

DCIEM REPORT NO. 902

**THE NATIONAL DEFENCE COMMAND
SYSTEM: HUMAN ENGINEERING
DESIGN CONSIDERATIONS**

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ABSTRACT

An improved Operations Centre, the National Defence Command Centre, is required in the new National Defence Headquarters Building to act as the operational hub of the National Defence Command System.

This report outlines human engineering advice provided during the design of the National Defence Command Centre in terms of (a) visual information (b) verbal communications management and (c) desk design. A new method is proposed for scheduling management for the airlift section.

THE NATIONAL DEFENCE COMMAND SYSTEM: HUMAN ENGINEERING DESIGN CONSIDERATIONS

INTRODUCTION

The relocation of the National Defence Headquarters (NDHQ) in a new building includes the replacement of the present Canadian Forces Operations Centre with a modern secure facility for the direction of defence efforts, to be called the National Defence Command System (NDCS). This facility includes the National Defence Command Centre (NDCC) together with its supporting services.

The Defence and Civil Institute of Environmental Medicine (DCIEM) was requested to review the human engineering aspects of the planned NDCS, in cooperation with the Directorate of Operations (DOPS) staff, during the planning and design stages. This report summarizes the work carried out and the recommendations made in response to that request.

FUNCTIONS OF THE NDCS

The NDCS provides the Minister of National Defence (MND), the Chief of the Defence Staff (CDS) and their supporting staff with a facility for directing defence efforts from a central location during periods of an increased readiness posture, during peacetime emergencies such as national or international disasters when aid to the civil powers is required, and during normal peacetime daily operations.

This facility must be capable of receiving current information which can be stored, analyzed and displayed, so that the NDCC staff are fully conversant with the military and political situation. Action has to be initiated within the facility, as required, by the timely dispatch and monitoring of the implementation of Command decisions. This implies the availability of (a) a rapid information retrieval system, (b) reliable, quick, secure and non-secure voice communication systems, and (c) conference capabilities between the NDCC and Allied Command Centres, Canadian Forces (CF) subordinate commands, selected governmental control centres and other NDHQ agencies. Formal and informal briefings will be presented in the NDCS, requiring appropriate audio and visual communication systems.

PHYSICAL LAYOUT OF THE NDCS

The formal statement of requirement for the NDCS, "National Defence Command System in the New National Defence Headquarters Building," (1) notes the Treasury Board direction that there be no major construction changes to the building nor modifications to the constructional phasing plans. The area of the building designated as the NDCS area was therefore predetermined in outside dimensions, and for some internal structures.

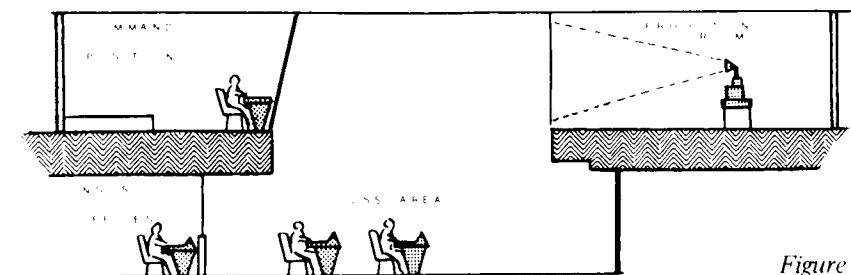


Figure 1. Elevated View of NDCS

NDCC Commander's Support Staff Area (CSS)

The main floor area of the NDCS is a room measuring 25 feet deep, 40 feet wide and two stories in height (Figure 1). This was designated as the Commander's Support Staff Area, which is the operational core of the NDCS, and provides the experienced operational staff for the direct support of the MND, CDS, and their immediate subordinates. Figure 2 shows the recommended floor plan for the CSS to accommodate the six working positions and the two spare positions, one accommodating a projection table for small informal briefings.

The NDCC Director, as the senior officer in the area, requires a wider range of communications and display facilities than the other CSS officer. He should be located on a raised platform at the rear of the room flanked by the officers responsible for Sea Operations, Land Operations, Air Operations and Civil Operations. The spare desks are located in front of these flanking the central Alert and War Measures Desk.

These work stations face a wall display area which is 30 feet wide and 19 feet high, including three 7-foot square rear-projection screens across the upper floor level and 8-foot-high situation display boards mounted on tracks at the lower floor level.

