VOLUMETRIC SIZING RATIONALE

for

MANNED SPACECRAFT

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Initial studies toward identification of influencing variables and a process through which mission responsive volume can be determined.

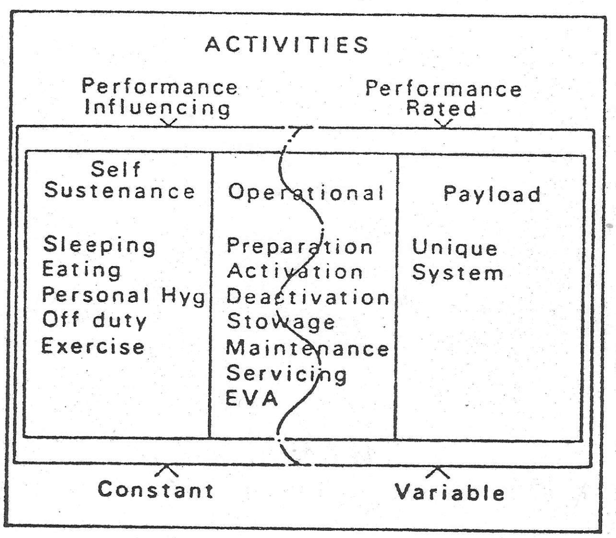
Golden Volume

There is, unfortunately, no golden volume, at least of the universal constant variety. The task of volumetric sizing for manned spacecraft is inherently cumbersome and complex, in fact, quite the antithesis of this ideal. Attempts to generalize or reduce this sisyphean effort to convenient absolutes or all-inclusive ranges, necessarily results in a product of limited usefulness. Albeit, the Dow Jones average serves a purpose, it is not the order of information desired for individual stock investment.

Methodology

This report begins to outline an approach whereby responsive volumetric parameters can be determined. Process and not product, is incorporated as a volume determining technique. This allows the user relative freedom to manipulate the variables according to particular mission profile; also, it avoids the inevitable preconceived solution implied by rigid volumetric projections.

Performance



With alliegence to "performance of activities necessary to achieve mission goals", these activities are categorized as either performance-influencing or performance-rated.

Performance-influencing refers to that family of activities which indirectly affects mission goals, typically eating, sleeping, etc., whereas, performance-rated activities actually comprise the mission goals and are generally experiment oriented. By being "rated" these activities can be measured against experience (actual or simulated) and are calibrated by time and cost*. A fair analog is available in surgery, that is, training is required, each case is slightly different, yet the operation nominally takes x time and cost y amount.

Paradox

This division announces the significance of performance-influencing activities as a constant. Essentially every mission must provide for eating, sleeping, hygiene, and the like, while the performance-rated tasks change from mission to mission. They become, as an element, included yet unsized, since the specifics necessary for volumetric allotment are taken from particular experiment requirements. This points out a curious paradox: The activities which are "only" influencing remain constant yet, those for which this mission is actually intended are variable. Considering subsequent design decisions, this ordering could easily manifest itself physically.

Procedure

The procedure to determine responsive volume involves three steps. 1. First, based on the mission description, an activity scenario is constructed. 2. Then, the relative influence of volume adjustment

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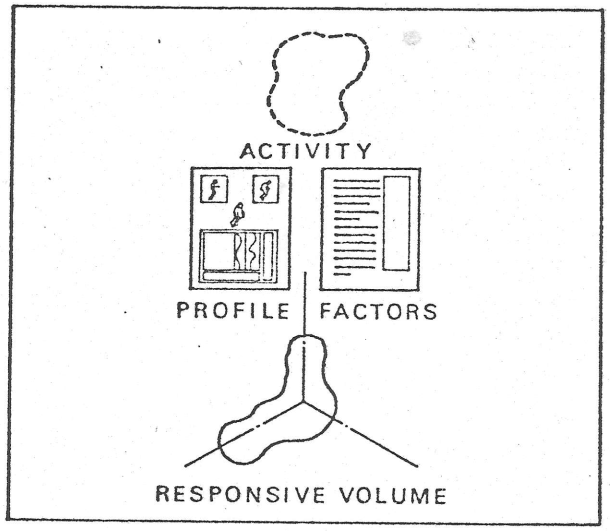
*Cost in this case refers to metabolic rate, oxygen consumption, fatigue, etc.



factors is established, 3. Finally, activities are integrated.

