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SAFETY NOTICE

SUBJECT: ENHANCING SITUATIONAL AWARENESS IN THE CONTROL TOWER

GENERAL: Safety Notices (SNs) are issued by the Civil Aviation Authority – Macao, China to convey advisory information to Macao aviation entities to enhance safety. SNs contain safety-related recommendations, guidance and/or industrial best practices to specific subjects which may or may not have been addressed by established requirements and regulations.

RELATED REGULATIONS: AC/ATS/006 Manual of Standards – Air Traffic Management

APPLICABILITY: This SN applies to Macao Air Traffic Service Provider.

CANCELLATION: This SN is the first SN issued on this subject.

REFERENCES: The following material was referred to for the development of this SN:

- Cooperative Development of Operational Safety & Continuing Airworthiness Programme – South East Asia (COSCAP-SEA) Advisory Bulletin CSEA 015

1. Introduction

1.1 Human performance is cited as a causal factor in the majority of accidents. 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. The most important Human Factors issue in regards to human-technology interface is the ability of the human operator to maintain situational / system awareness. It is an established fact that human-technology interfaces have not always been intuitive. Non-intuitive, 'opaque' interfaces lead to operational complexity which often forces the operator to allocate increased attention to maintain an adequate mental model of the situation / system status. This becomes the breeding grounds for loss of situational awareness, decreased system performance and eventually human error and safety breakdowns.

1.2 It may not always be clear what exactly is meant by the term "Situational Awareness" (SA). In particular there appears to be confusion between thinking of SA as simply knowing the relative position of other traffic in the vicinity of one's own aircraft (pilots), or "having the picture" or awareness of the traffic situation (controllers), as opposed to

knowing what is happening in a far wider sense. The accepted definition of SA from the scientific community would seem to support the wider interpretation of the phrase: "Situational Awareness is 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". The guidance material discusses in detail the elements that are relevant to Situational Awareness in the Air Traffic Control environment. For each element, the relationship to the design, implementation and operation of an ATM system is also highlighted.

1.3 The objective of this safety notice is to provide practical guidance to those concerned with ATC systems. It is intended to show how human capabilities and limitations can influence task performance and safety in ATC.

2. Elements of Situational Awareness in ATC

2.1 The elements listed below are highly dynamic and present subtle to large changes that may occur at short notice, and that can or will influence the way a controller works at any particular moment. How these changes interact with a controller's SA may only be recognized after having gained considerable experience in ATC in general, and at a specific location in particular:

- personal factors;
- weather;
- aerodrome infrastructure;
- individual differences;
- traffic;
- operators and pilots;
- environment;
- navigational aids;
- aircraft performance;
- equipment; and
- adjacent units.

(a) Personal Factors

i) A person's physical and mental state will very much determine the interaction with other persons and will also influence the performance of certain tasks by that person. Simply put, someone who does not feel well will probably be performing in a less-than-optimal fashion.

ii) In ATC, typical physical comfort factors affecting individual performance include the ambient temperature (too cold/too hot), lighting (too bright/too dark), humidity, as well as the noise level at the working place. Knowing that any of these factors is present, or could occur, when at work helps to shape the SA of a controller. For example: when realizing that the noise level is higher than usual, a controller may wish to give extra care to ensuring that radiotelephony (R/T) read-backs are correct. Similarly, the controller may take more care to ensure that the microphone is close to the mouth.

iii) Another important personal factor is being aware of personal stress level. A controller with a high SA will realize when stress (usually caused by external factors) influences performance and may arrange to be relieved from the working position earlier or more often than usual.

iv) The last personal factor that could be considered is fatigue. Recognizing fatigue is not easy, but recognizing the conditions that can cause fatigue increases the SA. The onset of fatigue should be expected after working a high number of consecutive shifts, after a period with intensive physical activity during off-duty hours, or towards the end of a single nightshift. If such conditions apply, it may not be prudent to work the busiest position in the operations room if less busy positions are available. A controller with a high SA will know that when fatigue could be a factor all actions should be double-checked, and high attention demanding traffic situations should be avoided, if possible.

v) Consequences for the design, implementation and operation of ATM systems:

- In the design of ATC workstations, and of the entire ATC operations room with multiple workstations, ergonomic principles should be taken into consideration.

- When analyzing and developing safety-related working conditions for air traffic controllers, consideration must be given to the reduction of stress- and fatigue-inducing factors.