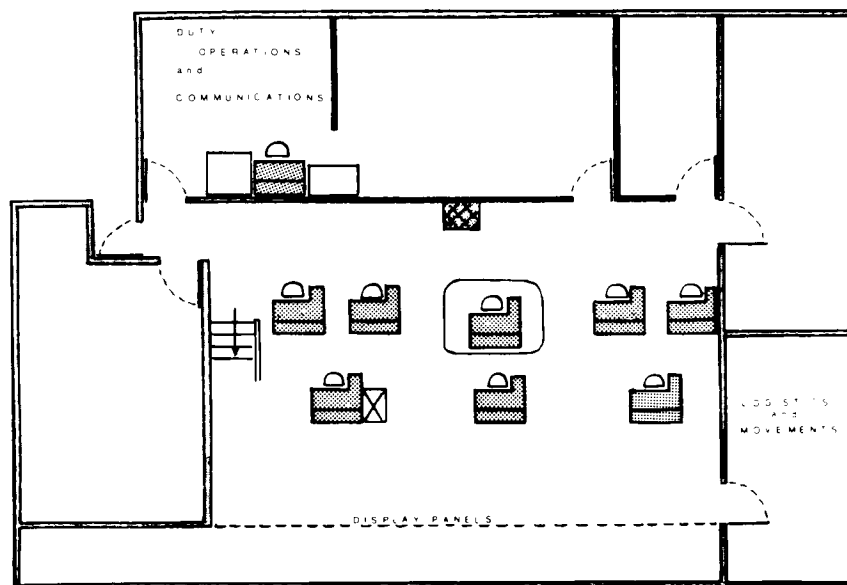


Figure 2. Plan View of Commander's Support Staff Area

The Command Position

The Command Position is housed in a gallery located in the upper floor level of the NDCS, to the rear of and overlooking the CSS area (Figure 3). This gallery is designed to accommodate senior DND personnel and their associates for the purpose of receiving up-to-date information on a particular operation and participating in its direction. This would normally occur during an increase in the NDHQ readiness posture and during peacetime operations.

The principal working positions are those of the NDCS Commander and Deputy Commander who are isolated from interruption and noise by a glass partition dividing the gallery from the CSS area. Desks are provided for the Minister, for the Chief of the Defence Staff and the Vice-Chief of the Defence Staff, and for one observer of senior rank along the front of the Command Position. Sixteen other observers seated at the rear of the Command Position can listen to briefings.

The Command Position gallery has a floor area 40 feet wide and 15 feet deep, with a 12-inch-high raised floor across the rear for the 16 observers' chairs. All the personnel in the Command Position are provided with an adequate view of all display areas at the front wall of the room.

The NDCS Offices

Offices are provided on the lower level around the outside of the CSS area and below the Command Position gallery for the services required to support the operation of the NDCC. The positions of interest from the point of view of work station design are the duty officer position in the duty operations and communications office, and the logistics and movements officer positions in the logistics office (Figure 2). These three work stations may require similar communications and information displays to the work stations in the CSS area.

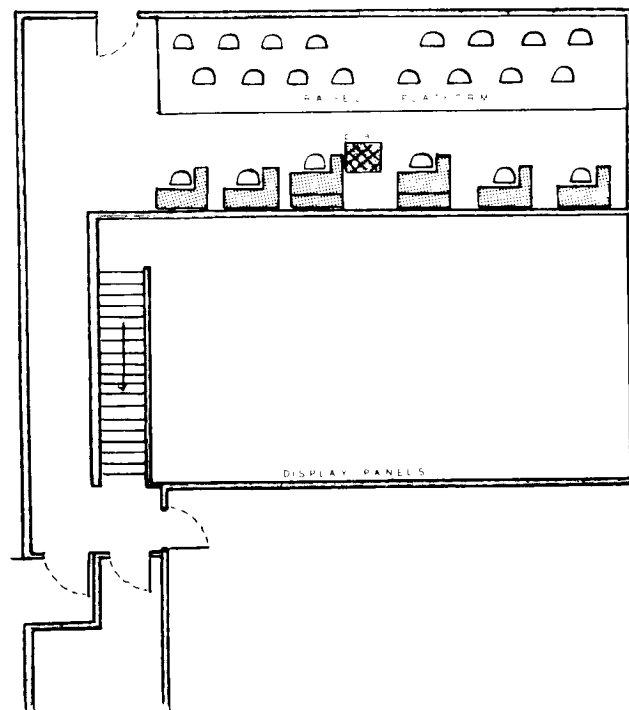


Figure 3. Plan View of Command Position

INFORMATION: HANDLING REQUIREMENTS

Visual Display of Information

Information may arrive in the NDCS by message, letter, telephone or by commercial radio or television. Provision must be made for the immediate dissemination of this information to the Command Position and to the CSS area, and for the retrieval of additional information from storage as required. Since computer information handling and display is not acceptable for use in the NDCS due to cost considerations, advice was provided by DCIEM on a possible information handling procedure which would both satisfy the requirement and be economically acceptable.

