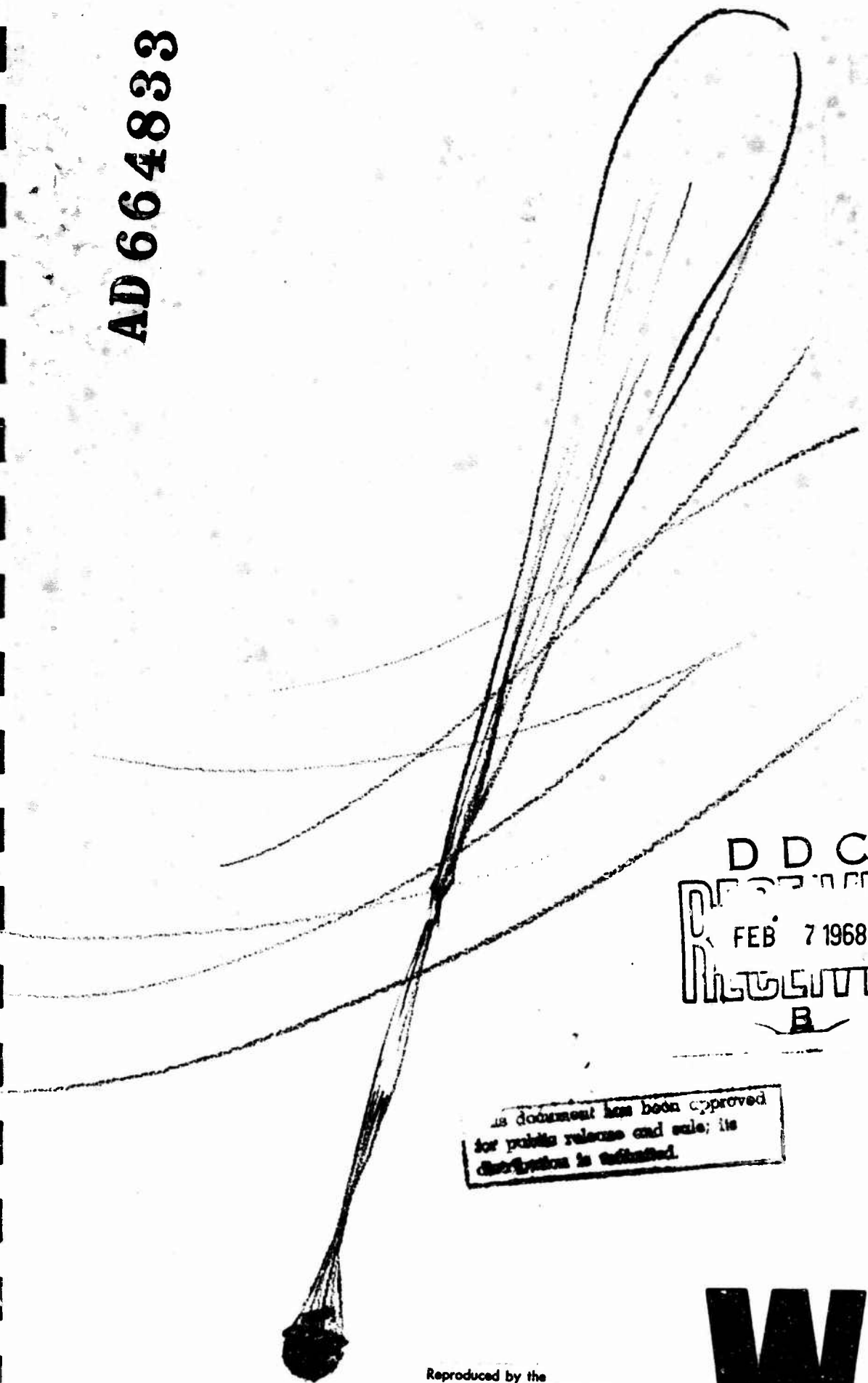


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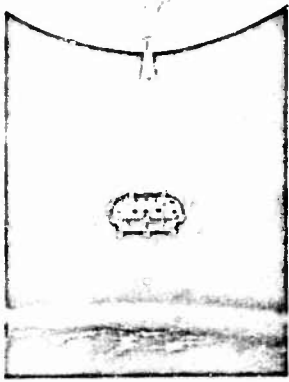
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Final Report

Launch Facility Study

Performed Under
Contract N00014-67-C-0350
Contract Authority NR 211-125/1-6-67

For

Office of Naval Research
Washington, D. C. 20360

26 January 1968

Prepared by: Winzen Research Inc.
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Final Report
Contract N00014-67-C-0350
Launch Facility Study

INTRODUCTION

Section A of the Statement of Work of the subject contract stated that the contractor . . . "shall conduct a methodical analysis of the national research and development effort related to cosmic ray studies, X-ray and gamma ray astronomy and aeronomical studies to justify a cooperative mobile launch facility for balloons and rockets capable of economical operation in ocean areas. Said research shall include, but not necessarily be limited to, a study of ship launch facilities combined with suitable shore activities and other ships and aircraft for recovery purposes."

To accomplish the above effort, the tasks originally proposed were modified as follows:

Task I - Establish a generalized outline of possible Research and Development effort in order to meet the National Mission objectives.

In accordance with the work statement this task was modified to cover areas related to astronomy and aeronomical studies including some ocean science where this was related to the atmosphere-ocean interface.

Task II - Establish the specific R&D effort being conducted by the various U. S. agencies, to determine overlap and duplication of programs and the areas of effort not presently being covered.

This task was also modified to limit the coverage to astronomical and aeronomical studies.

Task III- Establish the types of facilities necessary to conduct acceptable programs within the various R&D areas of effort.

Task IV - Establish the facilities presently being employed by the various agencies in their R&D programs and from this determine the overlap and duplication of these facilities.

Task V - Develop an objective organization of Integrated Research and Develop--

ment Units which if employed would reduce overlap, redundancy and duplication of effort and facilities, increase our R&D scope of effort, and increase the effectiveness of the overall National Research and Development Program.

Tasks III through V were also modified to meet the work statement but also included consideration of additional research facilities other than just those required for launching balloons and rockets.

Each of the tasks were completed with the exception that Task II. could have been more extensive if more information relative to the projects of agencies other than CNR, could have been acquired. Although considerable difficulty was encountered in attempting to gather data concerning active projects, sufficient knowledge was obtained from various National Academy of Sciences reports to permit extrapolation of enough information to be used as examples in the subject analysis.

It is believed that the results of the analysis not only justifies a cooperative mobile launch facility for balloons and rockets capable of economical operation in ocean areas, but in addition, the findings demonstrate a research facility capable of reducing overlap, redundancy, and duplication of effort and at the same time increasing the scope of research effort and effectiveness.

TECHNICAL DISCUSSION

The study utilized a very specific method of analysis. Rather than describing the methodology separately, the discussion which follows will bring out the basic concepts of the methodology by showing how they were applied to the problem at hand.

Basically the methodology employs a technique for examining a complex problem in an orderly and systematic way so that bias and opinion is minimized in favor of logic based upon fundamental relationships. To determine these fundamental relationships it is necessary first to define the factors involved in a relationship, and second, to define the nature of the relationship itself.

In this instance we are concerned with various aspects of astronomical and aeronautical research.

The primary factors involved then are the constituents of the universe and the atmosphere, and phenomenological characteristics. The relationships we seek to understand are the specific characteristics which are pertinent to each of the constituents. To implement the determination of the fundamental relationships, a matrix consisting of the two sets of factors was utilized, which for purposes of this analysis provided a means for identifying the objectives of the various research projects being examined.

In addition to the specific research objectives, we are also concerned with the means and methods for conducting the research effort. The factors involved here are the projects themselves and the facilities, vehicles and support services required to execute the research projects. The relationships are then the correlation of these two sets of factors which were determined by a second matrix. This second matrix provided a means for establishing the specific facilities, vehicles, and support services being utilized by each of the research projects.

A third area of concern which is most pertinent to the problem is the determination of methods for maximizing the efficiency of astronomical and aeronautical research effort. In this instance one set of the factors involved consists of the facilities, vehicles, and support services, and the other set comprises the operational parameters such as availability, flexibility, capability, and cost. In order to equate these factors, a third matrix was developed which permitted an examination of the operational parameters relative to the major classes of facilities, vehicles, and support services which in turn established the optimal class for the subject type of operation.

The remaining steps in the analytical procedure consisted primarily of applying the results of the previous effort to determining the requirements for the cooperative facility and to justifying its effectiveness by relating the facility capabilities to specific project requirements. Before expanding on these latter steps, it is necessary to return to a more detailed description of the matrices previously referred to and

explain how they were developed.

