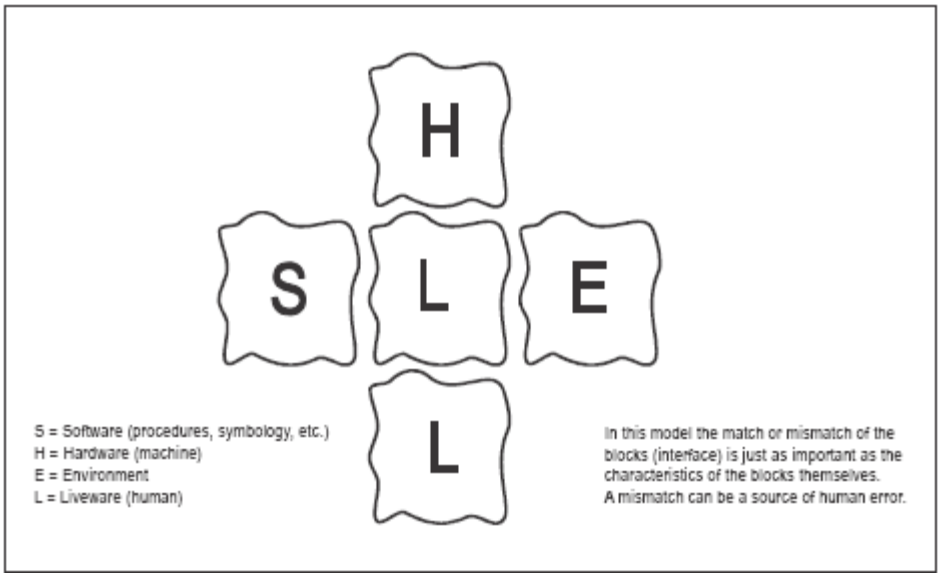

Figure1. The SHEL model as modified by Hawkins

2.4.2 Errors at the Model Interfaces

Each of the interfaces in the SHEL model has a potential of error where there is a mismatch between its components. For example:

(a) The interface between Liveware and Hardware (human and machine) is a frequent source of error: knobs and levers which are poorly located or lack of proper coding create mismatches at this interface.

(b) In the Liveware-Software interface, delays and errors may occur while seeking vital information from confusing, misleading or excessively cluttered documentation and charts.

(c) Errors associated with the Liveware-Environment interface are caused by environmental factors (noise, heat, lighting and vibration) and by the disturbance of biological rhythms resulting in irregular working/sleeping patterns.

(d) In the Liveware-Liveware interface, the focus is on the interaction between people because this process affects personnel effectiveness. This interaction also includes leadership and command, and shortcomings at this interface reduces operational efficiency and cause misunderstandings and errors.

3 INDUSTRY NEED FOR HUMAN FACTOR

The industry's need for Human Factors is based on its impact on two broad areas, which interrelate so closely that in many cases their influences overlap and factors affecting one may also affect the other. These areas are:

(i) Effectiveness of the system (Safety and Efficiency)

(ii) Well-being of operational personnel.

3.1 Well-being of operational personnel

Three of the many factors which may influence the well-being of operational personnel are fatigue, body rhythm disturbance, and sleep deprivation or disturbance. These are briefly explained below. Other factors affecting **physiological or** psychological well-

being include temperature, noise, humidity, light, vibration, workstation design and seat comfort.

(a) **Fatigue ─** Fatigue may be considered to be a condition reflecting inadequate rest, as well as a collection of symptoms associated with displaced or disturbed biological rhythms. Acute fatigue is induced by long duty periods or by a string of particularly demanding tasks performed in a short term. Chronic fatigue is induced by the cumulative effects of fatigue over the longer term. Mental fatigue may result from emotional stress, even with normal physical rest. Like the disturbance of body rhythms, fatigue may lead to potentially unsafe situations and a deterioration in efficiency and well-being. Hypoxia and noise are contributing factors.

(b) **Body rhythm disturbance ─** Safety, efficiency and well-being are affected by the disturbed pattern of biological rhythms typical of today's long-working hours. Maintenance technicians and RFF personnel with frequently changing shift schedules can suffer a similar deterioration in their performance.

(c) **Health and performance ─** certain pathological conditions - gastrointestinal disorders, heart attacks, etc. have caused sudden failure on human performance. Physical fitness may have a direct relationship to mental performance and health. Improved fitness reduces tension and anxiety and increases self-esteem. It has favourable effects on emotions, which affect motivation, and is believed to increase resistance to fatigue.