Rear projection screens should be installed in the NDCC for showing films, slides and transparencies. It was recommended that all visual information be displayed in this way. Transparencies can be made on an electrostatic copying machine from documents arriving in the administrative office, and then taken to either the projection room for display to the whole complex, or to the individual desks for display on table-top viewers. Transparency copies can also be sent to the NDCS library for storage, and subsequent retrieval when required.

Microfilming of documents with the film stored in the form of microfiche jackets provides a more convenient method for desk-top viewing and for library storage. Projection of microfiche, although possible, is not as fast as projection of transparencies because of the delay required for film development.

Maps of geographic areas are made available to NDCC personnel in the form of wall-board situation displays, measuring 8 feet high and 4 feet wide, mounted on tracks below the rear-projection screens. These display boards are stored in an area to one side of the display wall (Figure 2) when not in use. The viewing distance to the display boards for CSS personnel is from 10 to 18 feet, and for Command Position personnel it is approximately 25 feet, at an angle of 25° below the horizontal. With the recommended light levels below 30 foot candles (3) perception of detail on low-contrast map displays will be very difficult. The recommendation was made therefore that these geographical situation displays be produced on transparencies to be displayed on rear-projection screens which would replace the wall boards. This would permit (a) the simultaneous presentation of several maps of different scales and of different locations, (b) the use of overlays to show the development of the situation and (c) allow simplified display updating. Because of the divergent responsibilities assumed by the personnel in the CSS area, it is probable that they would not all refer to the same map display at the same time. Since wall displays assume group viewing and a commonality of interest, the use of map transparencies on individual desk-top viewers would be more appropriate for detailed planning, with the large-screen map projections providing the necessary information for briefings to the Command Position.

Control over personnel access to the NDCS from the rest of the NDHQ building is required for security reasons, and entry control procedures were established using closed-circuit television (CCTV). The cameras located at the entrances to the upper and lower floor areas will provide surveillance of personnel requesting admittance, and will be controlled by the Duty Officer and the Command Position clerk using CCTV monitor screens. A two-way intercom will provide a means of voice communication between these positions and the exteriors of the entrances.

A colour television receiver will be located in the CSS area for the showing of commercial television transmissions which may have relevance to the activities of the NDCC personnel. The audio signal of the transmission should be available through the PA/intercom system.

Auditory Display of Information

The two primary voice communication systems in the NDCS are a secure interpositional telephone and public address system, and a non-secure telephone system. Most of the work stations

will be provided with access to both of these communication systems but to varying extents (2). The several local, national and international voice communication systems which are not secure will all terminate in call-director telephone installations, one of which will be provided at each work-station.

Requirements for voice communication facilities at the individual work-stations in the NDCC vary. The Deputy Commander in the Command Position and the Command Director in the CSS area must be provided with access to the manual PBX network which will provide them with direct access lines to a broad range of subscribers, and to the automatic PABX which provides three-digit dial completion to any other subscriber in the network. They also will have the only access to three other specialized voice communication networks. All positions in the NDCC will be provided with PBX access, but, in addition to the officers already identified, only the MND, CDS, VCDS and the NDCS Commander have access to the PABX system.

The interpositional intercom system is to be in-house secure, that is, is to be operated without encrypting devices. The number of circuits to be provided range from six at the Commander's position to 19 at the Deputy Commander's position. The PA system for internal briefings will be integrated with the secure intercom system so that incoming messages on either can be received by telephone handset or by desk-mounted loudspeaker with volume control and muting capability. Transmissions on the PA system can be made by telephone handset or by desk-mounted microphone. Recording of telephone messages on a cassette tape recorder mounted in the desk will be accomplished by induction pick-ups switching. Some of these recordings will be classified.

Security Requirements

The internal secure and the external non-secure voice communication systems, and all electrical and electronic items associated with them, must be physically and electronically isolated from each other to prevent any mutual interaction. Noise-excluding mouthpieces will be installed on the secure telephone handsets to reduce the likelihood of inadvertent security violations.