One of the concepts upon which the employed analytical technique is based is that any entity within our total environment can be treated as an element of an hierarchial distribution ranging from macroscopic to microscopic proportions. Since an understanding of these entities within the environment is the objective of research, and when the domains of the environment being examined are as extensive as they are in astronomy and aeronomy, it becomes necessary to carefully identify and categorize each of the entities within the selected range of the total hierarchial distribution. To accomplish this, a selection and classification of terms was prepared as follows:

1. The first level was divided into Space, Space/Atmosphere Interface, Atmosphere, Atmosphere/Hydrosphere Interface, Hydrosphere, Hydrosphere/Lithosphere Interface, Lithosphere, and Lithosphere/Atmosphere Interface.

2. At the second level, Space was further divided into Extra Galactic, Galactic, Planetary, Solar, Lunar and Interstitial Space. Atmosphere was divided into Exosphere, Heterosphere, Thermosphere, Ionosphere, Mesosphere, Homosphere, Chemosphere, Stratosphere, Ozonosphere and Troposphere. Hydrosphere was categorized as Surface Layers and Deep Layers, and the Lithosphere was divided into the Sediments, Crust, and Mantle.

3. Since each domain is comprised of Gaseous, Liquid and Solid Forms along with Energy Forms, these terms were used to define the next lower level.

4. The last level consisted of the specific types of Gaseous, Liquid, Solid and Energy Forms which will not be listed in the text of this discussion but can be found on Fig. 1, along the horizontal axis.

Since an understanding of any entity in the environment is dependent upon knowledge of its characteristics, any research effort can only be identified by determining the specific characteristics of the entity being examined. It is necessary then to also identify and categorize these characteristics.

The selection and classification of terms to represent the overall characteristics was prepared as follows:

1. The first level was divided into Determination of Constituents, the

Synoptic Factors, and the Dynamic Factors.

2. The second level was divided into Structure and Properties with a further division of Properties into Mechanical, Electromagnetic, Thermodynamic, Chemical, and Biological.

3. Each of the second level terms were further categorized by the pertinent specific fundamental physical terms. In the interests of keeping the text of this discussion as short as possible these terms are not listed but can be found along the vertical axis of Fig. 1.

Taking the terms as described above, the first matrix (Fig. 1) was prepared. This represents the fundamental relationships which constitute Astronomical and Geographical Research and to some extent Ocean Sciences Research. The utilization of Fig. 1 will be explained later in the report.

To deal with the second set of relationships with which we are concerned, i.e., the means and methods for conducting research, a compilation of terms was prepared to represent the facilities, vehicles, and support services as follows:

1. The first level was divided with respect to the operational media, i.e., Land, Sea, Air and Space.

2. Each of the above were further divided into Facilities, Vehicle Operations, Deployed Vehicle Operations, and Support Services.

3. The second level terms were further divided into more specific terms as shown in Fig. 2.

The second set of factors, namely, the projects could not be categorized in general terms but provision was made in preparing the matrix (Fig 2) for classifying each project relative to the Agency, Work Unit Number, Specific Characteristic/Specific Constituent, Work Unit Cost, and Support Cost. The utilization of Fig. 2 will be explained later in the report.

The third area of concern was the relationship of operational parameters relative to the facilities, vehicles, and support services to determine methods for maximizing the research effort. The terms for facilities, vehicles, and support

services were already established (See Fig. 2). An additional set of terms representing the operational factors was developed as follows:

1. The first level was divided into Capability, Flexibility, Availability and Cost.

2. The second level under Capability was further divided into Facilities, Vehicle Operations, Deployed Vehicle Operations, and Support Services. Under Flexibility the divisions are Geographical Coverage, Local Area Coverage, Mobility, Individual Observations, and Simultaneous Observations. Availability was divided into Number of Months, Number of Days, Day Operations, Night Operations, and All Weather Operations. Cost was divided into Initial and Operational.

3. The only third level breakdown applied to Individual and Simultaneous Observations under Flexibility and each was further divided into the Areas of Research, i.e. Space, Space/Atmosphere Interface, Atmosphere, etc.

Utilization of the Matrices

Starting with Matrix 1 (Fig. 1) a series of columns were added to the right hand side of the matrix under Project Work Unit Code with the following headings: Project/Work Unit Number, Type of Effort, Specific Characteristic/Specific Constituent, Operation Facility or Vehicle, Support Facility or Vehicle, Geographic Location, and Cost.

These columns were used to record the various astronomical and atmospheric research work units furnished by the Physics Branch, ONR. An additional set of work units from Code 408 on Ocean Sciences were also recorded as well as projects for agencies other than ONR which were extrapolated from National Academy of Sciences reports.

Each of the projects were coded as follows: The first set of digits in column one represent the major intersection of the matrix which best identified the research effort. For example, 09/17 would indicate that the work unit consisted of research relative to the Dynamic Mechanical Properties of the Stratosphere. The number recorded under this set of digits indicates the work unit number as shown on the

1498 form. The number recorded in the second column indicates the type of effort being conducted. The first eight numbers displayed under the Code along the horizontal axis represents the various types of effort. For example if the number 04 appeared in the second column it would mean that the work unit called for Field Observation and Experiments.

The third column was used to denote the Specific Characteristic and the Specific Constituents using the Codes along the vertical and horizontal axes. For example, if the entry were 08/20 it would mean that the work unit involved examination of the Velocity of Vertical Winds.

The fourth column was used to record the Operational Facility or Vehicle, the code being taken from numbers 119 through 133 from the horizontal axis code. The fifth column indicated the Support Facility or Vehicle taken from the horizontal code from numbers 119 through 148 since Instrumentation and Equipment was also considered as supporting effort. Thus if columns four and five showed the numbers 129 and 119 respectively it would indicate that the work unit called for the operation to be carried out by a Balloon and operated from a supporting Land Base.

The sixth column was used to indicate the Geographical Location of the effort such as Palestine, Texas. The seventh column was used to indicate the work unit funding in thousands of dollars.

In summary then if the code appeared in the columns as;

09/17
211-096 - 04 - 08/20 - 129 - 119 - Palestine, Texas - 50

it could be read out as a Physics Branch work unit investigating the dynamic mechanical properties of the stratosphere by conducting field observations, specifically with respect to the velocity of vertical winds, with a balloon operating from a land base at Palestine, Texas at a cost of \$40,000.

In addition to the coding, the work unit numbers were also recorded in the appropriate intersections on the matrix.

Matrix 1 (Fig. 1) has many uses. When work units are recorded in the intersections it shows the distribution of effort, areas of heavy concentration, and areas where no activity is being conducted. If all agencies projects were also recorded it would show areas of overlap and areas of duplication. To determine whether duplication exists, it is only necessary to refer to the codes for each of the projects in question to determine the specific characteristic and specific constituent being examined, or the operating facility or support facility, equipment being used, or the geographical location.

In this analysis the matrix was utilized to define each of the work units examined. It can also be utilized as a guideline to prepare new 1498 forms.

When large numbers of work units are being administered, the matrix coding provides the programming information for computerizing the data handling.

For the subject analysis, however, the reason for recording the work units was primarily to establish the various factors and relationships relevant to the study objectives. Specifically the exercise was carried out in order to define the work units in terms of the factors required for utilization of Matrix 2 (Fig. 2)

Referring to Matrix 2, the work units were recorded along the vertical axis as coded in Matrix 1. Each work unit was then examined relative to the Facilities, Vehicles, and Support Services as indicated on the horizontal axis. Wherever a specific facility, operational vehicle, deployed vehicle, etc. was found to be either stated as being utilized or found by inference to be required, the appropriate intersection was marked.

Further analysis of the distribution of the marked intersections provided the means for establishing a reasonably accurate list of the facilities, vehicles, and support services required for effective astronomical and aeronautical research.

It is obvious that a broader coverage of research work units would provide a more thorough delineation of the facilities, vehicles, and support services required, but the work units which were recorded, represent enough of the research spectrum to establish the general requirements.

The next step in the analysis was to determine the most effective and economical

combination of facilities which could be organized and operated as a cooperative effort. To do this, Matrix 3 (Fig. 3) was examined and coded to establish which of the various types of facilities, vehicles, and support services provided the greatest capability, flexibility, availability and lowest operational cost.

When the distribution of marked intersections on Matrix 3 was analyzed it became obvious that a combination of ships can provide the greatest concentration of capability, the most flexibility, and the maximal availability. Although information relative to cost was not available for this analysis, it can be hypothesized that since a ship is essentially a mobile base of operations the operating cost for one ship would certainly be less than the operating cost of several land bases. It is believed that if operating cost figures could be made available, a relatively modest analysis would show a very significant reduction in the cost of conducting the subject type of research by employing ships, as opposed to the cost of operating the relatively large number of land bases presently being utilized.

