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SPACE STATION GROUP ACTIVITIES HABITABILITY MODULE STUDY : A SYNOPSIS

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OBJECTIVES

The purpose of the study is to explore and analyse architectural design issues involved in the Group Activities Habitability Module identified in the Space Station Reference Configuration (ref. 1) as Habitability Module 1 and hereinafter referred to as HM1. The principal features of HM1 are the galley, wardroom and health maintenance (exercise) facilities, of which the wardroom is the most significant in terms of size and operation. Various design strategies for the interior of HM1 are proposed in scale model form. Each strategy demonstrates an approach that addresses certain design issues or requirements and how they impinge on the interior of the Common Module. The results will be combined in a set of preliminary illustrated design guidelines and recommendations for the interior of HM1.

SCHEDULE

The study is divided into a research phase and a design phase. The research phase, which commenced in June 1985 and completed in August 1985, identified a set of architectural design program requirements and a set of preliminary habitability design guidelines for HM1. The design phase, which commenced in September1985 and will complete in December 1985, comprises the study of a series of schematic approaches to the interior configuration of HM1 with appropriate evaluations and recommendations.

RESEARCH PHASE: ARCHITECTURAL DESIGN PROGRAM

The Architectural Design Program developed during the research phase identified a range of accommodation and facilities required within HM1 in terms of broad design characteristics and outline design requirements. The range of accomodation and facilities are designated in terms of ten activity types which are summarized as follows:

1 Meetings and Teleconferences
2 Planning and Training
3 Relaxation and Entertainment
4 Eating and Drinking
5 Food Preparation and Cooking
6 Exercises and Games
7 Housekeeping and Hygiene
8 Space Station Operations
9 Meditation and Study
10 Shift and Crew Handovers

RESEARCH PHASE: PRELIMINARY HABITABILITY DESIGN GUIDELINES

The Preliminary Habitability Design Guidelines developed during the research phase comprise background advisory guidelines necessary to support the design phases of the study. They include information on crew activity routines, crew activity proximities, crew activity ergonomic envelopes and crew activity group volumes.

Crew Activity Routines

A study of crew activity routines provides a necessary reference framework for establishing the types and sequence of crew activities likely to occur in HM1. Original criteria on crew make-up and scheduling were taken from Space Station Definition and Preliminary Design (ref. 2). 24-hour routine activity timetables are used to compare crew routines with crew numbers, groupings and shifts. Key activities occuring in HM1 are identified as a flow sequence with the number of sequence cycles in a 24-hour period governed by the number of crew shifts involved. A single sequence cycle includes activities occuring consecutively in time and activities occuring in parallel. A single cycle occuring twice in 24-hours for a two shift crew contains the following activities summarized in chronological order:

A Lunch
B Training
C Station Specialist Operations
D Planning + Exercise and Recreation (parallel)
E Breakfast + Shift Handover and Unscheduled Time (parallel)
F Dinner
G Station Specialist Operations + Exercise and Recreation (parallel)

Crew Activity Proximities

A study of crew activity proximities is used to identify crew activity spatial and organizational interrelationships and key activity adjacency criteria using significant Space Station habitability recommendations (ref. 3), and extended spaceflight human requirements (ref. 4). A matrix is used to interrelate each activity type on a 5-point scale of spatial compatability showing which activities can be combined or adjacent, and which activities need partial or complete separation. The matrix is summarized in a simple bubble diagram which outlines significant activity proximities and separations as well as typical crewmember daily circulation routes. The proximity studies indicate that the key crew activities in HM1 can be wholly or partly combined into five spatial or compartmental groups, of which the first is volumetrically and socially the most significant. The five groups are:

- Meetings and Teleconferences, Eating and Drinking, Planning, Relaxation and Entertainment
- Meditation and Study
- Food Preparation and Cooking
- Exercises and Games
- Space Station Operations

Crew Activity Ergonomic Envelopes

A set of scale diagrams is used to identify a preliminary range of ergonomic geometries for individual crewmember activities using established anthropometric criteria (ref. 5) and background workstation design studies (ref. 6). The diagrams examine the interfaces between a single figure and different ergonomic envelopes for a range of activities common to HM1. Each interface is illustrated as three different geometries describing a minimum feasible, a maximum feasible and a median approach to the envelope involved. Anthropometric neutral body postures for the 5% female and 95% male percentile groups are applied to the envelopes in plan, front and side view. Related reach envelopes and sightlines are indicated. The following five activities drawn from the activities identified in the Architectural Design Program are examined using this technique:

- Meetings
- Planning and Training
- Eating and Drinking
- Food Preparation and Cooking
- Space Station Operations

As an example, Figures 1 is the composite diagram for Planning and Training.