1. The activity scenario is an assemblage of anticipated mission tasks. Most of the collection is selected from a library of activity profiles, however, unique cases, which are not catalogued, could be simulated, then included.

2. The volume adjustment factors compose a listing of determinate variables which record the influence each has on an activity. The governing factorial value is then applied to a minimum surviveable volume producing the modified volume particular to that activity. Requisite information for determination of these values is obtained from the mission description and a file of relevent data.

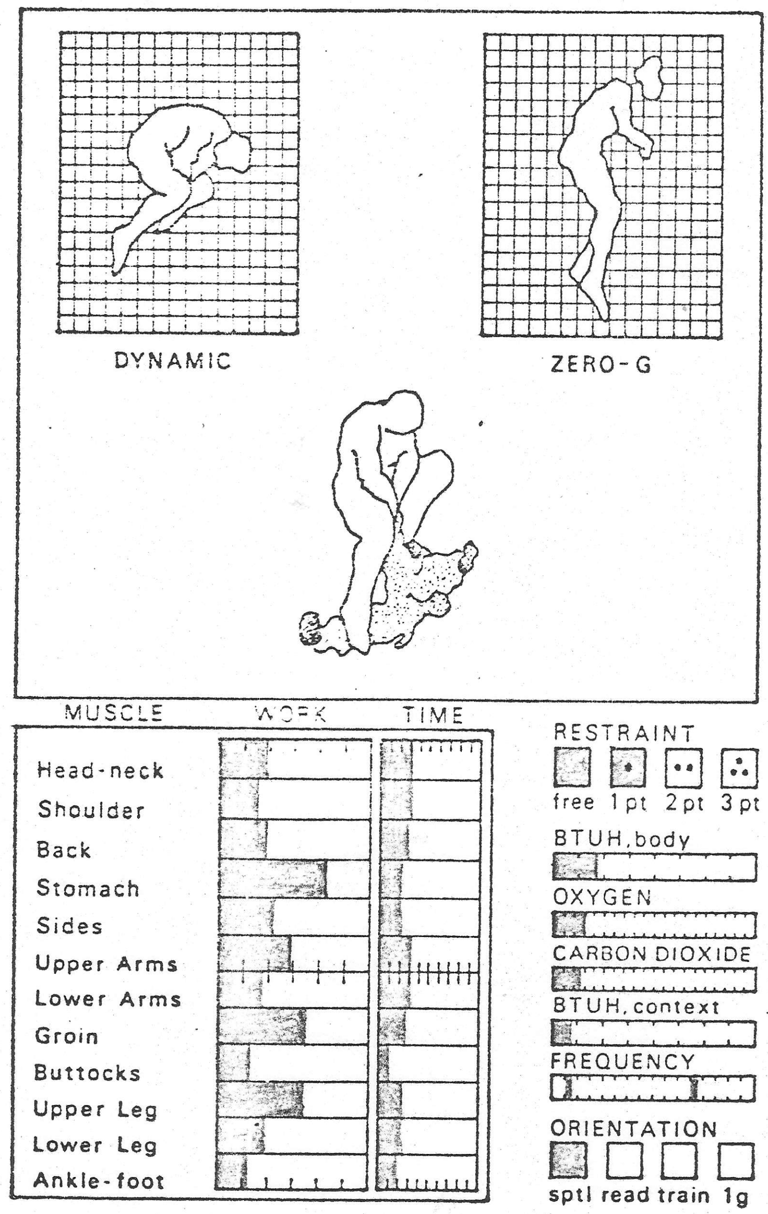
3. Integration of activities provides for user descretion and is based on compatibility and time management (that is, random, dispersed, sequential or simultaneous occurance in time).

Two Elements

The volume generating process is composed of two major elements: Activity Profiles and Volume Adjustment Factors.

Profile

Activity Profiles are a compilation of multi-mode measurements which describe activity characteristics such as metabolic rate, orientation, restraint and so on. Each profile includes three figures. One depicts the zero-gravity posture, another shows the activity's nominal anatomic position, while the third deliniates the position in three dimensional form.



Superimposed on the "static" zero-gravity posture is a moment diagram representing work necessary to achieve the displaced posture. This graphic information is further defined by a quantitative breakdown of work by major muscle groups.

Together, the graphic and quantitative mode of activity description implies an anthropometric envelope and expresses amount and distribution of work performed within those limits.