The final steps of the analysis consisted of preparing Matrix 4 (Fig. 4) which shows the advantages of a research fleet of ships by correlating the various ship facilities with the facilities necessary for conducting astronomical and aeronautical research as well as land and ocean sciences research. One properly fitted aircraft carrier made available for research would provide a definite increase in research capability. Additional benefits would be added in proportion to the number and type of ships added to the research fleet complex.

To further justify the advantages which could be gained from a fleet of research ships, Matrix 5 (Fig. 5) was prepared in which those work units specifying field observation and operations were plotted relative to the capabilities of the units of the proposed ship complex. It is quite evident that all of these projects could be executed with a single aircraft carrier as the operating support facility. It is also believed that the research results could be more extensive and that the overall time for conducting the projects could be greatly reduced.

SUMMARY AND CONCLUSIONS

The effort as described in the report produced the following results.

1. A generalized outline of the major factors and relationships relative to astronomical and aeronautical research was established and in addition was prepared in the form of a matrix which can be very useful in management of pertinent research programs.
2. An analysis of the ONR research work units was accomplished which identified the individual work unit effort and provided a distribution of these projects relative to the subject research areas.
3. A delineation of the facilities, vehicles and support services required for astronomical and aeronautical research was achieved and served to justify the utilization of a research oriented ship complex.
4. A cooperative mobile launch facility for balloons and rockets capable of economical operation in ocean areas was also justified and could be achieved with a single aircraft carrier.

RECOMMENDATIONS

As hypothesized in the proposal, one of the greatest sources of information relative to the nature of any entity within our range of observation, lies at the interface of that entity with another. In reviewing the present effort being conducted in astronomy, aeronomy, and ocean sciences, there appear to be very few work units related to the major interfaces of land, sea, air and space. This is probably due in part to a lack of coordination of the various scientific disciplines but it is believed to be primarily due to the lack of a facility to accomplish the observations required.

It is recommended that a project be established in which an aircraft carrier is assigned to operate in company with ocean science research vessels and coordinate with the earth satellite program. Such a combination of facilities would permit

simultaneous launching of a number of free and tethered balloons as well as deploying sounding units from the ocean science vessels. If the balloons and sounding units were programmed to level off at specified altitudes and depths, a series of measurements could be achieved almost simultaneously from the ocean bottom to the top of the atmosphere. If these measurements could be coordinated with the transit of an earth satellite, the measurement of energy and energy exchange as well as other parameters could be achieved at each of the major environmental interfaces.

It is believed that the results which could be realized from such an experiment would completely justify the concept of a mobile research facility and promote greater coordination of the research agencies.

It is further recommended that the subject analysis be extended to acquire additional work unit information from agencies other than ONR in order to permit a broader coverage of the subject research, and to expand the matrices to greater levels of detail.

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1c. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Launch Facility Cosmic Ray X-Ray *Astronomy Ships Aircraft Astronomical *Aeronomical *Balloons Rockets Atmospheric constituents						

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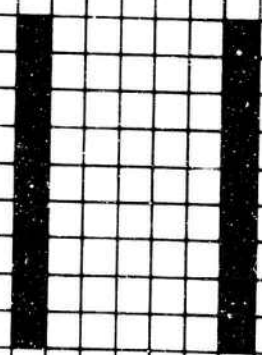
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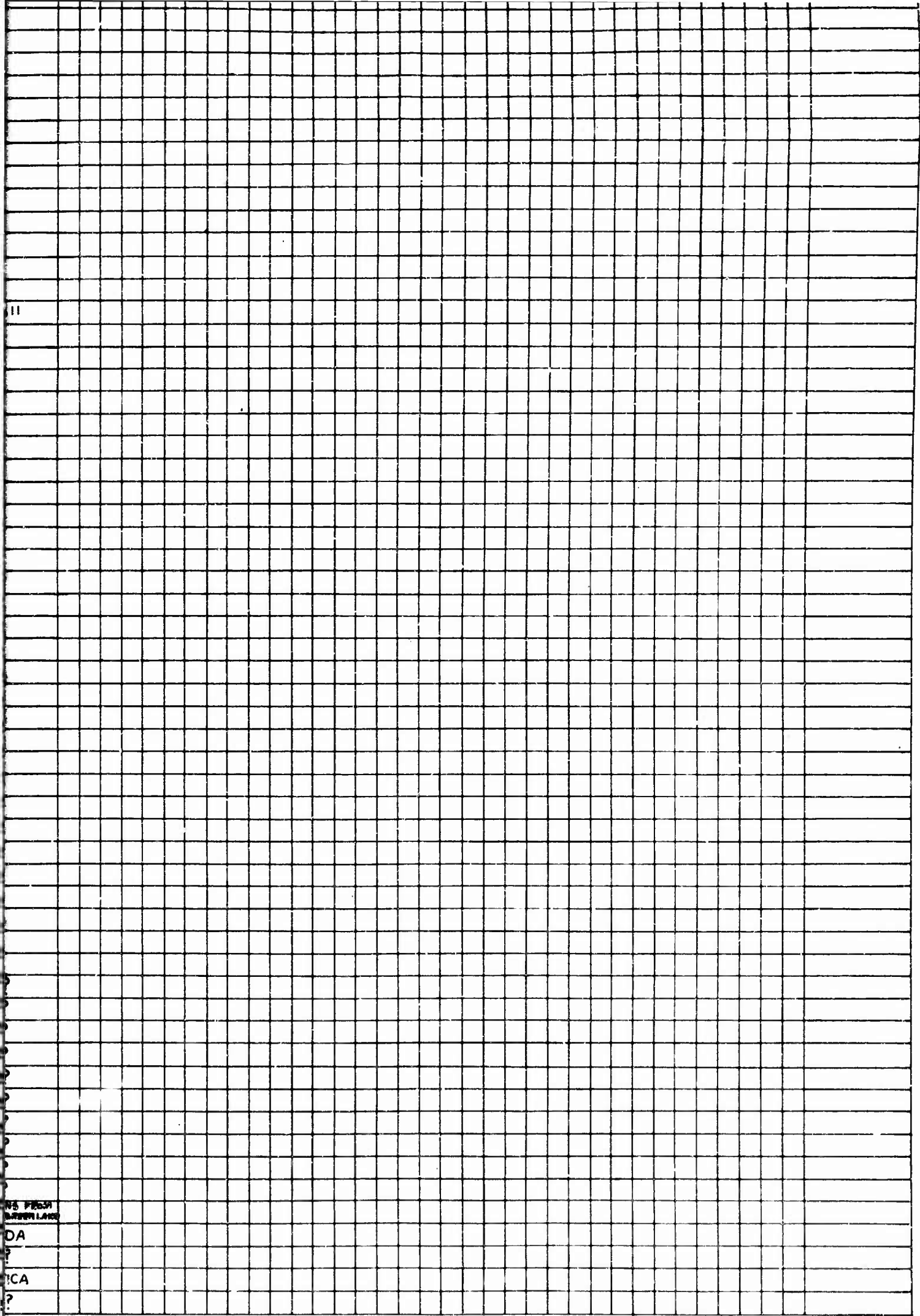
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FIGURE 1

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FORMS	MOTIONS									WATER MASSES						WATER MIXTURES		HYDROCARBONS			MOTIONS									LIVING																		
	CONTAMINANTS	TRANSLATIONS			ROTARY			OSCILLATORY			OCEANS AND SEAS	LAKES	RIVERS	DELTA	ESTUARIES	SEA WATER	DROPLETS - CLOUDS/RAIN	CONTAMINANTS	OIL	LAVA	MAGMA	TRANSLATIONS			ROTARY			OSCILLATORY			MAN	ANIMAL	PLANT	MICROORGANISM														
		PERSISTANT WINDS	EPISODICAL WINDS	VERTICAL WINDS	HURRICANES	CYCLONES	TORNADOES	CLOUD TURBULENCE	CLEAR AIR TURBULENCE	CIRCULATION												CURRENTS	MEANDERS	VERTICAL MOTIONS	CONVECTIVE MOTIONS	EDDIES	VORTICES	TIDES	WAVES																			
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63

SPACE				ATMOSPHERE											
RETARY	SOLAR	LUNAR	INTERSITIAL SPACE	SPACE ATMOSPHERE INTERFACE	ATMOSPHERE GENERAL	EXOSPHERE	HETEROSPHERE	THERMOSPHERE	IONOSPHERE	MESOSPHERE	HOMOSPHERE	CHEMOSPHERE			
04	05	06	07	08	09	10	11	12	13	14	15	16			
	211026				211026 211-097 082-164 AEC										
SA AF	NASA				211068 082-212				NASA						
	211-099 NASA														