(b) Weather

i) SA is heightened by knowing the current weather and the forecast trend for at least the duration of a controller's shift. For example: changes in wind direction may involve runway changes. The busier the traffic, the more crucial becomes the timing for a runway change. A controller will plan strategies to make the change with a minimal disruption to the traffic flow. For en-route controllers, knowing areas of significant weather will help to anticipate requests for re-routings or circumnavigation.

ii) Appropriate knowledge of local weather phenomena (e.g. turbulence over mountainous terrain; fog patterns, intensity of thunderstorms, etc.) and/or sudden weather occurrences like windshear or microbursts contributes towards greater SA. A controller with a high SA will apply more effective solutions in special circumstances.

iii) Consequences for the design, implementation and operation of ATM systems:

- Provisions should be included in systems design so that updated and accurate weather information is available to air traffic controllers at all times.

- When designing traffic situation displays, available weather data should be integrated in real time and in graphical format on the display.

(c) Aerodrome Infrastructure

i) Constant awareness of runway availability at the aerodrome(s) under the jurisdiction of a controller allows adequate response in case of emergencies requiring an immediate diversion. Such awareness should include not only the runway physical characteristics but also information on work in progress that might preclude runway use at any particular time.

ii) For aerodrome controllers, awareness of work in progress is not limited to runways but must also include taxiways and aprons, as well as special considerations such as temporary obstructions to visibility from the tower by construction work.

iii) Knowing how the aerodrome looks from a pilot's point of view - not just during the approach but also when taxiing - increases the SA of aerodrome controllers. Which visual 'aids (e.g. lighting, signs) can be referred to when explaining a required routing to a pilot? A controller who possesses such awareness will be more successful in transferring routing information.

iv) Consequences for the design, implementation and operation of ATM systems:

- Provisions should be included in the design of control facilities so that information on the status of aerodromes under their jurisdiction is available to controllers at all times.

- Training practices should provide the possibility to aerodrome controllers to regularly familiarize themselves with the visual aids at their airport.

(d) Individual Differences

i) Controller performance is expected to meet minimum standards. Controllers must perform according to these minima, but there are differences in the degree to which each individual controller performs in excess of the minimum standards. At any given facility, controllers are aware of these differences and will subconsciously or even consciously take each other's strengths and weaknesses into account when working together.

ii) Humans, unlike machines, do not perform exactly the same way over and over again. One of the ways in which this human attribute manifests itself in ATC is the feeling of "being a little rusty" after not having worked in a certain position for a certain time (even though that time is within the regulatory requirement). Recognition of this variation in performance level among people is an important component of SA.

iii) The social gradient influences each specific work situation within ATC facilities. This social gradient is also found in flight decks, where a situation in which a young captain working with an older first officer is different from a situation in which an older captain is working with a younger first officer. Substituting "captain" by "supervisor" and "first officer" by "controller" allows to see how social gradients could affect an ATC work situation and influence SA.

iv) Another factor that needs to be considered involves on-the-job training (OJT). Knowing that there is training in progress at an adjacent position, or at a position or facility with which frequent coordination is necessary, will influence the way a controller works. The degree of influence can be subtle, such as in adopting a slightly more formal phraseology during coordination, or overt, such as in accepting, for the benefit of the training, proposed solutions for traffic conflicts or handovers that normally would be regarded as less favourable.

v) Consequences for the design, implementation and operation of ATM systems:

- ATC training programmes in general should include teamwork training. Training programmes associated with the implementation of advanced systems should in particular include teamwork training.

(e) Traffic

i) Awareness of the exact traffic situation is a very important element of a controller's SA. In addition to "having the picture" of where all aircraft under the controller's jurisdiction are and will be next, it is equally important to be aware of the development of the traffic situation. Is it the beginning of a peak period, or is it the end of it? Will there be additional traffic, such as photoflights, training flights, calibration flights and so forth? Any of these aspects can influence the way in which a controller will handle traffic.

ii) A controller's awareness of the normal traffic patterns will help determine options for solving conflicts. These patterns are not necessarily the same as the airways, standard instrument arrivals (STARs) and/or standard instrument departures (SIDs) depicted on maps, which implies that a controller may only learn them over time, or by experience.

iii) A further aspect that may influence a controller's SA is awareness of the flow of the traffic under management. If a considerable amount of traffic is expected to move in the same general direction (e.g. to or from one particular aerodrome; north/east/south/westbound; and so forth), solutions different from those when traffic is moving randomly will be applied.

iv) Consequences for the design, implementation and operation of ATM systems:

- Design and organizational practices should ensure that all relevant information on the traffic situation and its development is available to the controller at all times.