(d) **Stress ─** Stress can be found in many jobs, and the aviation environment is particularly rich in potential stressors. Of main interest is the effect of stress on performance. In the early days of aviation, stressors were created by the environment: noise, vibration, temperature, humidity, acceleration forces, etc., and were mainly physiological in nature. Today, some of these have been replaced by new sources of stress: irregular working and resting patterns and life events.

(e) **Sleep -** Sleep has a restorative function, and is essential for mental performance. Sleep deprivation and disturbance can reduce alertness and attention. When this phenomenon is recognized, alertness and attention can at least be partly restored by the application of extra effort. The relevance of this phenomenon to safety is obvious.

Note - The above are minimum guidelines and not exhaustive. The aerodrome operators may adopt any additional human factors principle, which in the opinion of the operator, would enhance efficiency and safety in execution of any plan or procedure.

4 HUMAN FACTOR IN RESCUE AND FIREFIGHTING SERVICES

4.1 General

(a) A competent and professional RFF service must rely on a comprehensive and relevant set of training modules, coupled with an internal audit framework to regularly check the effectiveness and efficacy of these programmes. However, in the process of promulgating the training framework, one must not be overly fixated with the "hard" skills component of the training outcomes. Thought must be given to the "soft" human factor components during the promulgation and execution of the training programmes. Similarly, any assessment of the operational effectiveness of RFF personnel must take into account human factor principles such as team

coordination.

(b) Human factors principles are not only confined to the development of RFF training programmes; consideration must also be given to the formulation of drawer plans such as the aerodrome emergency plan and the unit tactical plans of the RFF service.

(c) The application of human factor principles to RFF services can therefore be classified into two broad pillars as follows:

(i) operational effectiveness and standards; and

(ii) safety and well-being of RFF personnel

4.2 Operational Effectiveness and Standards

(a) As the success of any RFF operations relies very much on teamwork, the importance of building mutual trust and team coordination among staff during training cannot be overstressed (Liveware vs. Liveware). Training must therefore be designed to guide RFF personnel towards achieving these objectives.

(b) In order for RFF training to be as realistic as possible, live fire training is crucial in helping RFF personnel acclimatize to a heated and smoke-filled environment (Liveware vs. Environment), so that in the event of an actual emergency, RFF personnel will be able to execute their tasks more confidently and effectively. Where possible, simulators replicating different facades of RFF operations (e.g. vehicle driving and operations; command and control, etc.) should be made available for RFF personnel to be trained in a controlled, safe and realistic environment.

(c) RFF operations require firefighting personnel to be proficient in the operations of fire vehicles and other rescue equipment (Liveware vs. Hardware). This is crucial as it enables the RFF service to control any aircraft fires swiftly and effectively, in order to facilitate the evacuation and rescue of survivors. The airport fire vehicle is therefore an extremely vital asset that must be designed to take into account the human instinct and intuition of the vehicle operator. Therefore, RFF services must place sufficient emphasis on the design ergonomics of fire vehicles during the prefabrication stage in order to optimize human performance during training and operations.

(d) The design of fire stations is another important factor that could affect the human performance of RFF personnel when responding to aircraft accidents or incidents (Liveware vs. Environment). This is especially relevant for large aerodromes which provide a high category of runway fire protection. Fire stations in such aerodromes are typically larger, thus requiring RFF personnel to travel a longer distance before reaching their fire vehicles. Such considerations must therefore be taken into account during the design phase of a fire station so that the RFF service is able to meet the stipulated response time in the event of an aircraft emergency.

(e) Communication is possibly the most important human factor in RFF operations. Operational readiness and safety standards will be compromised without effective communication among RFF personnel, air traffic control and pilots. Therefore, the type of communications equipment and the transmission of messages must allow critical information to be conveyed, assimilated, processed and executed (Liveware vs. Hardware and Liveware vs. Liveware).Therefore, RFF training programmes must incorporate components to ensure the accurate and timely transmission of information to avoid miscommunication which could result in serious consequences.

(f) The RFF service will need to be kept up-to-date with the constant development and innovation of more sophisticated rescue equipment and fire vehicles (Liveware vs. Hardware). It is equally important for RFF personnel to be well acquainted with the different configurations of various aircraft types operating at the particular aerodrome. Improving the knowledge of RFF personnel in these areas would indirectly enhance human performance during a response to any aircraft emergency.