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ENTATION AND EQUIPMENT	
RS	ENERGY SUPPLY DATA
138	ELECTROSTATIC
139	CHEMICAL
140	ENERGY CONVERSION
141	STORED ENERGY
142	STORAGE RETRIEVAL
143	COMPUTATION
144	CONTROLS
145	DISPLAYS
146	COMMUNICATION
147	SIMULATION
148	PROBE SYSTEMS

PROJECT/WORK UNIT CODE						PROJECT/WORK UNIT CODE						
TYPE OF FORT	SPECIFIC CONSTITUENT FACILITY OR EQUIV. CHARACTERISTICS	OPERATION FACILITY OR VEHICLE	SUPPLY FACILITY OR VEHICLE	GEOGRAPHIC LOCATION	COST IN 1000'S	PROJECT/WORK UNIT NUMBER	TYPE OF EFFORT	SPECIFIC CONSTITUENTS FACILITY OR EQUIV. CHARACTERISTICS	OPERATION FACILITY OR VEHICLE	SUPPLY FACILITY OR VEHICLE	GEOGRAPHIC LOCATION	COST IN 1000'S
04	00\09	129	119	?	?	01\17 NASA	04,07	03\70	129	148	?	?
04	00\88	129,134	119	?	?	01\17 NASA	04,07	03\95	129	134		
04	00\95	129,134	119	?	?	00\17 NASA	04,07	00\95	129	134		
08	00\129	129	119	MINN.	23	14\32 NASA	05	00\129	126	129		
08	00\144	129	119	MINN.	4	01\05 NASA	04,07	01\88	129	134		
04	08,11,30\17	129	119	CONTINENTAL U.S.	35	04\17 NASA	04,07	04\93	129	134		
04	09\129	129	119	MASS.	50	14\32 NASA	05,07	00\129	126	129		
08	01\09	119	32,33	WASH. D.C.	3	01\13 NASA	04,07	03\92	129	134		
01	04,05\129	119	143	N. Y.	21	00\02 NASA	04,07	00\87	129	134		
04	02\37,83	129,139	119	KWAJALIEN	0	10\17 NASA	04,07	10\98	129	134		
08	00\09,95,144	129	119	TEXAS	11	01\04 NASA	04,07	01\09	129	148		
08	TRAINING	129	119	MINN.	0	14\17 NASA	05	00\126	129	148		
08	09\17	119	143	S. DAKOTA	5	04\05 NASA	04,07	04\88	129	134		
08	00\129	129	119	MINN.	40	14\17 NASA	05,07	14\134	129	134		
08	00\09,95	129	119	CHURCHILL	350							
08	00\129,144	129	119	S. DAKOTA	4	10\17 USAF	04,07	24,25\92	129	134		
08	00\95,129	129	119	MINN.	44	06\18 USAF	04,07	51\83	129	139	11 STATIONS CANAL ZONE TO GREENLAND	
08	00\97,100	119	119	WASH. D.C.	30	01\17 USAF	04,07	03\101,102	129	134	CANADA	
08	LOGISTIC SUPPORT	LOGISTIC	119	MINN.	2	01\04 USAF	04,07	01\09,28	129	134		
08	00\17,96,97	129	119	CALIF.	0							
08	00\129	119	119	MINN.	42	BU STANDARDS	04,07	03\35	129	134		
08	14\102,129	129	119	MINN.	28	01\17 AEC WEATHERB.	04,07	03\97	129	134	ANTARTICA	
08	04\92	129	119	TEXAS	10	00\09 AEC	04,07	00\88	129	134		
08	00\87	129	119	CHURCHILL	418							
08	03\98	129	119	CANADA	116							
08	25\88	129	119	MASS.	65							
08	14\127	127	119	CHURCHILL	59							
08	LOGISTIC SUPPORT	129	119	CALIF.	?							
08	00\122,131	131	122,123	MICHIGAN	27							
08	00\95	129	131	S. DAKOTA	7.5							
08	11\21,37	147	119	FLORIDA	28							
08	26\37,38,71	147	119	NEW MEXICO	29							
08	09\16,43	147	119	MARYLAND	27							
08	16\37	147	119	MASS.	18							
08	19,28\13,81	143	119	ARIZONA	20							
08	19,28\13,81	143	119	ARIZONA	4							

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ELECTROMAGNETIC	DIELECTRIC CONSTANT	18	
	RADIOACTIVITY	19	
	MAGNETIC PROPERTIES	20	
	ELECTROSTATIC PROPERTIES	21	
	ISOTROPICITY	22	
	PERMEABILITY	23	
	INDEX OF REFRACTION REFLECTION	24	
	COLOR (SPECTRA)	25	
	ELECTRIC POTENTIAL	26	
		27	
	THERMODYNAMIC	TEMPERATURE	28
		COEFFICIENT OF THERMAL EXPANSION	29
		THERMAL CONDUCTIVITY	30
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MELTING POINT		32	
HEAT OF REACTION		33	
ENTROPY		34	
		35	
		36	
CHEMICAL	ATOMIC NO.	37	
	ATOMIC WEIGHT	38	
	MOLECULAR WEIGHT	39	
	LIGANCY	40	
	OXIDATION STATE	41	
	FORMAL CHARGE	42	
	VOLATILITY	43	
	SOLUBILITY	44	
	EQUILIBRIUM CONSTANT	45	
	BOND LENGTH	46	
	FORCE CONSTANT	47	
	BOND STRENGTH	48	
	DIPOLE MOMENT	49	
	POLARIZABILITY	50	
	CONCENTRATION	51	
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BIOLOGICAL	PHYSICAL CHARACTERISTICS	53	
	CHEMICAL COMPOSITION	54	
	METABOLIC REQUIREMENT	55	
	ENVIRONMENT REQUIREMENT	56	
	BY PRODUCTS	57	
	SUSCEPTIBILITY	58	
	GROWTH	59	
	REPRODUCTION	60	
	BEHAVIOR	61	
		62	
		63	

SYNOPTI		PROPERTY			
		BIOLOGICAL	CHEMICAL	THERMODYNAMIC ELECTRIC	
DYNAMIC	STRUCTURE	BIOLOGICAL	07	05	
		CHEMICAL	06		
	PROPERTIES	MECHANICAL	08		
			09		
		ELECTROMAGNETIC	10		
			11		
		CHEMICAL	12		
			13		
		BIOLOGICAL	14		

SUPPORT/
DEVELOPMENT

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		131	122, 123	MICHIGAN	27
04,08	00\95	129	131	S. DAKOTA	7.5
02	11\21,37	147	119	FLORIDA	28
02	26\37,38,71	147	119	NEW MEXICO	29
02	09\16,43	147	119	MARYLAND	27
02	16\37	147	119	MASS.	18
02	19,28\13,81	143	119	ARIZONA	20
02	19,28\13,81	143	119	ARIZONA	↑
01	00\37,71	143	119	ARIZONA	38
01,04	10\16,87	143	119	NEW MEXICO	25
03	09\21,50	147	119	FLORIDA	60
05	01\18 00\148	131	119	MASS.	25
01,04	12,14\25,113	136	119	NEW MEXICO	13
01,04	25\92,93,94	134	119,127	ARIZONA	25
01,04	09\16	134	119	NEW YORK	39
01	03\37	143,148	119	COLORADO	30
04	00\80	120	119	ARIZONA	25
02,04	51\82	139	119	GERMANY	3
04	10\104,105	138	119	ENGLAND	13
04	10\104	134	119	CALIF.	8
04	33,51\37,82,116	123,127,128	119	HAWAII	54
02	09\37,104	147	119	WASH. D.C.	36
05	00\129	129	119,123	CALIF.	13
01	04\37,71	143	119	ARIZONA	40
01	04\83	143	119	ARIZONA	↑
04	03\37	134	119	CALIF.	24
02	16\37	?	119	CALIF.	25
02	26\37,38,71	138	119	N. Y.	16
01	00\105,117	?	119	CALIF.	20
02	08,11\37,71	147	119	NEVADA	25
02	08\37,71,95	?	119	N. Y.	30
01	00\37,71	?	119	CALIF.	55
01	11\16	143	119	MASS.	4
04	26\37,113	134,143	119	NEW MEXICO	?
04	00\16,89	134	119	FLORIDA	19
01	00\16,37,104	142	119	N. Y.	12
01	10\16,117	142,143	119	RHODE ISLAND	35
04	04,10\10	134	122,123	FLORIDA	10
01	10\138	142\143	119	CALIF.	11
01	34\09	143	119	ILLINOIS	11
04	51\36,82	123	139,142	TROPICS	11.3
02,04	03\16,43	123	136,147	CHESAPEAKE B.	103
01,08	00,20	123	143	GULF OF MEX.	37
04	44\09,81	123	139	GULF OF MEX.	43
04	00\13,35	123	?	?	22
04	02\13,16	122,123	136	LONG ISLAND SOUND	89
04	24\36,93	123	134	?	60
04	07\10,56	123	136	BAHAMA BANK	69
04	09,11,12\13,16,46,134	123	134,136	?	60