(f) Operators and Pilots

i) Viewing surface operations at unfamiliar aerodromes is not unlike being in a strange city for the first time. There are signs providing names and directions, as well as maps with routes, but it takes time to properly interpret all that information. It is always useful if a person familiar with the place can provide further instructions. Aerodrome controllers, especially ground movement controllers, are often in the role of the "familiar person". If their SA is high, they will recognize operators and pilots with a low familiarity level with the local circumstances, and they can provide adequate assistance. (Recognizing

potentially unfamiliar operators is relatively easy by looking at the company or aircraft colours or may be evident from the call sign. Recognizing potentially unfamiliar pilots could be more difficult.) To a certain extent this also applies to area and approach controllers, with respect to their familiarity with specific, national or local procedures.

ii) "Corporate culture", in terms of the differences among airlines, has received considerable attention in aviation safety circles over the last few years. Subconscious awareness of these differences exists among controllers, who have learned to take the subjective performance level of the various operators into account. Solutions or manoeuvres that are acceptable to (and therefore applied to) one operator are not proposed to other operators. This awareness is part of a controller's SA.

iii) A third aspect, distinct from and yet closely linked to the other two mentioned here, is worth mentioning: a pilot's R/T level. Controllers get important cues from the degree of proficiency in R/T that a pilot displays, both in procedure and in vocabulary, and - given the right degree of SA - will adjust their R/T accordingly with respect to the complexity of instructions and/or procedures.

iv) Consequences for the design, implementation and operation of ATM systems:

- Training programmes for air traffic controllers should include awareness of the importance of specific aspects of differences between operators and between individual pilots.

(g) Environment

i) Although the environment could be considered of a semi-permanent nature, and therefore irrelevant as an element of SA, there are certain aspects that are important enough to warrant mention. Aerodrome controllers need, for example, to be aware of the significant obstacles at and around their aerodrome. This includes keeping track of new construction in the vicinity and the machinery associated with construction or maintenance work at airports.

ii) Awareness of the terrain characteristics could lead a controller to choose different solutions in given situations to those that might have been applied without that awareness. This could relate also to the familiarity level of the operator involved.

iii) Awareness of the noise sensitivity of populated areas in the environment of an aerodrome may be a factor when certain runway combinations must be considered. Even when not many options are available, the environment may dictate certain changes in the runway use to be effected at certain times of day

(curfews; landing/departure runway change; and so on). Awareness of the part of the environment affected by traffic patterns or runway(s) in use at any time is therefore part of an aerodrome controller's SA.

iv) Consequences for the design, implementation and operation of ATM systems:

- When designing traffic situation displays, the inclusion of maps depicting relevant terrain, obstacles and noise sensitive areas should be considered.
- When designing advanced ATM systems, the inclusion of a minimum safe altitude warning (MSAW) system should be considered.
- Organizational procedures should be in place to keep air traffic controllers constantly updated of temporary changes in the surrounding environment.

(h) Navigational aids

i) An obvious aspect of this element is availability, i.e. whether the navigational aid (navaid) is serviceable or not, but there are further considerations. A navaid (or way-point) may be situated in the area for which a controller is responsible, but pilots may not have immediate access to its frequency or coordinates. If a flight is following a standard instrument departure (SID) that is based on specific navaids and is cleared to proceed to a navaid or way-point that is not specified in the SID, the pilots might be unable to locate the navaid. A controller with a high SA either will use navaids and way-points that are likely to be familiar to the pilots concerned or will use radar vectors to overcome these problems.

ii) Similarly, controllers need to consider the performance level of navaids. Navaids should work according to operational specifications, but this is not always the case even though the aids meet the required technical specifications. Experienced controllers will develop awareness of specific conditions impairing navaid performance. This awareness is part of their SA.

iii) Consequences for the design, implementation and operation of ATM systems:

- Equipment design and organizational procedures should ensure that:
  - Information on the status of navigational aids is available to the controller at all times.
  - Procedures applicable in case of failure of navigational aids are established.

- Training for air traffic controllers should include proficiency in the application of procedures related to the failure of navigational aids.