WORK STATION DESIGN

Due to the unique requirements for work station design presented by the visual and voice communications systems used in the NDCC, DOPS requested that DCIEM design desks for use in the Command Position and the CSS area. In addition, recommendations were required on a suitable design for a desk for the duty officer position due to this unique location and function. The functions performed by the movements and logistics officers were also reviewed by DCIEM, with the conclusion that a standard office desk of the type to be provided to the rest of the NDHQ building would satisfy their needs.

CSS Area Work Stations

Figure 2 shows the recommended layout of the six work stations in the CSS area, together with the two spare positions. The functions to be carried out at the civil land, and maritime desks are primarily those of planning and document preparation, with a secondary function of presenting briefings to the Command Position from a seated position at the desk. The DCIEM desk design for these positions (Figure 4) provides for storage of reference manuals and documents in the shelf area on the left side, and has a work table surface 48 inches wide and 20 inches deep.

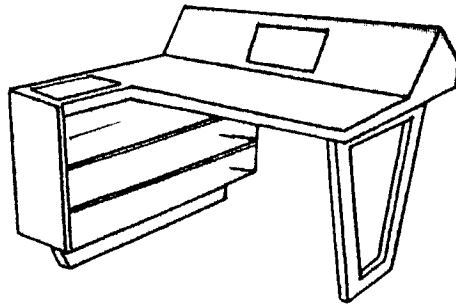


Figure 4. CSS Area Desk

The equipment necessary for the secure and non-secure voice communication systems at the CSS area desks is comprised of a standard telephone set with a push-button pad for the secure intercom, and a larger call-director set with 18 call buttons plus an outboard rotary dial for management of all non-secure networks. The secure intercom is located on a separate wing on the left side of the desk, so guaranteeing that any item of electronic equipment installed in the turret will be outside the required security separation. The call director set is located in the centre of the desk turret. Wells are provided in the desk into which these sets can be placed, but which will also accept flush-mounted telephone sets should these become available. (Attempts to arrange a contract for flush-mounted sets had been unsuccessful to the time of desk construction). The 4-inch speaker and the desk microphone associated with the PA system will be located in the turret to one side of the call-director set. The cassette tape recorder to be used in the NDCC desks had not been selected at the time of console design, but the space provided to the left of the call-director is adequate for the largest of the recorders under consideration, whether used in a secure or a non-secure mode.

The righthand end of the turret portion of the desk is to be used for the display device necessary to give each officer the necessary flexibility and speed of information retrieval. It is recommended that a small personal microfiche viewer be used, since it provides the freedom to refer to any document irrespective of the trend of the information on the main projection screens, together with a simple and compact information file.

The viewing distance from these desks to the display wall is 18 feet and the viewing angle to the centre of the projection screens on the upper floor level, 15 feet 9 inches above the floor, is 33° above the horizontal. The recommended minimum viewing distance to a projection screen is twice the screen width (6). At a distance of 18 feet, the seven-foot-wide middle screen will be viewed comfortably, but viewing of the screens on either side of it will be difficult. The recommended viewing angle is 10° above or below the horizontal so some degree of discomfort is inevitable for those looking up to the screen from the front row of desks in the CSS area. CSS officers, however, will make most reference to the projection screens during their own briefings to the Command Position.

Duty Officer's Position

DCIEM received a specific request for advice on the total layout of the Duty Officer work station, including recommendations on a suitable desk design for this location.

The Duty Officer requires all the facilities provided to the CSS officers, and in addition has to operate the television monitor and door controls for the security control of the entrances to the NDCS. He is also responsible for manning a special communications console and a pneumatic tube terminal through which most of the documents will arrive in the NDCS. Delegation of the responsibility for the tube terminal from the Duty Officer to the administration office staff under certain NDCS operations requires that this device be located in a position accessible to both rooms (Figure 5).