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FIGURE 4

FACILITIES - VEHICLES - SUPPORT - SERVICES						RESEARCH FLEET		
SHIP	FACILITIES	VEHICLES FOR DEPLOYMENT	SUPPORT SERVICES	EQUIPMENT COST	OPERATING COST/YR.	RESEARCH LABORATORIES		
						01	02	03
A AIRCRAFT CARRIER	GEOPHYSICAL SCIENCE RESEARCH LABORATORY							
	OCEAN SCIENCE RESEARCH LABORATORY							
	ATMOSPHERIC SCIENCE RESEARCH LABORATORY							
	SPACE SCIENCE RESEARCH LABORATORY							
	EQUIPMENT DEVELOPMENT LABORATORY							
	OPTICAL OBSERVATORY							
	RADIO/RADAR OBSERVATORY							
	PHYSICAL OBSERVATORY							
	TRACKING NETWORK							
	COMMUNICATIONS NETWORK							
	DATA PROCESSING FACILITY							
	SIMULATION AND TEST LABORATORY							
		LAND SURFACE VEHICLES						
		SUBTERRANEAN VEHICLES						
		BOATS						
		AMPHIBIOUS CRAFT						
		SUBMERSIBLES						
		UNDERSEA BASES						
		BUOYS						
		FIXED WING AIRCRAFT						
		ROTARY WING AIRCRAFT						
		BALLOONS						
		SOUNDING ROCKETS						
		BOOSTERS/SPACECRAFT (LIMITED)						
		PERSONNEL						
		MAINTENANCE AND REPAIR						
		CONSTRUCTION (LIMITED)						
		FOOD AND HOUSING						
		MEDICAL						
		SUPPLY						
		RECOVERY RESCUE AND SURVIVAL						
		ADM. LIBRARY, CLASSROOMS, CLERICAL, DRAFTING, ETC.						
		RECREATION						

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SPACE

FACILITIES			SPACE VEHICLE OPERATIONS				DEPLOYED VEHICLE OPERATIONS				SUPPORT SERVICES				GEOGRAPHICAL LOCATION	
103	OPTICAL OBSERVATORIES		111	SPACE PROBES		119	SPACE PROBES		125	PERSONNEL (FUTURE)		131	RECOVERY, RESCUE AND SURVIVAL LIMITED ADMINISTRATION (FUTURE)		136	
104	RADIO RANGE OBSERVATORIES		112	BOOSTERS		120	BOOSTERS		126	MAINTENANCE AND REPAIR (FUTURE)		132	RECREATION (FUTURE)			
105	PHYSICAL OBSERVATORIES		113	EARTH ORBITING SATELLITES AND STATIONS		121	LIFTING BODIES		127	CONSTRUCTION (FUTURE)		133	TRANSPORTATION			
106	TRACKING		114	PLANETARY ORBITING SATELLITES AND STATIONS		122	BALLOONS		128	FOOD AND HOUSING		134				
107	COMMUNICATIONS		115	SOLAR ORBITING SATELLITES AND STATIONS		123			129	MEDICAL (FUTURE)		135				
108	DATA PROCESSING		116	SPACECRAFT		124										
109	SIMULATION AND TEST (FUTURE)		117			118										
110	INSTRUMENTATION & EQUIPMENT		118			119										

ACCESS TO ANY REGION OF SPACE

Y

	AND REPAIR			27	
	CONSTRUCTION (LIMITED)			28	
	FOOD AND HOUSING			29	
	MEDICAL			30	
	SUPPLY			31	
	RECOVERY RESCUE AND SURVIVAL			32	
	ADM. LIBRARY, CLASSROOMS CLERICAL, DRAFTING, ETC.			33	
	RECREATION			34	
	TRANSPORTATION			35	
ATMOSPHERIC & OCEAN SCIENCES RESEARCH VESSELS	TOTAL ENVIRONMENT SENSING EQUIPMENT			36	
	TOTAL ENVIRONMENT SAMPLING EQUIPMENT			37	
	ENVIRONMENT ALTERATION EQUIPMENT			38	
	SURVEYING EQUIPMENT			39	
	TRACKING NETWORK			40	
	COMMUNICATIONS NETWORK			41	
	DATA PROCESSING EQUIPMENT (RELAY)			42	
		SOUNDING AND TETHERED BALLOONS			43
		ATMOSPHERE AND OCEAN PROBES			44
		BOATS AND BUOYS			45
		DIVERS			46
			CREW AND LIMITED RESEARCH PERSONNEL		47
	SUBMARINES	TOTAL ENVIRONMENT SENSING EQUIPMENT			48
		TOTAL ENVIRONMENT SAMPLING EQUIPMENT			49
ENVIRONMENT ALTERATION EQUIPMENT				50	
SURVEYING EQUIPMENT				51	
TRACKING NETWORK				52	
COMMUNICATIONS NETWORK				53	
DATA PROCESSING EQUIPMENT (RELAY)				54	
		BOATS			55
		BUOYS			56
		PROBES			57
		DIVERS			58
			CREW AND LIMITED RESEARCH PERSONNEL		59
SUPPORT VESSELS (DESTROYER CLASS)		TRACKING NETWORK			60
		COMMUNICATIONS NETWORK			61
	DATA PROCESSING EQUIPMENT (RELAY)			62	
		SOUNDING AND TETHERED BALLOONS			63
		BUOYS			64
		BOATS			65
		DIVERS (LIMITED)			66
			PLANE GUARD		67
			RECOVERY RESCUE AND SURVIVAL		68
			ICE BREAKING		69
			TRANSPORTATION		70
	SUPPLY VESSELS	TRACKING NETWORK (LIMITED)			71
		COMMUNICATIONS NETWORK (LIMITED)			72
		DATA PROCESSING RELAY (LIMITED)			73
		SOUNDING AND TETHERED BALLOONS (LIMITED)			74
		BUOYS (LIMITED)			75
		BOATS (LIMITED)			76
			SUPPLY		77
			TRANSPORTATION		78

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ACCESS TO MOST INLAND AREAS
VIA SHIP, BOAT & AIRCRAFT
TRANSPORTATION

