Ergonomics of the Aircraft Approach Control Centre And Aircraft Control Tower

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1. Introduction

Human factors or ergonomics refers to the safe, efficient interaction of men with their machines to achieve a designated purpose(Sanders & McCormick, 1987). Nowhere is this relationship more important than in air traffic control. This assignment examines ergonomic factors in air traffic control which contributes to its high safety record. The review is based on the distinct stages apparent in the model of information processing.

2. Information Input

Theoretically, Saunders and McCormick (1987) note that the model involves the original sources of stimuli, being either objects, events, other people or in this case, planes, either on the ground or in the air. Information inputs in the information processing model are coded, converted or reproduced and are directly or indirectly sensed through various means. Results are presented as light, sound, mechanical or thermal energy. These signals are interpreted by human sensory receptors using eye, hearing or touch. The information is processed by humans and decisions made. These decisions are acted upon using machines. These machines in turn output information to update the operator on the situation.

In the area approach control centre (AACC) at Perth Airport, these functions are well illustrated. Information on planes is received in a variety of modes, either by telex messages which contain flight plans, departure or update information, aurally by long range HF radio, VHF radio within 160 nautical miles, or by computer simulated radar displays. The information is processed and acted upon to ensure appropriate vertical and horizontal separation of planes and appropriate queuing for landing and taking off.

3. Information Coding

Information is coded onto small cards by a coding officer when initially received by AACC. Colour coding of the strips is used, red for departures, yellow for inbound traffic, and pink for crossing or local traffic. Necessary information includes identification, times of departure and arrival, navigation instruments and planned route. Colour aids in categorising the slips and speeds up identification. Information is also typed into the computer system to allow the radar transponder to designate aircraft with the suitable call letters and codes.

One person handles the coding of data from the telex machine, while two people handle the HF and VHF encoding of airplane movements. When planes come within 160 nautical miles of Perth, they appear on the long range radar, under the control of two people who handle the planes to within 30 miles of Perth. At thirty miles, planes are handed to approach controllers who hand the planes on to the control tower for landing.

Advantages of the process include the range of ways that information may be input into the system, via telephone, telex, radio or radar. Use of Telex and VHF radio reduces noise, or communication difficulties. There may be poor communication, however, by HF radio with planes over the ocean due to sunspot activity. Use of satellite communications will eliminate this problem in the future. False returns from birds or buildings may also cause problems on the radar screen in distinguishing targets. Furthermore, screens are slow to refresh images and may predict inaccurate positions of planes, creating "noise" in terms of signal noise theory. Use of transponder responses or blip labels with identifying call signs assists in diagnosing identities of planes and helps in overcoming this problem. Consequently processes for the identification of planes are relatively noise free.

The paper strip system provides a low cost reliable method of recording the data. However, new paper strips are made for the aircraft each time it passes from one controller to another. This magnified the work load and opportunities for error in data encoding as opposed to an electronic display.

4. Decision Making

Completion of cards does emphasise in working memory that a plane is within the control sector because of the focus of visual attention and psychomotor activity in completing the card. Ready accessibility of cards in front of the operators and the requirements that they be updated as progress information also focuses attention on the plane. Use of code chunks such as 3 letter call designations also aids memory recall and speeds up verbal communications. Information processing through decision making is assisted by focussed attention and having all the data together on one radar display. There are clearly defined control sectors and familiar and well defined processes for passing planes from one controller to another. The latter processed is assisted by the computer which upon request by the controller captures planes electronically and passes them on to the attention of the next controller. Overlay maps and measurement pointers on radar screens are aids in this process. GMT (-8 hours from Perth) is used as a means to standardise times for aircraft from other time zones to avoid confusion over standards.

5. Staff Mental Workload

Training requires three years of study in Melbourne or Launceston followed by practical apprenticeships in the less demanding positions such as service movement control and annual testing. Training ensures that staff have an aptitude and capacity for the type of vigilance and mental workload demanded by air traffic control. Approach control is most difficult and requires approximately fifteen years of experience.