(g) The RFF industry is a highly specialized one therefore, the management and leadership team of RFF services are compelled to promulgate a system of self-audit. Such systems must not only include the ratings and revalidation of individual standards. More importantly, as we recognize the importance of teamwork and team coordination in RFF operations, RFF services should place heavy emphasis on the collective performance of an RFF outfit during such an audit (Liveware vs. Liveware). The audit can then reveal observations and findings about the effects of human behaviour on pre-stipulated procedures. Similarly, such audits can also highlight human reaction to any unforeseen circumstances in the form of disruptions during a unit proficiency test. Results from the audits can then be used to modify, tweak and improve training programmes in order to enhance human performance during RFF operations.

4.3 Safety and Well-being of RFF Personnel

(a) In the aftermath of an aircraft accident, it is often necessary to provide psychological treatment for the survivors. However, the airport operator and RFF services must also not neglect the mental and psychological well-being of emergency responders such as RFF personnel who may suffer from post-traumatic stress disorders. Appropriate counselling of psychological therapy should be provided to RFF personnel who responded to such emergencies and who subsequently are not able to cope with the stress they faced thereafter. Such situations may arise from the gruesome sight of a crash scene making them unable to carry on with their normal lives. It will therefore be essential to also provide psychological treatment for RFF personnel after a major crisis (Liveware vs. Liveware) both from a welfare perspective and also from a business continuity standpoint. Such treatment and counselling can be provided by other RFF or airport personnel who have undergone the proper training, or more likely, by external medical institutions. Arrangements for the latter should then be formalized in the form of mutual aid agreements or can be incorporated into the airport emergency plan (Liveware vs. Software).

(b) The nature of the RFF job/role poses numerous potential hazards (Liveware vs. Environment). The risk of inhalation of carbon or smoke particles when extinguishing a fire, either during an incident or during training, is very high. Therefore, RFF services must provide all firefighters with the appropriate personal protective equipment (PPE) such as self-containing breathing apparatus (SCBA), helmets, boots, protective clothing, etc. In relation to day-to-day operations, the uniform worn by RFF personnel should also be of a suitable material depending on the local climate and conditions.

(c) To ensure that RFF personnel are able to perform their roles effectively, thought needs to be put into designing an appropriate physical fitness programme to condition them for the physical rigours of the job (Liveware vs. Environment). In the process of designing any physical fitness programmes, due consideration must be given to individual human limitations. RFF management must also accept that not all personnel can perform at the same level of physical fitness standards. The

key is to establish the minimum physical fitness requirements of a firefighter and design a programme that can best replicate these demands.

(d) Noise is an important human factor (Liveware vs. Environment) that is omnipresent in an airport environment and cannot be ignored. Most fire stations are located within close proximity of the runway and aircraft movement areas, thus exposing RFF personnel to constant loud noises. Besides posing as disruptive interferences during the transmission of messages, long term and regular exposure to noise can have serious implications on one's health (e.g. temporary, partial or permanent hearing loss). To address this issue, RFF services should issue and mandate the use of suitable hearing protection devices. In addition, personnel who are subjected to constant exposure to noise should be sent for regular noise induced deafness (NID) hearing tests.

(e) Fatigue is one important factor that directly affects human performance and is greatly influenced by the shift system of RFF services (Liveware vs. Software). Besides the need to conform to State labour rules and regulations, there must be considerations to ensure that RFF personnel can have sufficient rest despite the need to be on 24-hour operational readiness at most airports.

(f) A leader is an individual whose ideas and actions influence the thoughts and behaviours of others (Liveware vs. Liveware). Through the use of motivation and persuasion, and an understanding of the goals and desires of the team, the leader becomes an agent of change and influence. Skilled leadership may be needed to understand and handle various operational, training and administrative situations. For instance, personality clashes within a team complicate the task of a leader and can affect both safety and efficiency.

5 HUMAN FACTORS IN AERODROME EMERGENCY PLANNING

(a) Emergency planning is the process of preparing the aerodrome to cope with an emergency occurring at the aerodrome or in its vicinity. The objective of emergency planning is to minimize the effect of an emergency particularly in respect of saving lives and maintaining aircraft operations.

(b) Basic human factor principles shall be included in procedures and processes for emergency response, including how people interact with tasks, other people, machines, information sources and the environment, with the consideration that humans have limitations and capabilities.

(c) Examples of human factor considerations include:

(i) Developing checklists for agencies and operators (this then steers a person down a prescribed path or behaviour);

(ii) Clear labelling and signage for the Emergency Operations Centre (EOC) or control post components to reduce confusion (want to reduce thinking and opportunities for incorrect decisions). Clear identification signs to aid the location of Rendezvous point;

(iii) Nominating a person who is responsible for the AEP (create ownership/leadership so the AEP remains updated) ;

(iv) The layout of the AEP is important (this is critical to providing an effective and efficient plan);

(v) Use of standby mobile trailer to allow immediate conveyance of all necessary items such as blankets, stretchers, body bags, hand gloves to the accident site and to forestall any critical time lag that would otherwise arise from transfer of the items from their storage space to a vehicle during an emergency.