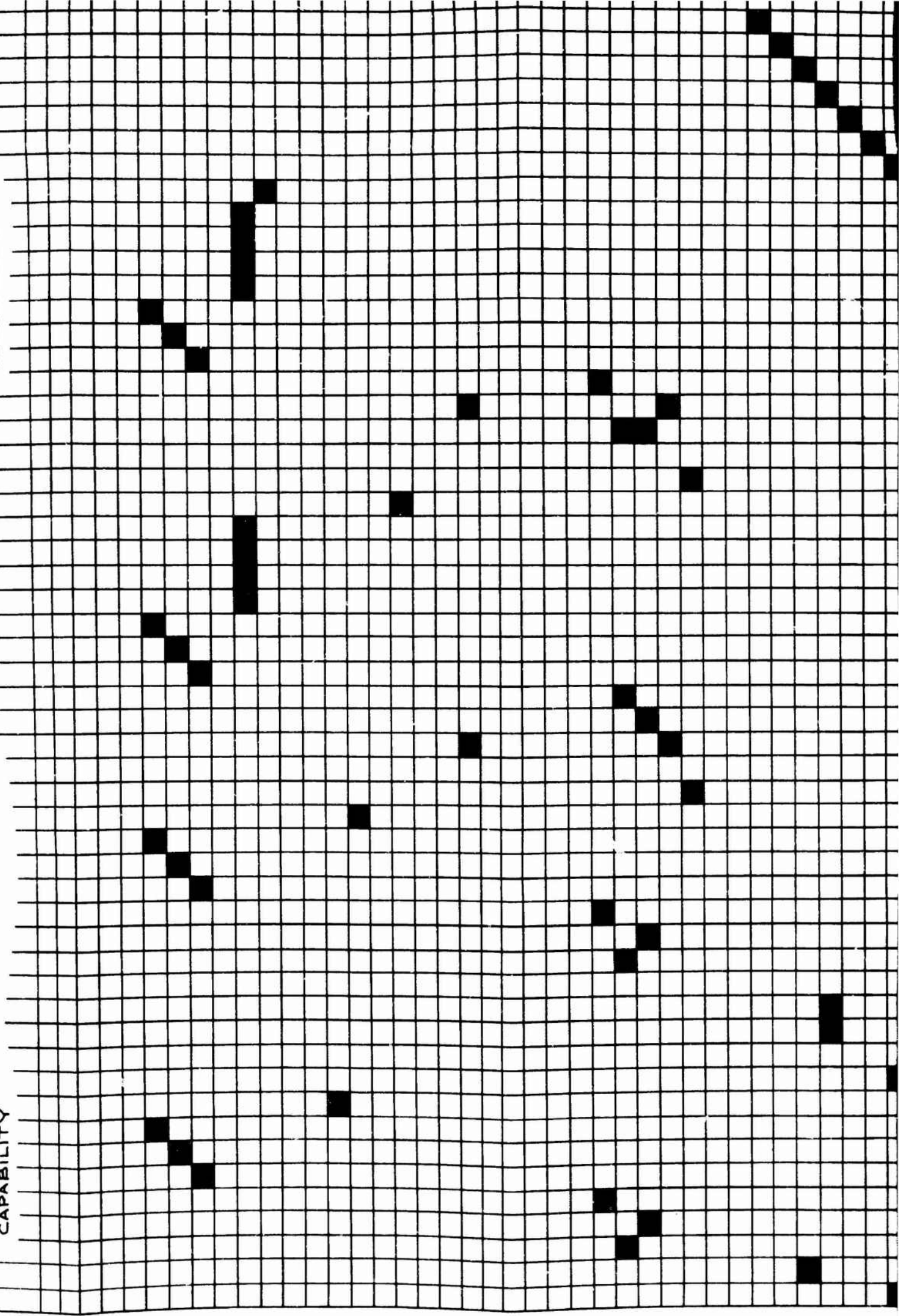
ACCESS TO THE LAND/OCEAN & LAND/ATMOSPHERE
INTERFACES WITH SIMULTANEOUS MEASUREMENT
CAPABILITY

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ACCESS TO THE LAND/OCEAN & LAND/ATMOSPHERE
INTERFACES WITH SIMULTANEOUS MEASUREMENT
CAPABILITY

ACCESS TO MOST INLAND AREAS
VIA SHIP, BOAT & AIRCRAFT
TRANSPORTATION



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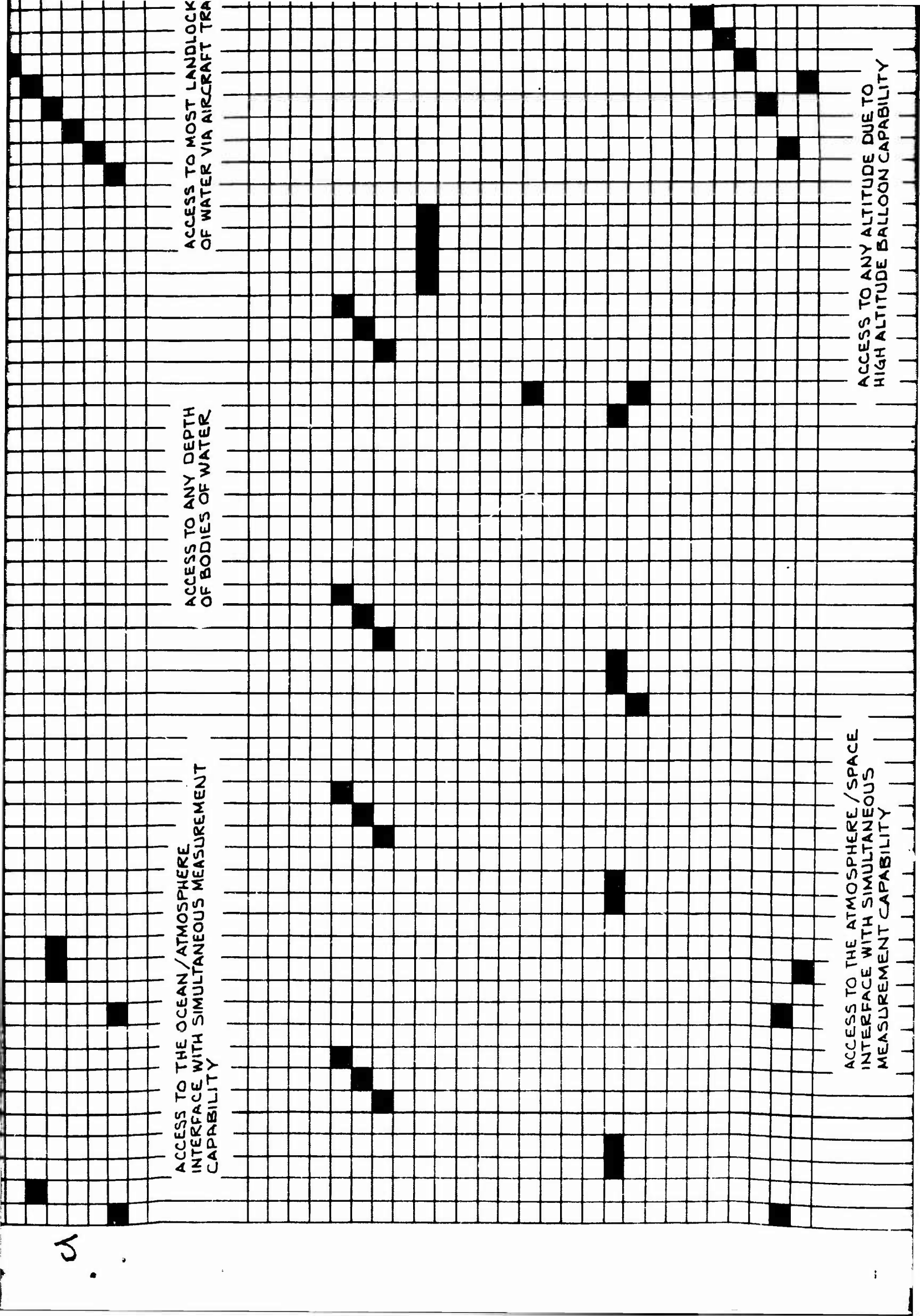
ACCESS TO THE OCEAN / ATMOSPHERE
INTERFACE WITH SIMULTANEOUS MEASUREMENT
CAPABILITY