Figure 1 overlays the separate diagrams for minimum and maximum feasible envelopes (shown in Figure 1 as dashed and dotted outlines respectively), and illustrates the median envelope between the two. The median envelope is determined by optimizing worksurface and viewing surface areas within acceptable arm reach and sightlines of 5% female and 95% male percentile groups while remaining compact in overall physical form. The worksurface area comprises keyboard, checklist display, notebook, object restraint and ancillary control zone of 0.33 sq.m., and viewing surface area comprising twin monitor, tapedeck, a/v control, reference manual display and instrumentation zone of 0.66 sq.m. The shape and size of the median envelope is considered to be close to a recommended reference envelope for Planning and Training workstation activities.

Crew Activity Group Volumes

The set of scale diagrams developed as Crew Activity Ergonomic Envelopes is used to develop a set of scale diagrams which examine preliminary complex spatial envelopes for each major group activity in HM1. Using the median individual activity envelopes as building-blocks, the diagrams identify alternative volumetric geometries generated by the number of crew involved in each group activity. The volume shapes and sizes are determined by the combined stationary crew envelopes, associated physical movement patterns and activity sightline requirements. The following five activities drawn from activities identified in the Architectural Design Program are examined using this technique:

- Meetings
- Teleconferences
- Planning and Training
- Eating and Drinking
- Food Preparation and Cooking

As an example, Figure 2 shows alternative crew group volumes for Planning and Training.

The diagrams are based on the median individual activity envelope for Planning and Training illustrated in Figure 1. Six alternative arrangements are identified for two adjacent Planning and Training workstations. In order of sequence they are: (A) face-to-face direct, (B) face-to-face angled out 90°, (C) side-to-side direct, (D) face-to-face offset, (E) side-to-side angled out 90°, (F) back- to-back. Each diagram also shows an adjacent crew circulation route requirement.

SCHEMATIC DESIGN PHASE: BASIC METHOD

The schematic design phase (in progress at the time of writing) involves the development of a series of outline design concepts for the interior configuration of HM1 in scale-model and explanatory drawing form . Each design concept expresses an alternative design approach based on individual interpretations of how the programmatic requirements identified in the Research Phase can be resolved within the shape and size constraints of the Common Module interior.

SCHEMATIC DESIGN PHASE: INDIVIDUAL CONCEPTS

Ten outline design concepts for the interior configuration of HM1 have been selected as test concepts with substantially different design objectives. At a schematic design level, the value of choosing and pursuing widely and deliberately different concepts is twofold:

- Wide-ranging interpretations of a common design problem at an early stage can sometimes herald or highlight innovatory design concepts which potentially can develop superior operational potential to more traditional or conventional counterparts.

- The process of developing and documenting such innovatory design concepts at a schematic level broadly identifies their field of feasibility and gives an early indication of the nature and extent of their realistic application before commitment to design development.

The ten alternative design concepts, not in any ranked order, are summarized as follows:

1 Flexible, freeform envelope highly responsive to fluctuating crew activity requirements using air-activated transformation / rigidization of interior linings.

2 Dedicated architectural organization and circulation with sequence of fixed compartments and adaptable elements determined by established activity requirements.

3 Highly adaptable operation with frequent or cyclical crew-generated compartment changes using modular and articulated partition and lining elements/equipment.

4 Twin, partly-adaptable, interlocking compartment complexes containing circulation paths and crew activity enclosures with integral equipment and storage facilities.

5 Organizational identity responsive to community and privacy needs using combination of fixed and telescopic compartments and adaptable elements and equipment.

6 Transformable, modular, internal configuration achieving changes using articulated and linked pentahedral capsules with various equipment and storage functions.

7 Open, unrestricted volume with discrete multi-purpose element and equipment features adaptable and responsive to variable daily crew activity requirements.