(d) Within the EOC, the following features could critically impact on human limitations and capabilities:

(i) Provision of availability board in the EOC to reduce the number of verbal exchanges;

(ii) Creation of individual lockers for every member of the EOC for storage of vital items such as walkie-talkie and chargers

(iii) Effective access control to prevent distractions and unwanted individuals within the EOC

(iv) Partitioning of the walls of the EOC

(v) The use of headsets by members of the EOC

(e) The AEP shall have specific procedures and specialist agencies involved when the aerodrome is located near large bodies of water, swamps or where the approach\departure areas are over water. This could include use of the coast guard, divers, boats\hovercraft and the local harbourmaster. These specialist rescue services shall be involved in testing of the emergency procedures on a regular basis.

6 HUMAN FACTORS IN INVESTIGATION

(a) The investigation of Human Factors in incidents should be an integral part of an investigation and its resulting report. Humans do not act alone; they are but one element of a complex system. Often, the human is the last barrier that stops the sequence of events from causing an incident.

(b) The formal definition of an accident is useful in determining the criteria for reporting the occurrence to the Sierra Leone Aircraft Accident and Incident Investigation Bureau (SLAAIIB) and in identifying when an investigation should be conducted. The extent of an investigation will be governed by the SLAAIIB's legislative mandate.

Note: For detailed guidance on investigation of human factor in accidents and incidents, refer to ICAO Doc 9683, Human Factor.

7 CONTROL OF HUMAN ERROR

(a) To contain and control human error, one must first understand its nature. There are basic concepts associated with the nature of human error: the origins of errors can be fundamentally different; and the consequences of similar errors can also be significantly different. While some errors are due to carelessness, negligence or poor judgement, others may be induced by poorly designed equipment or may result from a normal reaction of a person to a particular situation. The latter kind of error is likely to be repeated and its occurrence can be anticipated.

(b) The control of human error requires two different approaches. First, it is necessary to minimize the occurrence of errors by: ensuring high levels of staff competence; designing controls so that they match human characteristics; providing proper checklists, procedures, manuals, maps, charts, SOPs, etc.; and reducing noise, vibration, temperature extremes and other stressful conditions. Training programmes aimed at increasing the co-operation and communication between personnel will reduce the number of errors (the total elimination of human error is a difficult goal, since errors are a normal part of human behaviour).

The second avenue to the control of human error is to reduce the consequences of the remaining errors by cross-monitoring and personnel co-operation. Equipment design which makes errors reversible and equipment which can monitor or complement and support human performance, also contributes to the limitation of errors or their consequences.

7.1 Motivation

(a) Motivation reflects the difference between what a person can do and actually will do, and is what drives or induces a person to behave in a particular fashion. Clearly, people are different and driven by different motivational forces. Even when selection, training and checking ensure capability to perform, it is motivation that determines whether a person will do so in a given situation.

(b) There is a relationship between expectancy and reward as motivators, since the utility of a reward and the subjective probability of its achievement determines the level of effort which will be applied to obtain the reward. This effort must be accompanied by the proper skills. It is important for high performers to see that they are in a better position than poor performers to achieve a reward, otherwise motivation may decline. Job satisfaction motivates people to higher performance.

(c) Modifying behaviour and performance through rewards is called positive reinforcement; discouraging undesirable behaviour by use of penalties or punishment is called negative reinforcement. Even though positive reinforcement can be more effective in improving performance, both must be available to management. Different responses are to be expected from different individuals in relation to positive and negative re-enforcers. Care should be taken not to generate an effect which is opposite from that which is intended.

7.2 Documentation

Inadequacies in aviation documentation have a twofold impact: there is a monetary aspect associated with increased time or the impossibility of performing a particular task and there is also a safety aspect. With reference to documentation, some basic aspects require Human Factors optimization:

(i) written language, which involves not only vocabulary and grammar, but also the manner in which they are used;

(ii) typography, including the form of letters and printing and the layout, has a significant impact on the comprehension of the written material;

(iii) the use of photograph diagrams, charts or tables replacing long descriptive text is advantageous to help comprehension and maintain interest. The use of colour in illustrations reduces the discrimination workload and has a motivational effect;

(iv) the working environment in which the document is going to be used has to be considered when print and page size are determined (for example, an airport chart which is too small may induce interpretation error).