This workload requires maintaining vigilance during long periods of boredom, yet performing tasks correctly in times of crises and stress. Only one twenty minute break is allowed, leading to reduced concentration over long periods. Reduced arousal during quiet problems creates the risk of being unready for a sudden crisis. One staff member in the AACC was heard to comment as his solution, for instance, "I drink lots of coffee because there is nothing to do." At times Perth control may be very busy due to the need to control traffic at Pearce Airforce Base and Jandakot Airport. Workload is compounded by shift work, two daytime sifts or one night shift. One night is worked for every six days causing fatigue.

The 36 hour working week is light by the common standards but meals are eaten at the workplace. There is also the frequent requirement for overtime. Operators are not allowed to extend their seven hour shifts beyond nine and a half hours, however. Yet they may lose their weekends to cover for sick colleagues.

To summarise, frequent rotations and requirement for night shifts may lead to accumulating fatigue and the risk of fatigue created errors of commission, omission or of sequence.

6.Information Overload

There may be problems with information overload if too many planes are being handled at once. Such a situation requires divided attention between planes and monitoring both visual and auditory channels simultaneously. With three sectors and two operators, workload is shared. False returns on radar screen caused by buildings, weather and birds and slowness of radar updates may also contribute to stress. Although the radar will predict the location of the aircraft, the slowness of the update may result in an erroneous prediction. As load stress increases, Saunders and McCormick (1987) note, speed decreases. Use of additional operators with provision for up to three operators in each control region tends to reduce overload.

7. Anthropometry of the Displays

The work benches appear to have been constructed to anthropometric specifications. The work space envelope for each controller is adequate so that cards and the radar screen may be easily read. Controls are within reach. Chairs are provided with adequate back support and arm and foot rests for comfort. A foot rest is also built into the console.

The work surface is at a comfortable height for writing. Close proximity of operators allows ease in communicating with each other. This is facilitated by use of swivel chairs on wheels. Microphone cords inhibit movement and headsets are robust causing some discomfort over seven hours of wear. Wireless microphones using infrared or other technology could overcome this problem.

Each radar display position appears to be identical and is easily visible and legible due to computerisation. By maintaining compatibility between systems, it is straight forward to transfer from one position to another. This assists in staff training and ease of operation.

Surprising, little use is made of computers for provision of map details. Control operators use an old fashioned triangular map display to obtain data on routes, ATC frequencies, control zones and so on. Examination of the map requires leaving the radar screen. Such displays could be more easily displayed via a computer screen.

8. Environment: (Lighting, Air Conditioning)

The AACC room is enclosed to avoid distractions and glare on the radar screens. Carpeting quiets the room. However, the console design reflects the sound of conversation causing the room to become quite noisy when all operators are talking. High noise increases stress and interferes with communications. Noise levels are reduced by using light weight mouth microphones and earphones.

Lighting is carefully designed to provide adequate white light for reading the paper strips while being diffused and sufficiently dim not to reflect off the radar displays. Spot lighting over the control panels is available to provide greater intensity of lighting if required. These lights fall within the 1500 lx range recommended by Saunders and McCormick (1987, p. 419). Maintaining the room at a constant temperature all year avoids physical distraction and fatigue of the operators due to excessive heat or coolness.

Computer simulated, radar displays are bright and are easily seen even in the control tower with sunlight. Flicker apparent in older models has been removed by generating a computer display rather than presenting the primary display as received by the radar. Aircraft that have been positively identified are coded by the computer with a circle to separate the image from false returns. Future displays may colour code aircraft and present them in compatible aircraft shapes as aids for rapid identification. Transponders identify aircraft and alphanumeric lettering may be adjusted for size. The size of the screens are substantially larger than computer monitors to ease eye strain.

9. Human Control of Systems

Switches connected with the computer are labelled and provided with status lighting for rapid identification. Colours and flashing are not used as aids, but should be considered because of the volume of switches. At the least, banks of switches should be separated by lines to indicate groups of modules. As they are mounted in rows, the proximity of switches requires focussed effort to press the correct switch.