8 Evolutionary design approach responsive to future compartmental or equipmental adaptation generated by changing habitability operational requirements.

9 Definitive architectural character with regularly-spaced tubes acting as multi-purpose consoles for range of equipment and storage applications.

10 Clear anthropometric expression of linked and cellular compartments using series of anthropometric activity volumes as major design generators.

SCHEMATIC DESIGN PHASE: ANALYSIS AND EVALUATION

The analysis and evaluation of the outline design concepts for the interior configuration of HM1 will be carried out in matrix form. Matrix techniques will be used to analyse the ten individual design concepts outlined above, and expressed in scale-model and explanatory drawing form, with a range of ten key design factors applicable to all module types. The analysis results will be evaluated by taking each key design factor and identifying different methods of architectural interpretation using the ten outline concepts as examples. The ten key design factors to be used in this exercise are:

A Basic Configuration
B Communal Organization
C Spatial Perception
D Compartmental Modification
E Internal Circulation
F Anthropometric Conformation
G Ergonomic Operation
H Sound Propagation
J Materials Application
K Life-Cycle Utilization

The results of the analysis and evaluation process will be summarized as a series of observations which will have three main aims:

- To compare the broad advantages and disadvantages of the design concepts.
- To rank the design concepts in order of feasibility of overall resolution of the greatest number of design factors examined together.
- To identify the individual design concepts which exhibit the greatest potential for optimizing each individual design factor examined in turn.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations based on the combined results of the Research Phase and the Schematic Phase will be contained in the Final Report.

SOME PRELIMINARY CONCLUSIONS

- THE LONG-TERM OPERATIONAL EFFICIENCY OF THE SPACE STATION MAY REQUIRE A FUTURE CAPABILITY FOR SUBSTANTIAL, BUT SIMPLE, ON-ORBIT MODULE INTERIOR MODIFICATION OR RECONFIGURATION (PERHAPS WITHOUT DE-COMMISSIONING). THE IMPLICATIONS OF THIS SHOULD BE IDENTIFIED AT THE PRELIMINARY DESIGN STAGE IF THIS CAPABILITY IS TO BE EFFICIENTLY AND ECONOMICALLY INCORPORATED.
- A POTENTIAL REDUCTION OF THE I.O.C. MODULE CLUSTER FROM FIVE TO THREE (IF MADE NECESSARY BY BUDGET CONSTRAINTS) WOULD PROBABLY REQUIRE SOME MULTI-PURPOSE OR SPATIALLY-ADAPTABLE HABITABILITY MODULE FACILITIES. THIS, IN TURN, COULD SIGNIFICANTLY INCREASE THE DESIGN COMPLEXITY OF CONFIGURATION ELEMENTS AND EQUIPMENT. THIS FACT MAY NEED TO BE TAKEN INTO ACCOUNT NOW.

- FUTURE INCREASED FREQUENCY OF TRANSIENT CREW CIRCULATION THROUGH HABITABILITY MODULES PRODUCED BY ADDITIONAL MODULES, EXPANDED CREW COMPLEMENT , CREW HANDOVERS OR EMERGENCY PROCEDURES MAY INCREASE THE RISK OF UNFORSEEN OBSTRUCTIONS OR 'BOTTLENECKS' IN HABITABILITY MODULES. THIS POSSIBILITY SHOULD BE TAKEN INTO CONSIDERATION IN EVALUATING CIRCULATION ROUTES THROUGH I.O.C. MODULES.

- A 'LIBRARY' OR SHARED QUIET AREA FOR ONE OR TWO CREWMEMBERS MAY BE AN IMPORTANT INGREDIENT IN MITIGATING THE POTENTIAL SOCIAL POLARIZATION THAT MAY ARISE IF THE ONLY OFF-DUTY CHOICE IS BETWEEN A PRIVATE SLEEPING COMPARTMENT OR THE COMMUNAL WARDROOM. A 'LIBRARY' CAN PROBABLY BE ACCOMMODATED IN HM1 WITHOUT ANY DIFFICULTY OR PENALTY IF IT IS TREATED AS AN INTERMITTENT-USE FACILITY.