ACCESS TO ANY DEPTH
OF BODIES OF WATER

ACCESS TO MOST LANDLOCK
OF WATER VIA AIRCRAFT TRA

ACCESS TO THE ATMOSPHERE / SPACE
INTERFACE WITH SIMULTANEOUS
MEASUREMENT CAPABILITY

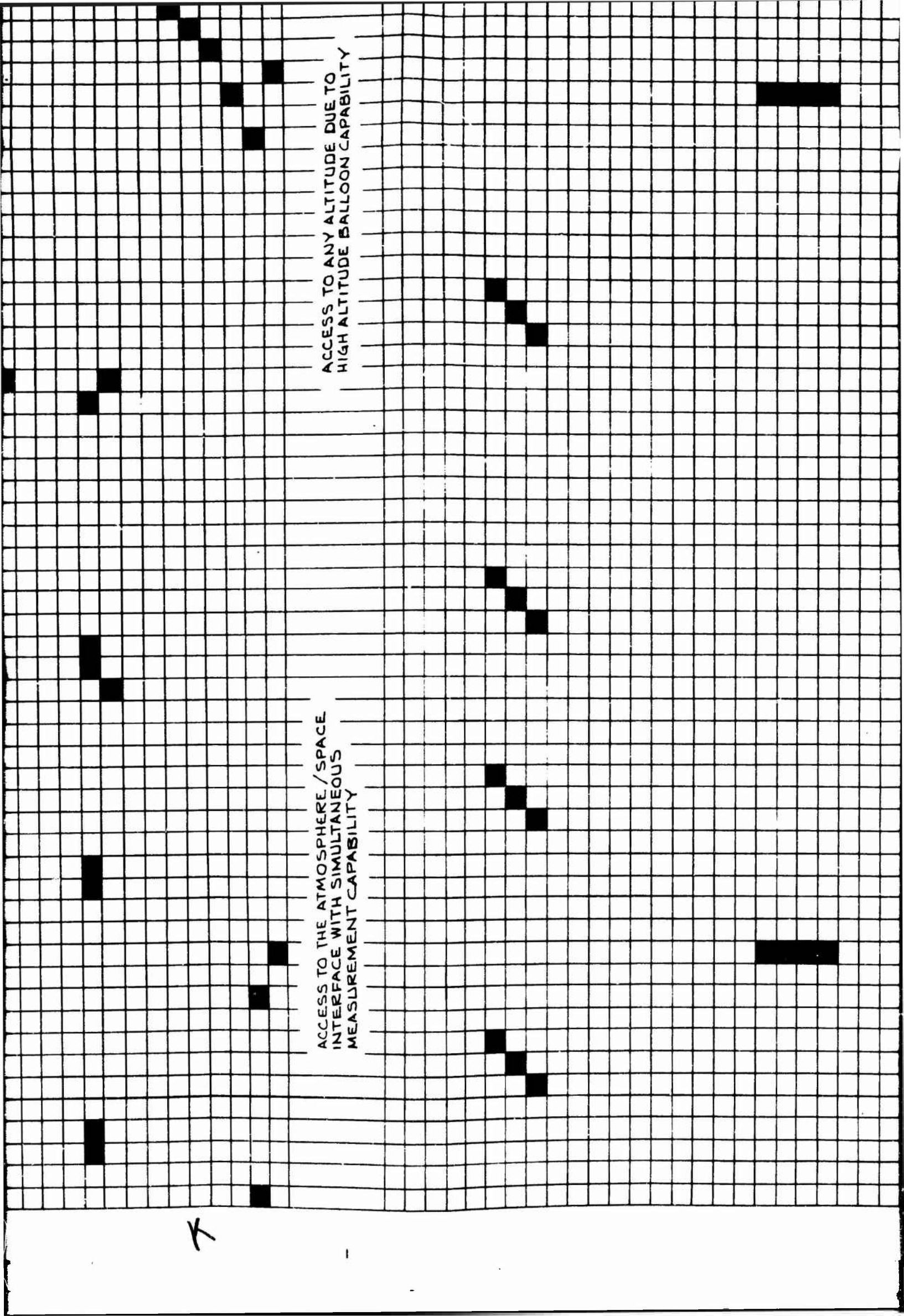
ACCESS TO ANY ALTITUDE DUE TO
HIGH ALTITUDE BALLOON CAPABILITY



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ACCESS TO THE ATMOSPHERE / SPACE
INTERFACE WITH SIMULTANEOUS
MEASUREMENT CAPABILITY

ACCESS TO ANY ALTITUDE DUE TO
HIGH ALTITUDE BALLOON CAPABILITY



ACCESS TO MEASUREMENT OF SOLAR & OTHER EXTRATERRESTRIAL
ENERGY SOURCES WITH MEASUREMENTS COORDINATED SIMULTANEOUSLY
WITH ATMOSPHERE, LAND & SEA MEASUREMENTS

FACILITIES - VEHICLES

SEA

FACILITIES										OCEAN VEHICLE OPERATIONS										DEPLOYED VEHICLE OPERATIONS										SUPPORT SERVICE									
OPTICAL OBSERVATIONS	RADIO / RADAR OBSERVATORIES	PHYSICAL OBSERVATION	TRACKING	COMMUNICATIONS	DATA PROCESSING	SIMULATION & TEST	TOTAL NUMBER	RESEARCH VESSELS	CONSTRUCTION & REPAIR VESSELS	AIRCRAFT CARRIERS	SUPPLY VESSELS	SUPPORT VESSELS (DESTROYERS)	SUBMERSIBLES	SUBMARINES	UNDERSEA BASES	BUOYS / PLATFORMS	TOTAL NUMBER	FIXED WING AIRCRAFT	ROTARY WING AIRCRAFT	SOUNDING ROCKETS	BOOSTERS / SPACECRAFT (LIMITED)	BALLOONS	BOATS & AMPHIBIOUS CRAFT	TOTAL NUMBER	PERSONNEL	MAINTENANCE & REPAIR	CONSTRUCTION	FOOD & HOUSING	MEDICAL	SUPPLY	RECOVERY & RESCUE	ADMINI	RATION	RECREATION					
34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69				
							9										9									6													
								U	R	U	U	R	R	U	L	L			L	L	L	L	L	L															
R	R	R	R	R	C	C		R	R	R	R	R	C	C	C	R			R	R	C	R	R	R			C	R	R	C	C	R	L	C	C				
R	R	R	R	R	C	C		R	R	R	R	R	C	C	C	R			R	R	C	R	R	R			C	R	R	C	C	R	L	C	C				
R	R	R	R	R	C	C		R	R	R	R	R	C	C	C	R			R	R	C	R	R	R			C	R	R	C	C	R	L	C	C				
R	R	R	R	R	C	C		R	R	R	R	R	C	C	C	R			R	R	C	R	R	R			C	R	R	C	C	R	L	C	C				

OPERATIONAL PARAMETERS

			RESEARCH LABORATORIES	DEVELOPMENT LABORATORIES	OPTICAL OBSERVATORIES	RADIO/RADAR OBSERVATORIES	PHYSICAL OBSERVATORIES	TRACKING	COMMUNICATIONS	DATA PROCESSING	SIMULATION & TEST	TOTAL NUMBER	SUBTERRANEAN	SURFACE	FIXED WING AIRCRAFT	ROTOR WING AIRCRAFT		
			01	02	03	04	05	06	07	08	09	10	11	12	13	14		
CAPABILITY	NUMBER OF DIFFERENT	FACILITIES	01									0						
		VEHICLE OPERATIONS	02											2				
		DEPLOYABLE VEHICLE OPERATIONS	03															
		SUPPORT SERVICES	04															
FLEXIBILITY		GEOGRAPHICAL COVERAGE	05															
		LOCAL AREA COVERAGE	06															
		MOBILITY	07											L	R	L	L	
	INDIVIDUAL RESEARCH EFFORT	SPACE	08															
		SPACE/ATMOSPHERE INTERFACE	09															
		ATMOSPHERE	10															
		ATMOSPHERE/HYDROSPHERE	11															
		HYDROSPHERE	12															
		HYDROSPHERE/LITHOSPHERE INT.	13															
		LITHOSPHERE	14															
		LITHOSPHERE/ATMOSPHERE INT.	15															
		SIMULTANEOUS RESEARCH EFFORT	SPACE	16														
			SPACE ATMOSPHERE INT.	17														
	ATMOSPHERE		18															
	ATMOSPHERE/HYDROSPHERE INT.		19															
	HYDROSPHERE		20															
	HYDROSPHERE/LITHOSPHERE INT.		21															
	LITHOSPHERE		22															
	LITHOSPHERE/ATMOSPHERE INT.		23															
	AVAILABILITY	MONTHS	24	U	U	L	L	L	L	L	U	U		L	L	L	L	
		DAYS	25	U	U	L	L	L	L	L	U	U		L	L	L	L	
		DAY OPERATIONS	26	U	U	L	L	L	L	L	U	U		L	L	L	L	
		NIGHT OPERATIONS	27	U	U	L	L	L	L	L	U	U		L	L	L	L	
ALL WEATHER OPER.		28	U	U	L	L	L	L	L	U	U		L	L	L	L		
COST	INITIAL	29																
	OPERATING	30																
OTHER		31																
		32																
		33																
		34																
		35																

09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40		
SIMULATION & TEST	TOTAL NUMBER	SUBTERRANEAN	SURFACE	FIXED WING AIRCRAFT	ROTTARY WING AIRCRAFT	SOUNDING / ROX	BOOSTERS / SPAC	BALLOONS	TOTAL NUMBER	PERSONNEL	MAINTENANCE & REPAIR	CONSTRUCTION	FOOD & HOUSING	MEDICAL	SUPPLY	RECOVERY, RESCUE & SURVIVAL	ADMINISTRATION	RECREATION	TRANSPORTATION	TOTAL NUMBER	LAND BASE COMPLETION	GEOGRAPHIC COVERAGE	LOCAL AREA COVERAGE	RESEARCH LABORATORIES	DEVELOPMENT LABORATORIES	OPTICAL OBSERVATION	RADIO / RADAR OBSERVATION	PHYSICAL OBSERVATION	TRACKING	COMMUNICATIONS	DATA PROCESSING		
	0		2						5											10													
U	L	L	L	L	L	U	L			U	L	L	U	U	L	L	U	U	L					U	U	R	R	R	R	R	R	U	U
U	L	L	L	L	L	U	L			U	L	L	U	U	L	L	U	U	L				U	U	R	R	R	R	R	R	U	U	
U	L	L	L	L	L	U	L			U	L	L	U	U	L	L	U	U	L				U	U	R	R	R	R	R	R	U	U	
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RESEARCH FLEET