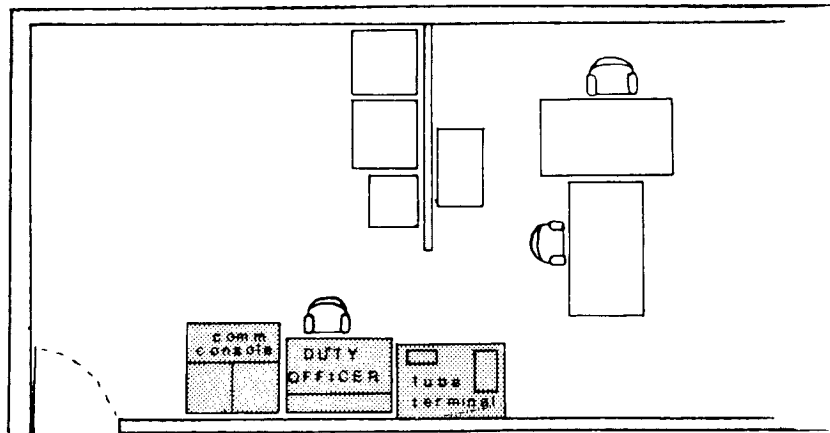


Figure 5. Duty Officer Position

Because of the traffic flow through the doorway in front of the tube terminal, and the requirement for the Duty Officer to have full access to the terminal on the left end of his desk, it was recommended that this desk be the same as the CSS area desks with the wing extension on the left side removed.

The pneumatic tube terminal has a chute at one end for delivering message cartridges which are arriving in the NDCS, and a cartridge storage bin at the other end. The cartridge transmission tube is located in the middle of the terminal. It was recommended that the tube terminal be placed against the partition dividing the offices from the CSS area, with the storage bin end nearest to the Duty Officer. If a removeable chute is provided to guide incoming cartridges from the fixed chute over to the storage bin end of the unit, the Duty Officer will be able to operate the tube terminal from a seated position at his desk. Removal of the additional chute section will allow the incoming cartridges to fall straight down in the area most convenient to the administration office staff at times when they assume responsibility for incoming messages.

Study of the special communications console which must be operated by the Duty Officer shows that the telephone handsets and most of the pushbutton controls which he uses are located to the left side of the four feet wide front panel surface. If this console is positioned on the right hand end of the Duty Officer's desk (see Figure 5) the main operating area of the console panel will be adjacent to the desk.

Allowing for body movement and stretching to obtain maximum reach, with a 20-inch-deep shelf and a 12-inch-high turret face at an angle of 55° , a 5th percentile man when seated at the desk will be able to reach the top edge of the turret panel face to a distance of 17 inches on either side of the panel centre line. He will also reach the lower edge of the turret panel face to a distance of 26 inches on either side of centre (9). His reach envelope will cover a 12-inch-square area in the near corner of the tube terminal, and the whole of the near side of the communications console. RCAF anthropometric data (10) show functional arm lengths to be 29.16 inches (5th percentile) and 34.07 inches (95th percentile), giving the largest individual five inches advantage in reach, and a correspondingly larger reach envelope. The Duty Officer therefore will be able to operate the communications console and the cartridge bin area of the tube terminal, with no chair manoeuvring, from a seated position at his desk.

Command Position Desks

There are six positions along the front of the Command Position gallery. Two of these are the operational positions of the NDCS Commander and Deputy Commander, who require all display and communications facilities together with adequate desk surface area and storage space for carrying out their administrative and planning duties. The same desk as those used in the CSS area should be used in these positions. Maximum coordination between the NDCS Commander and Deputy Commander can be achieved, and optimum utilization made of the space in the Command Position if their two desks are located on either side of the pillar near the centre of the front section (Figure 3). This leaves a space of 10 feet along the gallery face between the commander and the lectern, and 13 feet between the Deputy Commander and the south wall of the Command Position. It was recommended by DCIEM and agreed (4) that only one observer position be provided in the Command Position thus allowing the MND and CDS desks to be positioned with a required two feet access space between them (7).

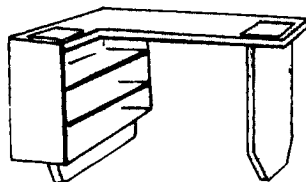


Figure 6. *Command Position Desk*

The four executive positions in the gallery, i.e., MND, CDS, VCDS and an observer, do not require the same facilities as the operational staff. The main reason for attendance of these individuals is to receive briefings from the support staff officers and from invited guests. During briefings they must have access to necessary telephone communications, and a simplified desk design with secure and non-secure telephones was developed for these positions (Figure 6). Since the stub wall below the glazing in the front of the Command Position gallery is 29 inches high, small devices could be laid on the 29-inch-high desk top without being visible from the floor below; an aesthetic recommendation (4).