- THE DECISION TO CHOOSE A 2-SHIFT OR 3-SHIFT DAILY CYCLE WILL SIGNIFICANTLY IMPACT THE DESIGN CONFIGURATION AND OPERATIONAL EFFICIENCY OF HM1. IN VIEW OF THE LARGELY UNKNOWN OPERATIONAL CHARACTERISTICS OF THE SPACE STATION AT THIS TIME, IT WOULD BE WISE TO ENSURE THAT ALL DESIGNS ARE EQUALLY APPROPRIATE TO BOTH SHIFTS.

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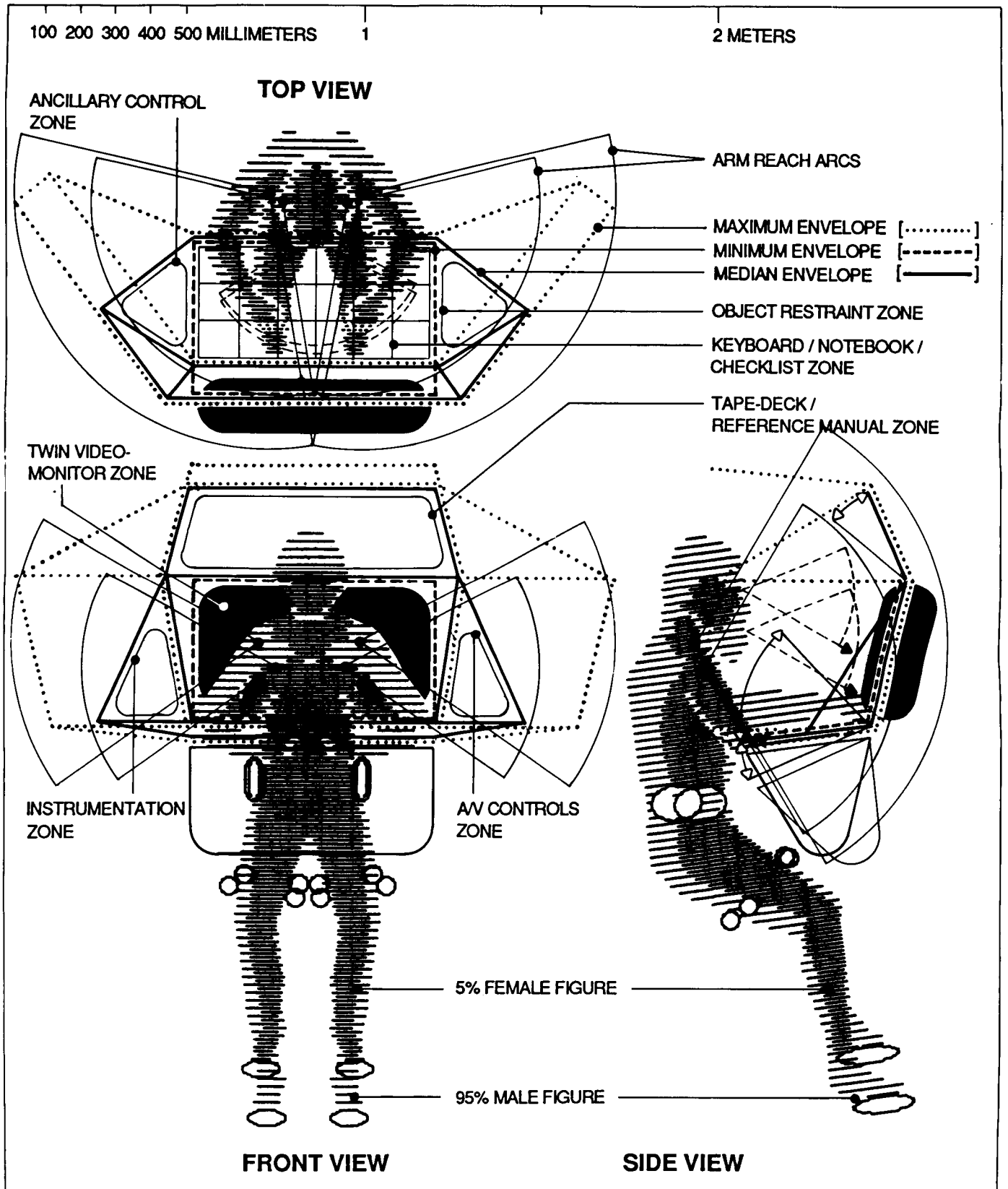