Only the microphone switch may be easily triggered by a foot peddle. In the air traffic control tower, no such peddles are provided. The microphone switch is buried in a bank of switches. A controller was witnessed talking to an aircraft briefly,m before he realised that he had not depressed the press to talk switch. Voice operated transmitter options would alleviate this problem. Voice operated speaker microphones are available but contribute to the overall noise level in the room.

10. Air Traffic Control Tower

11. Physical Layout

The tower is ten stories high with security doors controlled from the inside to prevent intrusions and distractions. A 360 sweeping view is provided by large windows with pull down anti-glare blinds. These blinds are easily scratched and reduce vision. Consequently they are not used frequently. Sunglasses are the main device used to reduce glare.

Three support columns provide some minimal interruption of the view of two main runways and require controllers to physically move to see around these pillars. Clearly these pillars represent a design deficit.

12. Staffing

Three control operators run the tower during the day while one person operates the tower at night from 11 pm to 6 am. Since coffee facilities are on the ninth floor, reached by a steep spiral staircase, use of the washroom and kitchen facilities pose a problem. A handheld two way radio is provided to enable the sole operator to respond at night while away from the windows.

Use of a single operator at night introduces some element of risk since an operator might fall ill and the tower would be unmanned.

Reduced arousal at night and the danger of falling asleep is also a concern.

One operator is responsible for ground movements. A second requirement for the ground movements operator is the completion of cards. This duty provides an extra workload which distracts from the primary task of control of ground movements. A computer system which displays this information without the need to copy it onto cards would eliminate this chore.

Two other operators control the aircraft during day shifts.

13. Functions

Control operators assume responsibility for safe ground movements, take offs, and for scheduling and separating incoming aircraft for landing. Airspace extends for 5 miles. Provision of radar screens, continuous input of information from AACC and airport VHF radio, as well as vision aided by binoculars provide information input. Two runways are provided with automatic precision approach landing systems for aircraft landing in poor weather. Catabolic turbulence and wind shear during the summer months create some difficulties for traffic management.

As in AACC, all movements are coded onto cards from information received by telex or radio and these cards are kept updated. Work load during the day averages 250 flights including activity from Pearce Air Base.

14. Anthropometry

A console is designed to provide access to radar screens, communications equipment and hand written cards while being able to see all runways and air traffic. Radar screens are sufficiently bright to be visible on sunny days. The two screens with their controls are mirror images of each other, increasing adaptability and reducing risk of error when transferring from one position to another. The console provides easy communications between controllers on an informal level. The use of chairs on wheels and a console footrest, permits manoeuvrability and comfort. Buttons are configured in rows and are identified by colour, label and lights. Distribution of buttons by functional groups might speed their recognition. The microphone button is buried with others and needs to be placed closer to the controllers.

Red and Green aldis lamps is provided within easy reach overhead to signal aircraft with radio malfunctions.

15. Workload

ATC duties are said to be less onerous than AACC approach which also controls traffic for Pearce and Jandakot Airbases. Airplanes should already be queued by AACC for landing with suitable separations. Nevertheless, 270 planes a day are contacted with up to 370 planes contacted daily during peak periods. Information must be transferred, displayed, and processed efficiently, quickly and accurately. The job varies from boredom to terror and may cause physical symptoms such as headaches from a demanding day's work.

16. Conclusion

The environment in the AACC and ATC is not a problem as it is highly controlled to optimise performance. The interface between the controllers and their equipment is also good and functions reliably. Areas for concern include the periods of boredom which may lull operators into complacency. Shift work induces fatigue as does the need for frequent overtime. Reduction of the number of staff required to handle the workload is a concern as is employment of single staff members at night.

Finally, the rate of innovation in the computer and electronics industry is rapid. It is essential that the latest technology continue to be incorporated into the system to reduce risks of human error due to faulty input, interpretation or output of information. The traditional civil service time lag in reviewing, purchasing and installing new equipment is inadequate. Rapid review and regular updates in technology must be undertaken to maximise the smooth operation of the system.

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