DCIEM provided advice (5) to CFHQ/DOPS on the layout of the 16 observers positions in the raised rear position of the Command Position gallery. This area measures 35 feet wide, $7\frac{1}{2}$ feet deep and is raised 12 inches above the forward area. With the use of standard auditorium style seats, there should be a minimum centre-to-centre spacing of 3 feet between the seats. With a 12-inch aisle between the backs of the

rear row of seats and the east wall, the recommended distance of 40 inches can be attained between the seat reference points of the front and rear seats (8). Staggering of the seats between the rows allows a 3-foot space in the middle of the front row for access to the rear seats, and gives the rear observers a field of view of 45° between the heads of front row observers. This exposes a 24-foot-wide area of the display screens.

AIRLIFT SECTION

The Airlift Section of CFHQ is located adjacent to the NDCS and is responsible for maintaining a current record of transport aircraft usage and scheduling. Because of the close relationship between the Airlift Section and the NDCS, DCIEM was requested to provide advice to this group within the NDCS study.

There are three work stations in the Airlift Section: light aircraft, heavy aircraft, and VIP flights. Within the first two there are regularly scheduled flights which remain relatively constant, and non-scheduled flights. Flights are scheduled two months in advance. Since a lot of requests are by telephone, the officer must have easy access to the full two-months schedule for all aircraft of any one type. This requires a matrix table of 62 days by the number of aircraft, possibly 24 at any one desk.

The present system presents this information on plastic covered wall board, 12 feet long by 6 feet high, on which the aircraft reservations are written with grease pencil. Different colours of pencil are used to denote the different classes of aircraft. Legibility is enhanced by having very low ambient illumination in the room with indirect lighting around the board, but this has proved to be inadequate. Telephone reservations require the officer to leave his desk to consult the board at close range, and he may make several trips between the telephone and the board before the call is completed. In spite of the size of the board, each cell is inadequate in size for the amount of information displayed.

A record of each month's schedule is made on a coloured photograph (8 by 10 inches) before the board is erased. These photographs must be viewed with a magnifying glass to extract any information at a later date. After being photographed the board is erased and the scheduling for the current month re-written one place to the left to allow the new month to be inserted at the right end of the board.

This method of handling aircraft scheduling information is unsatisfactory since:

1. it is not available at the work desk,
2. there is not enough space to record the necessary data, and
3. the information is not in a form suitable for storage and retrieval.

It has the advantage, however, of providing an immediate picture of total aircraft utilization, and of aircraft type utilization over the two-month period.

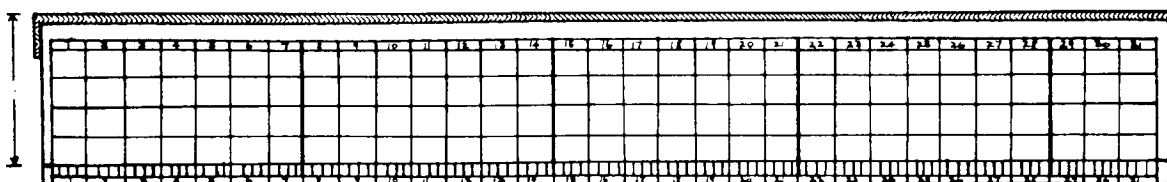


Figure 7. Airlift Section Planning Board.

A DCIEM letter report (5) outlined the system recommended for use in the Airlift Section. It is based on the use of a Sched-U-Graph Planning board, available from the Remington Rand Division of Sperry Rand of Canada Ltd. Each planning board has a number of horizontal overlapping pockets each measuring 40 inches long by 5 inches. A series of pre-printed cards can be inserted into the pocket to form the data filing system. Each card (Figure 7) schedules one aircraft for seven days, showing four boxes corresponding to four time-periods for each 24 hour day. When an aircraft is reserved for a part (or all of) a day, the details can be written in these boxes, and the small square under the plastic edge-tab on the lower edge of the pocket is filled with a marker-pen. Each card overlaps the portion "a" (Figure 7) of the next card below, allowing only the edge-tabs to be visible, thus presenting a coded display of aircraft scheduling.

Each board covers one month of aircraft scheduling for any number of aircraft required, corresponding to the number of cards mounted on the board. It is recommended that each board be mounted on a mobile rack, which can sit beside the appropriate desk, and the cards can be consulted or removed for data logging from a seated position of the desk. The mobile board can also be moved easily to another desk if necessary.

The main advantage of the planning-board approach is:

1. the officer can see aircraft utilization at a glance while using the telephone at his desk.
2. data entry is simply by handwriting.
3. normal office illumination levels can be used.
4. a single set of forms can be used for all stages of the procedure i.e., long range planning, short range scheduling and data storage.

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