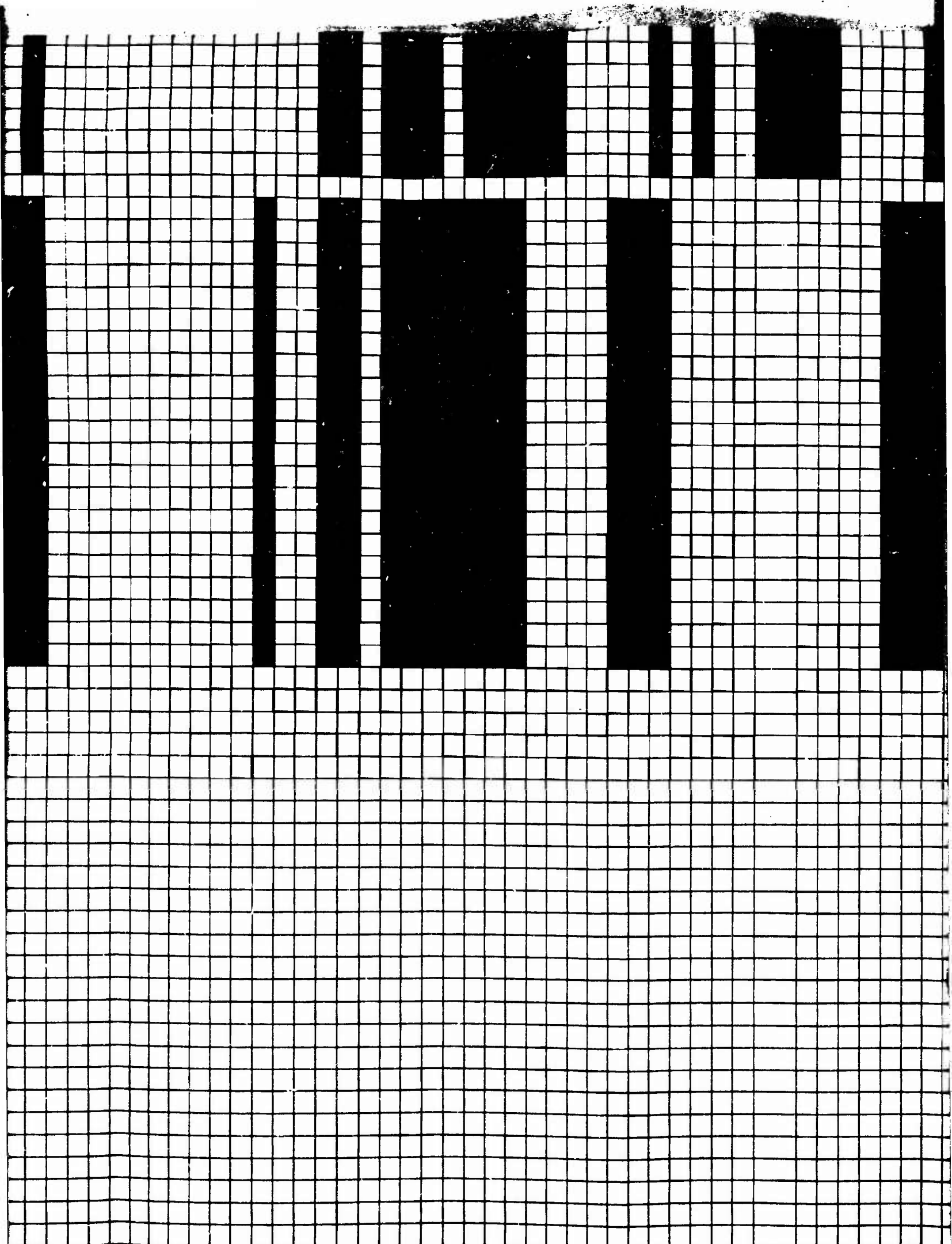
AIRCRAFT CARRIER

ATMOSPHERIC AND OCEAN SCIENCES RESEARCH VESSELS

SUBMARINE

	VEHICLES FOR DEPLOYMENT	SUPPORT SERVICES	FACILITIES	VEHICLES FOR DEPLOYMENT	SUPP. SERV.	FACILITIES
11	COMMUNICATIONS NETWORK	PERSONNEL	TOTAL ENVIRONMENT SENSING EQUIPMENT		CREW & LIMITED RESEARCH PERSONNEL	TOTAL ENVIRONMENT SAMPLING EQUIPMENT
12	DATA PROCESSING FACILITY	MAINTENANCE & REPAIR	TOTAL ENVIRONMENT SAMPLING EQUIPMENT			TOTAL ENVIRONMENT SAMPLING EQUIPMENT
13	SIMULATION AND TEST LABORATORY	CONSTRUCTION (LIMITED)	SURVEILING EQUIPMENT			ENVIRONMENT ALTERATION EQUIPMENT
14	LAND SURFACE VEHICLES	FOOD & HOUSING	ENVIRONMENT ALTERATION EQUIPMENT			SURVEILING EQUIPMENT
15	SUBTERRANEAN VEHICLES	MEDICAL	TRACKING NETWORK COMMUNICATIONS NETWORK			TRACKING NETWORK COMMUNICATIONS NETWORK
16	BOATS	SUPPLY	DATA PROCESSING EQUIPMENT (RELAY)			DATA PROCESSING EQUIPMENT (RELAY)
17	AMPHIBIOUS CRAFT	RECOVERY, RESCUE & SURVIVAL	BOUNDING & TETHERED BALLOON			
18	SUBMERSIBLES	ADM., LIBRARY, CLASSROOMS, CLERICAL & DRAFTING	ATMOSPHERIC & OCEAN PROBES			
19	UNDERSEA BASES	RECREATION	BOATS & BUOYS			
20	BOUOYS	TRANSPORTATION	DIVERS			
21	FIXED WING AIRCRAFT					
22	ROTARY WING AIRCRAFT					
23	BALLOONS					
24	SOUNDING ROCKETS					
25	BOOSTERS/SPACECRAFT LIMITED					
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UNIV.	003-036-9	CHARACTERISTICS	INTERACTIONS	31	30
ONR / TEXAS A&M UNIV.	083-036-7	SOLUBILITY	GAS & ORGANIC CARBON IN SEAWATER	43	29
ONR / TEXAS A&M UNIV.	083-036-8	OVERALL CHARACTERISTICS	AIR-SEA INTERACTIONS	22	30
ONR / N.Y. UNIV.	083-046-3	STRUCTURE	AIR TURBULENCE OVER SEA WATER	89	31
ONR / N.Y. UNIV.	083-046-4	REFLECTIVITY	ROBUST ENERGY AT SEA SURFACE	60	32
ONR / UNIV. OF MIAMI	083-060-6	OVERALL CHARACTERISTICS	ATM. & WAVE GENERATION	69	33
ONR / OREGON STATE U.	083-102-2	MECHANICAL PROPERTIES	AIR-SEA INTERACTIONS	60	34
					35
NASA / ?	?	SCALE / DIMENSIONS	EXTRA-TERRRESTRIAL MATTER	?	36
NASA / ?	?	SCALE / DIMENSIONS	IONIZING RADIATION	?	37
NASA / ?	?	OVERALL CHARACTERISTICS	IONIZING RADIATION	?	38
NASA / ?	?	OVERALL STRUCTURE	ELECTROMAGNETIC RADIATION	?	39
NASA / ?	?	OVERALL ELECTRO-MAGNETIC CHARACTERISTICS	VISIBLE RADIATION	?	40
NASA / ?	?	OVERALL CHARACTERISTICS	INFRARED RADIATION	?	41
NASA / ?	?	OVERALL CHARACTERISTICS	SPACE ENERGY	?	42
NASA / ?	?	ELECTROMAGNETIC PROPERTIES	BETA-RAYS (ELECTRONS)	?	43
NASA / ?	?	OVERALL CHARACTERISTICS	PLANETARY GASEOUS FORMS	?	44
NASA / ?	?				45
NASA / ?	?				46
NASA / ?	?				47
NASA / ?	?				48
NASA / ?	?				49
USAF / ?	?	OPTICAL CHARACTERISTICS	INFRARED RADIATION	?	50
USAF / ?	?	CONCENTRATION	PORE SUBSTANCES IN ATM	?	51
USAF / ?	?	SCALE / DIMENSIONS	IONIZING PARTICLES	?	52
USAF / ?	?	DET. OF CONSTITUENTS	PLANETARY GASEOUS & LIQUID FORMS	?	53
BU. OF STDS. / ?	?				54
AEC, WEATHER BU. / ?	?	SCALE / DIMENSIONS	GAMMA RADIATION	?	55
AEC / ?	?	OVERALL CHARACTERISTICS	RADIATION	?	56
					57
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