(i) Aircraft Performance

i) Controllers are taught general awareness of differences in aircraft performance, e.g. between jets and propeller-driven aircraft. However, there may be more subtle differences. An aircraft serving a destination that is only two hours' flying time from the departure airport has different performance characteristics than a similar aircraft taking off for a ten-hour flight. This difference affects aerodrome and area controllers alike. A controller with a high SA will take cues from the flight plan information available, or even just the call sign (flight number), to assess the expected performance of each flight and will adjust control strategies accordingly.

ii) A further factor may be the way in which an aircraft is usually operated by the various companies. Climb speeds, rates and/or angles may differ although the aircraft type is the same. Familiarity with such differences adds to a controller's SA.

iii) Controllers also need to be aware of potential degradations in aircraft performance, either as a result of atmospheric conditions or as a result of technical problems.

iv) Different types of aircraft have different possibilities and limitations, and awareness about these will increase a controller's SA. For example: modem aircraft have the capability for off-set navigation, to construct non-standard way-points, or can provide accurate wind information. Older aircraft often lack these capabilities and should therefore be handled in a different way. As another example, non-pressurized aircraft will normally not accept altitudes of more than 10 000 ft (3 050 m) above mean sea level, thus restricting the options for applying vertical separation with such aircraft.

v) Consequences for the design, implementation and operation of ATM systems:

- Organizational procedures should be established to ensure that verified information on the type of aircraft of a flight under a controller's jurisdiction is available to the controller at all times.

- Training programmes for air traffic controllers should include awareness about aspects of differences and variations in aircraft performance.

- Organizational procedures should be established to ensure that controllers have the possibility to make regular familiarization flights to observe from the flight deck the possibilities and limitations of relevant types of aircraft.

(j) Equipment

i) In line with the previous discussion on navaids, awareness about ATC equipment availability is essential. This includes spare (or back-up) equipment and equipment scheduled to the temporarily taken out of service for maintenance.

ii) The reliability of the equipment is an important factor. A high number of failures with a certain radarscope will dictate prudent use when working the position, including tactics such as accepting less traffic or applying wider separations than under normal circumstances.

iii) Also similar to the discussion on navaids, the performance of the equipment may not be optimal under all conditions. Awareness of these conditions, and the associated degradations in performance, increases a controller's SA.

iv) Degradations may also occur as a result of technical problems. The ability to recognize the problems, and know what the consequences are, are all part of a controller's SA.

v) Consequences for the design, implementation and operation of ATM systems:

- Organizational procedures should be established to ensure that information on the status of ATC equipment is available to the controller at all times.

- Procedures that are applicable in case of failure of ATC equipment must exit.

- Controller training must include proficiency in the application of procedures related to the failure of ATC equipment.

(k) Adjacent Units

i) Certain aspects discussed under the heading Individual Differences are also applicable to the traffic exchange among ATC units. Awareness of the actual performance level of different units, and the ability to compare this to a perceived average performance, are part of a controller's SA and may influence the choice of strategies. In some cases, a shift takeover in an adjacent centre has a significant bearing on the way traffic is handled by that unit and subsequently affects traffic exchange with that unit.

ii) A controller with a high SA will also be aware of possible limitations that adjacent units may experience. For example, significant weather may complicate adherence to agreed handover procedures. Another example could be staff shortages or equipment problems. In some cases this may lead the adjacent unit(s) to declare a lower capacity than usual.

iii) Consequences for the design, implementation and operation of ATM systems:

- Organizational procedures should be established to ensure that information on the status of adjacent centres is available to the controller at all times.

- Organizational procedures should be established to ensure that controllers have the possibility to make regular familiarization visits to adjacent centres in order to observe the working practices in those centres.

3. Developing Situational Awareness – Training Programme

3.1 Situational Awareness in ATC comprises more than knowing where all the traffic is at a given moment and what is the relative direction of movement of each aircraft. For air traffic controllers SA includes all the elements described in this Safety Notice. Consideration of all elements may be done consciously or unconsciously, and some elements can have a higher importance in one situation than in another.

3.2 When designing new systems and supporting procedures that include the goal of "enhancing the Situational Awareness of the controller", care must be taken to address all the elements from this Safety Notice. As a minimum, the controller should be formally provided with up-to-date information on the traffic, weather, aerodrome infrastructure, navigational aids, the status of the system itself, and the adjacent units. Such information should be available to the controller when required or presented to the controller in case of significant changes.

4. Recommended Actions

4.1 Air traffic service provider is encouraged:

- to note and disseminate the information promulgated in this Safety Notice to enhance the situational awareness in the control tower;

- to review the company's policies, procedures, and training programme to reflect the safety issues contained in this Safety Notice.

- End -