FIGURE 1 **PLANNING AND TRAINING : ERGONOMIC ENVELOPES**

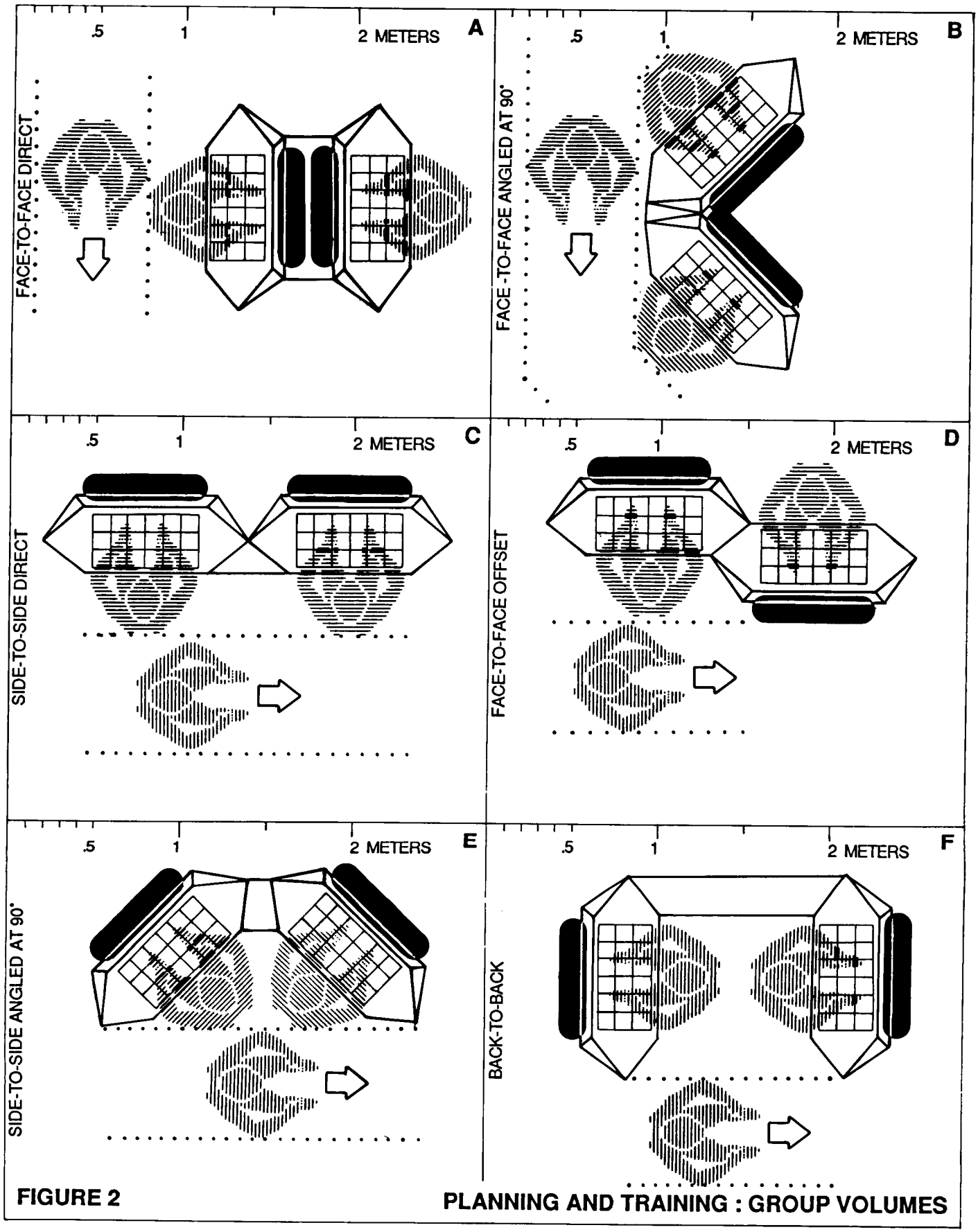

FIGURE 2 **PLANNING AND TRAINING : GROUP VOLUMES**