Additional profile data are provided to ameliorate responsive volume sizing. These include:

1. Restraint -- preferred restraint devices in combination with zero-gravity, posture affords useful volumetric limits.

2. Metabolic rate -- since there is no natural convection in zero-gravity, atmospheric flow is critical for removal of body heat (as well as, oxygen supply and contaminant removal). This influences sizing, in that, smaller volumes require higher velocities for convective cooling, with a cost in energy and deleterious effects for precision tasks and retention of loose objects.

3. Oxygen consumption/carbon dioxide production -- for physiological reasons oxygen must be supplied and carbon dioxide removed. This in conjunction with metabolic rate and no convection, combine to emphasize the gas flow/volume dilemma.

4. Orientation -- certain activities require a specific relationship for operation, this may necessitate volumetric accommodation. Areas of orientation concern are: a) spatial, b) reading, instrumentation, c) training similarity and d) one-g conditioning.

5. Context -- characteristics of the adjacent environment (such as, heat generated by equipment), when in union with planned activities, should influence volumetric sizing.

6. Privacy -- what is the nature of the desired privacy-visual, acoustic, access, and what are the volumetric consequences?

7. Frequency -- the number of times that an activity is performed may prejudice its volume allotment.

Factors

A collection of volume adjustment factors has been identified so that particular influencing responsibility can be assessed. This method of isolating variables provides a manageable structure for incremental volume determination. Eventhough these variables are intrinsically dependent, for the sake of being workable, the process considers them, not only independent, but, mutually inclusive. Thereby, the greatest influence becomes the governing factor, assuming that the less demanding factors can operate within that larger volume.

In operation, volume adjustment factors represent a range of internal and external forces which shape the design. The relative value of these

FACTORS	VALUE	Sg	Gv	VOL
Pressure Envelope	n.a.			
Atmosphere				
Contaminants	.1			
Exchange Rate	.1			
Flow Efficiency	.2			
Anthropmetrics	2.7			78.7
Metabolic Rate	.4			
Orientation	.1			
Context	.1			
Crew				
Composition	.3			
Hierarchy	.3			
Circadian Adjustment	.1			
Duration	.2			
Emergency	.2			
Crew Autonomy	.3			
Privacy	*			
Amenity Balance	.2			

Comments

*Privacy can be achieved through "non-volume" consuming partitions

pressures is assigned according to mission profile and user-input. This allows the method of determining volume to remain neutral, while accounting for the bias in decision making. A problem of this complexity cannot be solved in a linear fashion, therefore a record of decisions is valuable as base from which subsequent generations can be adapted.

Modification of a minimum surviveable volume*, according to these inate

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*Minimum surviveable volume is considered a coffin enclosure around a pressurized spacesuit less portable life support system.

activity characteristics, yields responsive volume. The resultant numerical value should not be taken without further definition, such as, proportionment or axial arrangement. By procedure it became tailored and is not amorphic. The values are the "words" of the language used to communicate the problem. Consequently, it is more important to design for intention rather than rigidily adhere to the particular communicating elements. The objective is to guide, not govern.

Volume adjustment factors include, not only the following, but a "comments" category for extension and elucidation of provided material:

1. Pressure Envelope -- efficient pressure container, delivery system constraints, operating environments, expendable/reusable, sub-system sizing efficiency, growth potential.

2. Atmospheric Exchange -- contaminent removal, temperature control, flow rate, flow efficiency.

3. Anthropometric Parameters -- reach and translation.

4. Metabolic Rate -- BTUH per activity.

5. Orientation -- spatial, reading/instrumentation, training simularily, one-g conditioning.

6. Context -- BTUH, specific atmospheric efficiency, etc.

7. Crew Composition -- numbers, training, hierarchy.

8. Circadian Adjustment -- continued use performance penalities, mission duration.

9. Mission Duration -- volume adjustment for number and frequency of activities related to duration.

10. Emergency Requirements -- sizing and location as a function of emergency procedures.

11. Crew Autonomy -- in-flight volume/activity modifications by crew discretion.

12. Privacy -- visual, acoustic, access.

13. Amenity Balance -- volumetric proportionment based on unique characteristics such as view, location, etc.

Continuum

The principal intent of this study is to begin to construct a rationale for volumetric sizing of manned spacecraft. In every sense of the word, it represents a beginning; displaying frequent signs of experiment and research anemia. However, the conceptual mechanism has been indentified, now only continued refinement can establish it's relative usefulness.